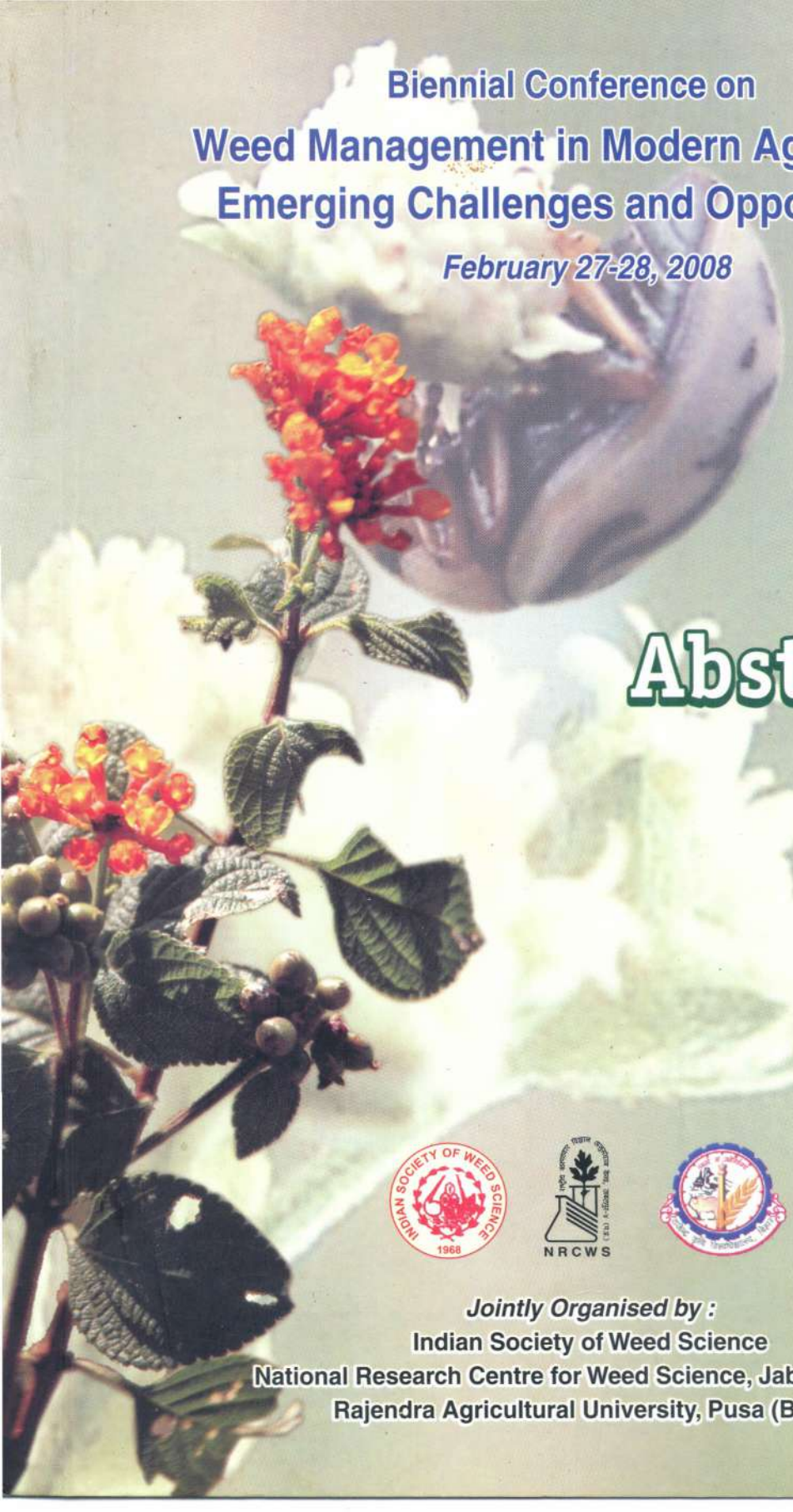
Biennial Conference on

Weed Management in Modern Agriculture : Emerging Challenges and Opportunities

February 27-28, 2008



Abstracts

Jointly Organised by :

Indian Society of Weed Science

National Research Centre for Weed Science, Jabalpur (M.P.)

Rajendra Agricultural University, Pusa (Bihar)

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Bihar Veterinary College, Patna

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Content

Inaugural Lecture

Invited Lectures

Weed managment - challenges and opportunities

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Weeds are plants that are undesirable to human activity at a particular time and place, and therefore, weeds will always be associated with human endeavours. Weeds are not only important in agriculture but are also a great nuisance in forestry, pastures and grasslands, wastelands, public amenity areas, aquatic bodies etc. They also affect biodiversity, environment and health of humans and livestock. Unlike other pests, weeds are ubiquitous and affect almost all the crops. Among all the biotic stresses, weeds cause the greatest losses amounting to nearly one third. Currently the country is losing about Rs. 1,000 billion per annum in food production on account of competition due to weeds. As the scope for horizontal increase has little possibility in view of the limited area available for cultivation, the only alternative feasible is the vertical increase which can be achieved with better genotypes and providing farmer-friendly input technology. The improved weed management is one such technology which has a tremendous potential in providing a plausible solution to meet the growing demand of food grains, pulses, oilseeds and other crops by the ever increasing population. Though weeds existed from time immemorial, the modern agriculture, characterized mainly by large scale adoption of dwarf HYVs and hybrids, increased use of irrigation & fertilizers, reduced tillage and globalization of agriculture has severely intensified manifold the weed problems. Some of the major challenges that the weed science in the country is currently facing as well as those that are likely to emerge in future are as follows:

- **Threat of invasive alien weeds:** Invasive alien weeds (IAWs) are plants that are moved from their native habitat to a new location and in the absence of their co-evolved predators and parasites they eventually become established and spread rapidly causing tremendous harm, often irreversible to the environment, economy and in some cases to human health.

  Majority of the important weed species in India have been introduced into the country in the past, either accidentally as contaminants in food or grain imports or deliberately. Especially, a large portion of non-agricultural area has been invaded by a number of unwanted plants, many of which are aliens. *Chromolaena odorata*, *Ageratum haustonianum*, *Mikania micrantha* are creating havoc in plantation crops in Kerala and north-eastern states. *Mimosa rubicaulis* has seriously infested the world famous Kaziranga National Park of Assam and is threatening the food source of several herbivores in the park including the much-endangered single horned Rhinoceros. Water hyacinth has spread over 2.0 lakh hectares of water surface in India covering almost all the states. *Parthenium hysterophorus* has invaded about 10 mha of non-cropped area throughout the country. *Lantana camara* is a serious menace in Himachal Pradesh, Madhya Pradesh, North-Eastern states etc. A large number of aquatic weeds such as water hyacinth, *Salvinia molesta*, *Hydrilla*, Alligator weed are a great nuisance to fisheries, navigation, irrigation, hydroelectric projects and in tourism. These weeds are severely affecting human and cattle health, biodiversity, productivity and quality of eco-systems.

Increasing trade and globalization coupled with liberalization policies will further increase the risk of invasion by such weeds. Hence, management of such IAWs is a great challenge to the weed research scientists in the country.

- **Weed risk analysis:** Increased exchange of grains and seeds following globalization of agriculture is bound to result in further introductions. The sanitary and phytosanitary (SPS) agreement of WTO suggests that the countries need to not only update their quarantine laws, but also incorporate the elements of pest risk analysis for making regulatory decisions for both import and export. Therefore, there is an urgent need to analyze the risk factor associated with different exotic weeds to design safeguards and to lower the risk of their entry. This entails generating data on weed biology, list of quarantine weeds to facilitate trade etc.

- **Herbicide residues and environmental safety:** Herbicides are the most successful weed control technology ever developed as they are selective, cost effective, fairly easy to apply, have persistence that can be managed, and offer flexibility in application time. They are eco-friendly if applied at proper dose, method and time, besides being quite safer in comparison to other pesticides like insecticides. However, the increasing consumption of herbicides in the country may pose challenges like the resultant build-up of residues not only in soil and water but also in the crop produce being exported which may be used as a non-tariff barrier in the world trade, herbicidal toxicity to succeeding crop and environment besides the likely development of herbicide resistance in weeds which need the immediate attention of weed researchers.

- **Global climate change:** The CO_2 level in the atmosphere has been rising owing to various human activities such as burning of fossil fuels, deforestation, industrialization urbanization etc. As weed populations show greater variations, it is possible that with a changed global climate weeds too will achieve a greater competitive fitness against the crop plants and development of new weed types.

- **Development of super weeds:** Imparting resistance to normally herbicide susceptible crops to produce herbicide-tolerant crops (HTCs) has been the most extensively exploited area of plant biotechnology. Introduction of HTCs besides helping in efficient management of problem weeds with minimum risk to the crop and increasing the yields may also lead to development of 'super weeds'. Their management will be essential in the days ahead.

- **Weed shift:** The growing public awareness on environmental pollution and the concerns for human health and sustainability of agricultural production are giving way for organic farming. In view of this, integrated weed management practices involving non-chemical methods such as mechanical and cultural (zero tillage, conservation tillage, plant residue management, growing intercrops, cover crops and green manure crops) be given due emphasis. However, it is a big challenge to make these non-chemical methods of weed management effective and economical.

- **Biological control of weeds:** Technologies employing natural systems, biological organisms, bio-pesticides should be resorted to wherever possible in order to overcome or reduce the dependence on herbicides. Though there is sufficient scope for managing weeds at least in non-cropped areas through the use of exotic insect pests as has been successfully proved in the management of *Parthenium* by the Mexican beetle (*Zygogramma bicolorata*), water hyacinth by *Neochetina* spp. and *Salvinia* by *Cyrtobagous salviniae*, however, the associated risks like change in the behaviour and host specificity of biocontrol agents has to be looked into with great depth and vision.

- **Management of parasitic weeds**: Parasitic weeds are posing problem in the productivity of some of the major crops and cropping systems. *Cuscuta* spp. is a major problem in niger (Orissa, parts of Madhya Pradesh and Chhattisgarh), in lucerne (Gujarat), blackgram/ greengram (in rice-fallows of Andhra Pradesh), berseem, lentil, linseed and chickpea (parts of Madhya Pradesh). Some species of *Cuscuta* also infest ornamental plants, hedges and trees. *Orobanche* spp. is a major parasite in tobacco in parts of Karnataka, Andhra Pradesh, Tamil Nadu, and Gujarat, mustard in parts of Gujarat, western Uttar Pradesh, Rajasthan, Haryana, etc., and more recently in tomato and potato in Karnataka. *Striga* spp. infest mostly sugarcane, maize, sorghum and pearl millet grown in dry areas in some parts of Karnataka, Madhya Pradesh and Chhattisgarh. *Loranthus* is noticed on economically useful tree crops in southern states. It is necessary to develop viable management technologies for such weeds.

- **Aquatic weed management:** India has a total area of about 7 million hectares under different kinds of water bodies such as reservoirs, tanks, lakes, ponds, oxbow lakes, derelict water and brackish water. In addition about 1.7 lakh km is under rivers and canals. In addition, the area under these aquatic bodies is increasing with the building up of dams, canals and tanks for irrigation and fisheries production. The most prevalent method of managing the menace of aquatic weeds is their physical removal from the water bodies which is highly laborious and expensive, besides the disposal of the harvested material which is also a big problem. In view of the restricted use of herbicides in aquatic bodies due to the multifaceted use of water for purposes like fish culture, irrigation, domestic use etc., in-depth and more comprehensive eco-friendly research work is required to be carried out on the management of such weeds.

- **Exploitation of weeds for beneficiary use:** Weeds like water hyacinth, *Chromolaena, Lantana, Parthenium*, *Ipomoea*, etc., are rapidly spreading through out the country at the cost of other useful vegetation. Proper utilization of such biomass through appropriate technologies like vermicompost, mulch, phyto-remediation etc., may help in supplementing chemical fertilizers besides adding organic matter to the soil. Utilization of weeds as a source of ayurvedic medicines, bio-pesticides and bio-fuel also has enough potential. Technology for using weeds for making paper, particle boards, furniture etc., has to be developed ahead.

- **Awareness raising and technology transfer:** The weed management technologies have not reached the farmers at the same pace as happened in case of varieties, fertilizers and

insecticides. One of the main reasons could be that unlike other pests, the losses caused by weeds are invisible and many a time these are ignored by the farmers in spite of the fact that they cause maximum losses. Lack of awareness regarding losses caused by weeds and ways to control them are still the major reasons for poor adoption of weed management technologies. Therefore, there is a need to popularize the cost-effective weed management technologies through field demonstrations, electronic mass media, trainings and participation in *kisan melas*, etc. It is also important to involve farmers in testing and refinement of the technologies. Efforts should also be made to study the impact analysis of weed management technologies. Since private sector is emerging as a strong force in technology generation, acquisition and transfer, suitable mechanism of linkage between public and private sector in assessing and transferring appropriate technologies in a complementary manner should be developed.

As the afore-mentioned challenges are multi-pronged in nature, a holistic approach with multi-disciplinary, multi-locational and multi-institutional involvement is imperative to solve these.

Weeds and weed management under a changing climate

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Introduction

The earth is warmed largely by short-wave radiation (0.15-4.0 μm) emanating from the sun, which has a high temperature (6000°C). This radiation includes visible light (~0.3-0.7 μm) and ultra-violet radiation (~0.2-0.4 μm). The earth intercepts only a part of this radiation and the warm earth's surface re-emits its own radiation. The latter ('terrestrial radiation'), is at longer wavelengths in the infrared or thermal part of the spectrum (~4-50 μm), and is invisible to the human eye (Rosenzweig and Hillel, 1998).

Atmospheric gases, particularly water vapour, CO_2 and other trace gases (Table 1), re-absorb terrestrial radiation leaving the earth at particular wavelengths, while being transparent to incoming solar radiation. The effect is to warm the earth's surface to an average of 15°C, which allowed life on earth to be first established. This is the '*natural greenhouse effect*' of the atmosphere, so called because it is similar to the effect produced by gases inside an actual greenhouse. In a greenhouse, the glass shielding is transparent to visible light, but partly opaque to IR radiation. Sunlight entering a greenhouse is absorbed by the gases, converted to heat, and then re-emitted as IR, which is partially blocked by the glass. The trapped radiation then warms up the greenhouse, until it reaches a temperature at which the intensity of the outgoing IR equals the incoming radiation.

Table 1. A summary of Greenhouse gas concentrations[1]

	CO_2	CH_4	N_2O	[2]CFC-12	[3]HCFC-22
[4]Preindustrial concentrations	280 ppmv	700 ppbv	275 ppbv	0	0
Concentration in 1994	358 ppmv	1714 ppbv	311 ppbv	503 pptv	105 pptv
Rate of concentration change	1.5 ppmv yr^{-1}	13 ppmv yr^{-1}	0.75ppmv yr^{-1}	18-20 ppmv yr^{-1}	7-8 ppmv yr^{-1}
Atmospheric lifetime (years)	50-200	12-17	120	102	13

[1]Source: IPCC, 1996a, b; [2]Chlorofluorocarbons, CFCs including CFC-12 are synthetic gases used as refrigerants, propellant sprays and foaming agents substitute; [3]A CFC substitute; [4]period between 1750-1800

The increased concentrations of greenhouse gasses have further blocked the escape of terrestrial radiation from the earth's surface, and have re-emitted this energy back to earth, leading to warming of the atmosphere near the surface and changes to hydrological regimes. The overall climatic consequences- called '*global warming*', is an *enhanced greenhouse effect*. The effectiveness of a greenhouse gas in warming the atmosphere depends both on its concentration and on the amount of time it remains in the atmosphere (Table 1). Of these gases, CO_2 is the most significant, contributing to ~64% of the effect, followed by CH_4 ~19%, CFCs ~11% and N_2O ~6%.

Effects of climate change

Various influential reports, books and articles (IPCC, 1996; Luo and Mooney, 1999; Parry, 1990; 1998; Patterson, 1995; Rosenzweig and Hillel, 1998; Bunce, 2001), have pointed out that enhanced greenhouse effect may affect agriculture and natural ecosystems in several ways. The most significant of these effects are:

(1) Increased CO_2 concentrations could have a direct effect on the growth-rates of crop plants and weeds and also cause vegetation communities to change;

(2) CO_2 induced climate changes may alter temperature, rainfall patterns and amounts of radiation received in different parts of the world, influencing productivity of natural ecosystems or agricultural landscapes; and

(3) Sea level rises, also with regional differences, may lead to loss of productive land, and to increasing salinity of groundwater in coastal zones.

This paper presents an overview of our current understanding of only the first two effects, which are most relevant to weed management.

Effects of CO_2 enrichment

CO_2 has risen 33% from a pre-industrial concentration (~280 $\mu L\ L^{-1}$) to a current estimate of ~370 $\mu L\ L^{-1}$ mostly due to population growth, global reliance on burning of fossil fuels for energy and changes in land use practices, including deforestation (Parry, 1990; 1998; Bunce 2001). Continuing increases in CO_2 and other trace gases could result in an increase in global surface temperature (IPCC, 1996) and alterations in the Earth's climate.

Effects on photosynthesis and growth

Consequences of increased atmospheric CO_2 are likely to be manifested through direct effects on plant physiological processes like photosynthesis and stomatal physiology, resulting in increases of growth rates of many plants (Drake *et al.*, 1997). Other consequences are related to increases in temperature, which can both directly and indirectly affect plant growth and metabolism. Increases in CO_2 concentration and temperature will alter a plant's ability to grow and compete with individuals within a given environment. There is also evidence (IPCC, 1996; Parry, 1998; Bunce 2001) that increased CO_2 would increases the tolerance of plants to stresses, such as drought, and high and low temperature. Increased tolerance of environmental stress is likely to modify the distribution of colonising species across the globe, and also their competitiveness in different habitats.

Plants vary in their response to CO_2 because of differing photosynthetic mechanisms, the C_3 and C_4 pathways. In C_3 photosynthesis, possessed by 95% of all known species, the first product of CO_2 fixation is a 3-carbon acid, pyruvic acid, and this involves the enzyme phospho enol pyruvate carboxylase (PEP Carboxylase). C_3 plants use up some of the solar energy they absorb in photorespiration in which a significant fraction of the carbon initially reduced from CO_2 and fixed into carbohydrates is re-oxidized back to CO_2, thus releasing part of the chemical energy that the plant had originally taken in. Photorespiration is an adaptation to protect against the damage that can be caused by too much sunlight (Kozaki and Takeba, 1996) and is one reason why C_3 crops (such as rice, wheat, soybean, barley and sunflower), exhibit lower rates of net photosynthesis than do C_4 crops (such as maize sorghum, sugarcane and millet), at ambient CO_2. However, due to the same reason, C_3 species respond more favourably to elevated CO_2 levels, because CO_2 tends to suppress photorespiration.

The alternative photosynthetic pathway, C_4 photosynthesis, involves converting CO_2 captured by mesophyll cells firstly into four-carbon acids, malic and aspartic acids, which are then transmitted to Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) enzyme in the bundle-sheath cells of leaves. There the acids release CO_2, raising the CO_2 concentration and promoting carboxylase over the oxygenase enzymatic reaction. In C_4 plants, the internal mesophyll cell arrangements are different to those of C_3 plants, making efficient transfer of CO_2 possible, and this minimizes photorespiration and favours photosynthesis (Drake *et al.*, 1997). Although C_4 plants are more efficient photosynthetically than C_3 plants under present CO_2 levels, they are likely to be less affected by CO_2 increases. One view is that in a CO_2 enriched atmosphere, important C_4 crops of the world may become more vulnerable to increased competition from C_3 weeds.

Effects on stomata and water use efficiency (WUE)

There is sufficient evidence that increased CO_2 concentration leads to partial closure of stomata through which CO_2 is absorbed and water vapour is released by transpiration. This lowers the water requirements of plants by reducing transpiration per unit leaf area, while promoting photosynthesis. The dual effect of promoting photosynthesis and reducing transpiration is to improve WUE (i.e. ratio of plant biomass, to the amount of water transpired). Kimball and Idso (1983) reported general improvement of WUE by 70-100% for both C_3 and C_4 species.

A doubling of CO_2 concentrations is predicted to cause a 30-40% decrease in the stomatal aperture in both C_3 and C_4 plants, reducing transpiration losses by as much as 25-40%. However, whether this effect also leads to reduced evapotranspiration (ET) from plants depends on the effects of elevated CO_2 on leaf area index (LAI), as well as on stomatal conductance. No savings in water can be expected, if elevated CO_2 stimulates increase in LAI more than it decreases stomatal conductance. In long-term field studies of whole plant responses to elevated CO_2 (see review by Drake *et al.*, 1997) LAI did not increase in any species, but ET was reduced compared with normal ambient in all of the species studied in a wetland, Kansas prairie and a Californian grassland. In a wetland, instantaneous values of ET averaged 5.5–6.5 mmol H_2O $m^{-2}s^{-1}$ for a C_3 dominated community at ambient CO_2. The corresponding value for the C_4 community was 7.5–8.7 mmol H_2O $m^{-2}s^{-1}$. However, at elevated CO_2, ET was reduced 17–22% in the C_3 and 28–29% in the C_4

community. Such studies indicate a relatively greater effect of elevated CO_2 on stomatal conductance in C_4 species. An outcome of this effect will be that many species will grow well in environments where moisture availability is currently a limitation for sustaining populations. However, our knowledge about the differential responses C_3 and C_4 species to such environmental changes is still rudimentary.

Effects of increased temperatures

Models of global climate predict that mean surface air temperature of the Earth will rise by 1.5-4.5 ^{0}C in the 21st century, due to the doubling of CO_2 concentrations (~600 $\mu L\ L^{-1}$) and the enhanced greenhouse effect (IPCC, 1996). Extreme high-temperature events are also anticipated to increase in frequency. Plants, in many parts of the world, are thus likely to experience increasing high-temperature stress.

A body of research is emerging (see reviews in Rosenzweig and Hillel, 1998; Luo and Mooney, 1999, and Bunce 2000), which indicates that elevated CO_2 levels could increase the ability of plants to tolerate both high and low temperatures. However, the response is linked with moisture availability, and possibly other factors like nitrogen deposition. Boese *et al.* (1997) established the increased tolerance of low temperatures under elevated CO_2 for several chilling sensitive plants of tropical or sub-tropical origin. Effects like improved plant water balance, less severe wilting and less leaf damage under elevated CO_2 compared with ambient levels are possible explanations.

Temperature is the dominant factor that controls plant growth at high mid-latitudes (above 45^{0}N, at high altitudes (above 50^{0}N) and at high altitudes, largely due to the influence temperature has on the length of the growing season. Probably the most significant effect of a future increase in temperature in regions where temperate is the main limiting factor, would be to extend the growing season available for plants. However, the effects of such warming on the length of the growing period will again vary from region to region and from crop to crop.

Effects on crop growth and yield

In general, higher atmospheric CO_2 is likely to stimulate the growth of a variety of crops, and C_3 plants are the most likely to benefit. Nevertheless, our knowledge of how crops will respond to the interactions of elevated CO_2 and global warming is still inadequate. Moya *et al.* (1998) confirmed that elevated CO_2 alone increased the biomass and seed yield of rice. However, higher temperature (ambient + 4^{0}C) alone consistently decreased the seed yield of several rice cultivars, including a standard semi-dwarf (IR 72) and a heat and drought tolerant cultivar from India (N-22) with little change in plant biomass. For all cultivars, the combination of increased CO_2 and elevated air temperature resulted in reduced grain yields, compared to increased CO_2 alone. Hence, simultaneous exposure to rising temperatures may negate the increased grain yield response to elevated CO_2.

The consensus of research during the past three decades is that a doubling of CO_2 concentrations may cause a 10-50% increase in the yield of C_3 crops, including rice, wheat and soybean, and a 0-10% increase in C_4 crops, such as maize, sorghum and sugar cane (Kimball,

1983; Poorter, 1993). Much will, however, depend on prevailing growing conditions and limitations imposed by availability of water and nutrients.

How will 'colonising species' (weeds) react to changing climate?

Weeds are best regarded as opportunistic '*colonising species*' or '*pioneers of secondary succession*' that are well adapted to grow in locations where disturbances, caused either by humans or by natural causes, have opened up space. Species can become weeds, because they are competitive, adaptable, highly fecund, and are able to tolerate a wide range of environmental conditions, including those in agricultural fields, or disturbed habitats.

A set of common biological characteristics allows weeds to colonise disturbed habitats, to form extensive populations and, sometimes, to dominate man-made or naturally disturbed landscapes. However, a species may become an invader of landscapes only if a chance combination of circumstances makes its attributes particularly advantageous to its growth and survival. In many cases, this opportunity arises because of lack of specific parasites or herbivores (i.e. 'natural enemies'), which gives them an advantage over crops or native flora.

Differential response of weeds to elevated CO_2

Over the past three decades, many experiments have tested the effects of higher atmospheric CO_2 on weeds with C_3 and C_4 photosynthetic pathways. Table 2 provides some examples from a literature review and early studies conducted by Patterson (1995). These results indicate significant and wide variations in response to CO_2 both within a species and between species, depending on experimental conditions, such as temperature, light, availability of water and nutrients. While the variability in plant responses is large, in general, C_3 weeds increased their biomass and leaf area under higher CO_2 concentrations compared with C_4 weeds.

Ziska & Bunce (1997) compared the effect of elevated CO_2 levels on the growth and biomass production of six C_4 weeds (*Amaranthus retroflexus* L., *Echinochloa crus-galli* (L.) P. Beauv., *Panicum dichotomiflorum* Michaux, *Setaria faberi* Herrm., *Setaria viridis* (L) P. Beauv., *Sorghum halapense* (L) Pers.) and four C_4 crop species (*Amaranthus hypochondriacus* L., *Saccharum officinarum* L., *Sorghum bicolor* (L) Moench, and *Zea mays* L.). Eight of the ten C_4 species showed a significant increase in photosynthesis. The largest and smallest increases observed were for *A. retroflexus* (+30%) and *Z. mays* (+5%), respectively.

Weed species (+19%) showed approximately twice the degree of photosynthetic stimulation as that of crop species (+10%) at higher CO_2, which also resulted in significant increases in whole plant biomass for four C_4 weeds (*A. retroflexus, E. crus-galli, P. dichotomiflorum, S. viridis*) relative to the ambient CO_2 condition. Leaf water potentials for three of the species (*A. retroflexus, A. hypochondriacus, Z. mays*) indicated that differences in photosynthetic stimulation were not due solely to improved leaf water status. This study confirms that C_4 plants may respond directly to increasing CO_2 in the atmosphere, and in the case of some C_4 weeds (e.g. *A. retroflexus*), the photosynthetic increase could be similar to those published for C_3 species.

Table 2. Response of some C_3 and C_4 weeds to doubled atmospheric CO_2 levels[1]

C3 Species	Range of response (x growth at ambient)		C4 Species	Range of response (x growth at ambient)	
	Biomass	Leaf Area		Biomass	Leaf Area
Abutilon theophratsii	1.0-1.52	0.87-1.17	*Amaranthus retroflexus*	0.9-1.41	0.94-1.25
Bromus mollis	1.37	1.04	*Andropogon virginicus*	0.8-1.17	0.88-1.29
Bromus tectorum	1.54	1.46	*Cyperus rotundus*	1.02	0.92
Cassia obtusifolia	1.4-1.6	1.1-1.34	*Digitaria ciliaris*	1.06-1.6	1.04-1.66
Chenopodium album	1.0-1.6	1.22	*Echinochloa crus-galli*	0.95-1.6	0.95-1.77
Datura stramonium	1.7-2.72	1.46	*Eleusine indica*	1.02-1.2	0.95-1.32
Elytrigia repens	1.64	1.3	*Paspalum plicatum*	1.08	1.02
Phalaris aquatica	1.43	1.31	*Rottboellia cochinchinensis*	1.21	1.13
Plantago lanceolata	1.0-1.33	1.33	*Setaria faberii*	0.93-1.35	1.0-1.4
Rumex crispus	1.18	0.96	*Sorghum halepense*	0.56-1.1	0.99-1.3

Weed/Crop competition

The reported differential responses of C_3 and C_4 plants to increasing CO_2 are especially relevant to weed-crop competition in agroecosystems. Of the 15 crops, which supply 90% of the world's calories, 12 have the C_3 photosynthetic pathway. In contrast, 14 of the 18 'World's Worst Weeds' are C_4 plants (Patterson, 1985). However, studies on competition outcomes between C_3 crops and C_4 weeds, or vice versa, are rather limited in the literature. In general, while higher atmospheric CO_2 would stimulate the growth of most C_3 crops, the same effect is likely to increase the growth of both C_3 and C_4 weeds. In all probability, this would lead to increased weed-crop competition, negating some of the otherwise beneficial effects of CO_2 'fertilization' of the major world crops and their yields. Some examples of outcomes of crop/weed competition studies are discussed below:

Carter and Peterson (1983) found that *Festuca elatior* L., a C_3, grass, performed much better, at the expense of *Sorghum halepense* (L.) Pers., a C_4 grass, in mixed cultures, under both ambient CO_2 levels and elevated CO_2, even under temperature unfavourable to C_3 photosynthesis (between 25 and 40°C). The authors predicted that global CO_2 enrichment would alter the competitive balance between C_3 and C_4 plants and this may affect seasonal niche separation, species distribution patterns, and net primary production within mixed communities.

Ziska (2000) evaluated the outcome of competition between 'Round-up Ready' Soybean (*Glycine max* L.) and a C_3 weed (lambsquarter, *Chenopodium album* L.) and a C_4 weed (redroot pigweed, *Amaranthus retroflexus*), grown at ambient and enhanced CO_2 (ambient + 250 μL L^{-1}). In a weed-free environment, elevated CO_2 resulted in a significant increase in soybean growth and seed yield, compared to the ambient CO_2 condition. However, soybean growth and seed yield were significantly reduced by the presence of either weed species at either level of CO_2. With lambsquarter, at elevated CO_2, the reduction in soybean seed yield relative to the weed-free control increased from 28 to 39%; concomitantly, the dry weight of lambsquarter increased by 65%. Conversely, for pigweed, soybean seed yield losses diminished with increasing CO_2 from 45 to 30%, with no change in the dry weight of the weed. This study suggests that rising CO_2 could alter yield losses due to competition from weeds, and that weed control will be crucial in realizing any potential increase in the yield of crops, such as soybean, as climate change occurs.

Alberto *et al.* (1996), studied competition outcomes between rice and a C_4 weed-*Echinochloa glabrescens* L. using replacement series mixtures at two different CO_2 concentrations (393 and 594 μL L^{-1}) under day/night temperatures of 27/21°C and 37/29°C. Increasing the CO_2 concentration, at 27/21°C, resulted in a significant increase in above ground biomass (+47%) and seed yield (+55%) of rice when averaged over all mixtures. For the C_4 weed, higher CO_2 concentration did not produce a significant effect on biomass or yield. When grown in mixture, the proportion of rice biomass increased significantly relative to that of the C_4 weed in all mixtures at elevated CO_2 indicating increased 'competitiveness' of rice. However, under elevated CO_2 level and the higher temperature regime, competitiveness and reproductive stimulation of rice was reduced compared to the lower growth temperature, suggesting that while a C_3 crop like rice may compete better against a C_4 weed at elevated CO_2 alone, simultaneous increases in CO_2 and temperature could still favour a C_4 species.

However, the effect of increased temperature would be felt in different regions of the world differently. It could be argued that in sub-tropical and tropical regions, an increase of temperature by a few degrees could lead to an increase in evapotranspiration rates to a point that the growth of some species would suffer, due to moisture deficiency. However, changes in rainfall patterns would offset such species responses, under a changing climate.

Implications for weed management

Given the physiological plasticity of many weed species and their greater genetic diversity relative to crops, it is possible that elevated CO_2 could provide an even greater competitive advantage to weeds with negative effects on crop production. Therefore, in future decades, when climate change effects are more consistently felt, weed management in agriculture or non-agricul-

tural situations will change. Aggressively growing C_3 or C_4 weeds will require more energy and labour intensive management. The abundance of perennial weeds may increase, since increasing CO_2 stimulates greater rhizome and tuber growth; greater increases in biomass result in dilution of herbicide applied, making weed control more difficult and costly (Patterson 1995).

Some direct evidence of this scenario comes from the increased glyphosate tolerance at elevated CO_2 shown by two perennial species- quackgrass (*Elytrigia repens*) and fathen (*Chenopodium album*). Research has shown that glyphosate is less effective in killing or suppressing these weeds grown at elevated CO_2 levels than when they were grown at ambient CO_2 concentrations (Ziska *et al.* 1999; Ziska and Teasdale 2000; Bunce 2001). The basis for this is not yet fully established, but was not related to plant size at the time of glyphosate application.

As discussed by Patterson (1995), growth at elevated CO_2 could result in anatomical, morphological and physiological changes, which alter herbicide uptake, translocation and overall effectiveness. Increasing CO_2 can increase leaf thickness, reduce stomatal number and decrease conductance, possibly limiting the uptake of foliar-applied herbicides. The evidence is that sustained stimulation of photosynthesis in perennial weeds as atmospheric CO_2 increases could reduce the effectiveness of chemical control, potentially increasing weed/crop competition.

Adapting to climate change

Projected changes in climate and crop yields in the latter part of the 21st century suggest that there will be positive yield changes in mid and high latitudes (Canada, Japan, European Union and New Zealand). These regions are recognised as having sufficient technology-based 'adaptive capacity' to face the changing global climate. In contrast, negative yield changes are predicted for tropical and sub-tropical regions of lower latitudes (mainly developing countries, including the Indian sub-continent, Middle East and South-east Asia), with important regional differences (Parry, 1998). In such regions, presently characterized by persistent poverty and food insecurity, temperature maxima are already near the optimum under the current climatic conditions. Modelling indicates that warming may lead to decreased yield and production with an increase in risk of hunger (IPCC, 1996).

Technically, adapting to climate change will require significant transformation of agriculture production by tapping three main sources for growth: (a) expanding the land area, (b) increasing the land cropping intensity (mostly through irrigation), and (c) boosting yields. The view that we may be approaching the ceiling for all three sources is not supported at the global level, although severe problems exist in some countries and even whole regions.

Experts agree that 80% of increased crop production in developing countries still has to come from intensification of agriculture- (a) higher yield crops; (b) increased multiple cropping; and (c) shorter fallow periods. However, regions other than tropical Latin America and Sub-Saharan Africa face a shortage of suitable land, and in these regions intensification through improved management and technologies will be the main source of production growth.

Control of weeds, pests and diseases are all likely to be more difficult and more expensive under climate change, and there will be more emphasis on regional cooperation for preventing the spread of certain weeds, pests and diseases (as in the case of control of diseases, such as HIV Aids).

The development and dissemination of new Science and Technology-based solutions will be much sought after for more holistic and integrated pest and weed management. Taking 'no regrets' actions, i.e. undertaking those strategies that make sense for reasons other than climate change is seen as important. Two such approaches are breeding more allelopathic crops and modification of crops by introducing genes that will confer resistance to pests.

Humans must take action to reduce the primary root cause: the high rate of CO_2 emissions, by a variety of approaches, such as decreased burning of fossil fuels, eradicating large-scale deforestation and reclamation of large wilderness areas for agricultural or other human uses. Among the most feasible actions to mitigate the CO_2 build up involve some combination of conserving energy, substituting alternative energy sources (e.g. solar, wind and hydropower) for fossil fuels, and reducing the deforestation occurring in the tropics.

In the past, environmental policies for agriculture have traditionally focused largely on practices of soil conservation, reducing land and water quality and reducing the impacts of excessive use of herbicides and pesticides in farming landscapes. More recently, agriculture has turned attention to conserving biological diversity on rural landscapes. Given that agriculture is a major contributor of the greenhouse gases methane and nitrous oxide, it seems prudent to expand these policies to limit emissions of CO_2, CH_4 and N_2O from agricultural practices. It is also necessary to encourage agriculture to more aggressively adopt and expand on agroforestry opportunities- for carbon sequestration benefits. The well-established conservation farming practices, and population management approaches to managing weeds, pests and pathogens, may also have to be revived.

Conclusions

The trend of increasing concentrations of greenhouse gases and enhanced greenhouse effect is likely to continue in the coming decades presenting serious threats to both agricultural systems and natural ecosystems (IPCC, 1996). Climate change is therefore predicted to be the biggest challenge faced by the human society. The response of crops, weeds, or natural vegetation communities, is inexorably linked to the climate modifications that humans have exacerbated. The theme of this Conference- "*Weed Management in Modern Agriculture: Emerging Challenges and Opportunities*" is therefore appropriate, as it seeks to stimulate the Weed Science community to seriously address some of the challenges posed by the global climate change, and its regional and local implications. This essay has provided an overview of some key issues and the complex and multiple-driver nature of global change.

Global Change is a somewhat deceptive expression for what is actually an exceedingly complex array of dynamic processes and specific interactions and manifestations in different regions (Rosenzweig and Hillel, 1998). Climate change, sea level rises, increases in CO_2 concentra-

tions, UV radiation and tropospheric ozone are but a few of the potentially fateful factors involved. In dealing with an issue as complex as climate change, there are many significant uncertainties, including the disordered behaviour of the physical climate and our inadequate understanding of that system, especially in regard to the interactions of oceans, clouds and ice. Still other uncertainties are the fast pace and unknown directions of future social, political and technological changes. Such uncertainties and unpredictable developments will impact on how the Earth's ecosystems and our agricultural landscapes respond to climate change, and ultimately, how humans will respond.

However, climate is not the only factor that will be changing as the 21st century unfolds. Population growth and varying economic and technological changes are likely to affect the environment no less than will climate change *per se*. Furthermore, the socio-economic and technological conditions will seriously interact with agriculture as well, and our ability to sustain effective production, whilst ensuring sustainable land use. To define how and what we may realistically achieve is a problem in itself, but taking no action is not an option.

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Spread and management of quarantine and invasive weeds

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Biological resources are the treasure of a country. India is blessed with its own biological resources of plants, insects, microorganisms, birds and animals. Ecological diversity in India represents various habitats such as cropping lands, forests, rangelands, protected areas, agro-ecosystems, wetlands, and mountain ecosystem. Each habitat represents its own diversity of species. Alien species are becoming serious threat to the environment and economic well being locally and globally. Negative effects of alien species have been identified on biological diversity, agricultural production, and human health hazards. Many alien species such as *Parthenium hysterophorus*, *Lantana camera*, *Phalaris minor* and others are invasive in nature, and have significant negative impacts on the ecosystems, economic systems and human health because of their high reproductive capacity, diverse dispersal mechanisms, colonizing ability in new habitats, capacity to outcompete native species. Habitat disturbances and degradation, frequent introduction with high magnitude of the alien species and lack of predators or natural competitors in the new habitat are the factors that promote invasiveness of alien species. In India, a number of alien species have been introduced unintentionally from around the world. Quarantine regulations are to be established to limit the introduction of new alien/invasive species in the future. An early detection and identification program must be developed at every level of potential entry points, and this program should be adopted throughout the country. The complexity of the environment and various ecosystems poses extraordinary challenges for the scientific community, government regulators, and other state agencies in developing a sound plant quarantine system. Management of invasive species requires immediate attention at the highest level to ensure the conservation of biodiversity and protection of production base in India. Knowledge base on invasive species such as their behavior in the ecosystems, their nature, scale and intensity of ropagation and colonization must be developed for appropriate management strategies.

Eco-biology of weeds in Indian dryland farming

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The plant cover is a good reflector of the environmental conditions and also integrates the variability aspect of the climate. Further, the regions derived from vegetational criteria point out the various lands units having a certain ecological uniformity and a particular degree of aridity. The physiognomy aspect of the desert presents a poor, scanty and xeromorphic vegetation, widely dispersed, leaving large areas bare.

Weed ecology in arid farming reveals that weeds have considerable adaptability to grow successfully in croplands. The prolonged germinability of seeds, sequential march and differential dominance are some of the adaptations, which have evolutionary significance for weed communities. Weeds of Indian dryland farming have large ecological amplitude, so that they multiply and flourish well even in the changed environment and adjust themselves well in such conditions. Large number of weeds appear together or in different sequence along with the crops during the short monsoon season in arid zone. Some of the important weeds of Indian desert are : *Arnebia hispidissima, Borreria articularis, Cenchrus biflorus, Corchorus tridens, Cyperus rotundus, Dactyloctenium* spp., *Dicoma tomentosa, Digera alternifolia, Eleusine compressa, Fagonia indica, Gisekia pharnacioides, Heliotropium* spp., *Indigofera spp., Mollugo* spp., *Oligochaeta ramose, Poycarpaea corymbosa, Pulicaria crispa, Tribulus terrestris, Tephrosia purpurea, Trianthema portulacastrum, Zaleya redimata,* etc.

In Indian desert higher density of weeds are seen only in the rainy season due to ample presence of moisture in the soil. With the very first shower, many weeds such as *B. articularis, Convolvulus microphyllus, Farsetia hamiltonii, P. Crispa* and *Trichodesma amplexicaule* sprout from their old rootstocks. Most of the weeds later make their appearance through seeds.

Seed germination is one of the most critical developmental phases in the life cycle of desert weeds. Extremes of environment are thus expected to lead to the evolution of mere clear-cut germination regulating mechanism, complicated in different species and even different plants of the same species.

The weeds are excellent examples of the successful struggle for existence. They are adapted by their abundant seed production, dispersal, varied types of seed dormancies, high competitive potentiality and adaptability to spread vegetatively. They have wide ecological amplitude, so multiply and flourish well even in changed environments.

Current status and future prospects of aquatic weed management

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All plants growing in an aquatic habitat will be considered as aquatic weeds when they interfere with the use of water bodies by forming dense vegetation, or by adversely affecting the growth of other useful plants. They are usually characterized by rapid growth and ability to regenerate by asexual means. Human interference has caused spread of aquatic weeds out of their natural habitat. *Eichhornia crassipes* (Mart.)Solms and *Salvinia molesta* Mitchell from South America has now become world problems due to spread by human beings. Similarly, *Hydrilla verticillata* (L.f.)Royle from Asia has been introduced to USA and *Elodea canadensis* Michx. from Canada to Europe.

I. Problems from aquatic weeds

Excessive growth of aquatic weeds causes difficulties in movement of irrigation and drainage water in canals and ditches, increases water loss from reservoirs, interferes with hydroelectric schemes by creating problems to turbines, adversely affect growth of fishes, causes hindrance to navigation, and increase problems of mosquitoes and health hazards.

Classification

Aquatic plants are classified as free floating weeds, emergent weeds, rooted weeds with floating leaves, submerged weeds and algae.

Table 1- Important aquatic weeds

S. No.	Scientific name	Common name(s)	Family
1	*Eichhornia crassipes* (Mart.)Solms	Water hyacinth, Lilac devil, Pickerel weed	Pontederiaceae
2	*Salvinia molesta* Mitchell	Kariba weed, Water fern	Salviniaceae
3	*Marsilia* spp	Marsilia	Marsiliaceae
4	*Alternanthera philoxeroides* (Mart.) Griseh	Alligator weed	Amaranthaceae
5	*Pistia stratiotes* L.	Water lettuce	Araceae
6	*Ipomoea aquatica* Forsskal	Water morning glory	Convolvulaceae

7	*Ipomoea fistulosa* (Martius ex Choisy) Austin (*I.carnea* Jaquin)	Shoe flower	Convolvulaceae
8	*Eleocharis dulcis* (N.L.Burman)Trinius ex Henschel)	Chinese water chestnut	Cyperaceae
9	*Hydrilla verticillata*(L.f.)Royle	Hydrilla	Hydrocharitaceae
10	*Limnocharis flava*(L)Buchenau	Water cabbage	Limnocharitaceae
11	*Polygonum pulchrum*(Blume) (*P. tomentosum* Willdenow)	Smart weed	Polygonaceae
12	*Nymphaea* spp.	Water lilly	Nymphaeaceae
13	*Nelumbo* spp.	Lotus	Nymphaeaceae
14	*Typha domingensis* Persoon (*T.angustata* Bory and Chub)	Cattail	Typhaceae
15	*Vallisnaria spiralis* L.	Eel grass	Hydrocharitaceae

II. Management of aquatic weeds

Physical and mechanical methods

Use of manual labour for pulling or cutting and removal of aquatic weeds is still in practice, eventhough non availability of labourers at cheaper rates have reduced the dependence on manual techniques. A large number of machines, floating as well as operating from the banks, are available for mechanical removal of aquatic weeds. The operation is costly and maintenance of the machinery exclusively for weed control is difficult. The weeds cut down or harvested by the machinery has to be removed from the aquatic body to prevent contamination of water.

Chemical methods

Herbicides offer cheap, effective and rapid control of aquatic weeds.

Use of chemicals for control of aquatic weeds has its impact on ecology of the aquatic systems due to direct toxicity to both target and non target organisms and indirect effect associated with destruction of target macrophytes. The decaying of the dead target plants may lead to increase in CO_2 concentrations, decrease in dissolved O_2 levels and changes in pH of water.

The residues of herbicides applied may affect the plants in the non target area and may have adverse effects on fishes and other organisms in the water. Studies at KAU under the ICAR

adhoc project have shown that 65 to 70 % of the Paraquat and 90% of glyphosate applied for aquatic weed control had dissipated from water within 15 days. Residues of paraquat and 2, 4-D in the fishes in the area sprayed were very much lower than the acceptable daily intake of 0.002 and 0.3mg per kg body weight for paraquat and glyphosate respectively. The major part of the herbicides were found to be strongly adsorbed on the mud portion.

Table.2- Important herbicides used in aquatic weed control

Herbicide	Types of weed controlled	Dose (ml^{-1} or kg/ha^{-1})
Sodium arsenite	Submerged weeds	5-8 ml^{-1}
Copper sulphate	Submerged weeds and algae	0.5-2.0 mgl^{-1}
Hydrogen peroxide	Submerged weeds	10-20 mgl^{-1}
Dalapon	Emergent grass weeds	18-25kg
2,4-D	Free floating and emergent weeds	2-10kg
	Submerged weeds	1 mgl^{-1}
Dichlobenil	Submerged and emersed floating weeds	1-2 mgl^{-1}
Diuron	Algae, submerged floating and emergent weeds	0.5-1.5 mgl^{-1}
Triazines	Algae, submerged and floating weeds	0.05-1.0 mgl^{-1}
Paraquat	floating and emergent weeds	0.8-1.2kg
Diquat	Algae, submerged and floating weeds	0.5-1.0 mgl^{-1}
	Floating and emerged weeds	1.0kg
Endothall	Submerged weeds	0.5-2.5 mg equivalent per litre water
Fluridone	Submerged and floating weeds	0.1-1.0 mgl^{-1}
Glyphosate	Emergent and floating weeds and bank side weeds	1.8-2.1kg

Biological method

Selective control of many aquatic weeds was successful with many arthropods and a few fungi. Fishes are the main nonselective organisms used for aquatic weed control.

Table.3 - Organisms used for control of aquatic weeds

Type of organism	Name of the weed	Biocontrol organism
Anthropods	*Alternanthera philoxeroides* (Alligator weed)	*Agasicles hygrophila* (Coleoptera: Chrysomelidae)
	Salvinia molesta (salvinia)	1. *Cyrtobagous salviniae* & *C.singularis* (Coleoptera: curculionidae) 2. *Paulinia accuminata* (Orthoptera: Acrididae) 3.*Samea multiplicalis* (Lepidoptera: Pyralidae)
	Eichhornia crassipes (Water hyacinth)	1. *Neoechaetina eichhorniae* and *N. bruchi* (Coleoptera: curculionidae) 2. *Sameodes albiguttalis* (Lepidoptera: pyralidae) 3. *Orthogalumna terebrantis* (Acarina: galumnidae)
	Pistia strateotes (water lettuce)	1. *Neohydronomus pulchellus* (Coleoptera: curculionidae) 2. *Epipsammia pectinicornis* (Lepidoptera : noctuidae)
	Hydrilla verticillata (Hydrilla)	1. *Parapoynx dimunutalis* (Lepidoptera : pyralidae) 2. *Bagous* sp.(Coleoptera: curculionidae) 3. Hydrellia spp.(Diptera: ephydridae)
Fungi	*Eichhornia crassipes*	1. *Alternaria eichhorniae* 2 .*Cerespora rodmanii* 3. *Fusarium equisetii*
	Hydrilla verticillata	*Fusarium roseum*
	Pistia stratiotes	1. *Cercospora sp.* 2. *Sclerotium rolfsi*
	Salvinia molesta	*Myrothecium roridum*
	Alternanthera philoxeroides	*Alternaria alternantherae*
Phytophagous Fish	Different aquatic weeds	1. *Ctenopharyngodon idella*(Grass carp) 2. *Hypothalamichthys molitrix* (silver carp) 3. *Tilapia melanopleurea*(Tilapia)

III. Integrated control of aquatic weeds

Integration of herbicides and biological agent was found to be successful in many areas. Some of the successful cases are summarized below.

Table-4 - Integrated control of aquatic weeds

Name of the weed	Successful Integrated approach	Location
Alligator weed	2,4-D + Flea beetle	USA
Water hyacinth	1)2,4-D+ water hyacinth weevil	USA
	2) Cercospora rodmanii + water hyacinth weevil	USA
	3) grass carp + water hyacinth weevil	USA
	4)Grass carp + mech. Means (cut down the weed during spring and early summer)	USA

Future prospects

Integrated control of aquatic weeds is still in the experimental stage. In most circumstances weed control activities are taken up only when the weed has became a serious problem. At this stage the method which gives a quick control is resorted to, often ignoring the environmental impacts. If properly planned in advance, integrated methods involving biological control organisms can be effectively used to give eco-friendly control of aquatic weeds. For infestations covering large areas, biological control is the cheapest and viable option.

Chemical control of aquatic weeds should be taken up only for short term control in limited areas. Even then the effects on ecosystem including the fishes in water, the contamination of water with herbicides and their residual life of the herbicides in water should be understood before using herbicides for control of aquatic weeds. More studies in this line are to be conducted.

Herbicide tolerant crops: a boon to Indian agriculture

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Indian agriculture is at cross-roads. After a phenomenal turn-around during the *'green revolution'* the momentum has slackened and the sector has not been able to break the shackles of a trend line growth of around 1.5-2per cent during the last decade. The share of agriculture in India's Gross Domestic Product (GDP) has fallen dramatically from 59per cent to around 24per cent. The agriculture sector providing livelihood to around 110 million of the work force continues to influence the overall growth in the economy. As many experts have pointed out India cannot aspire to achieve a sustained 7per cent plus growth unless agriculture also grows by at least 4per cent.

The government's mission of *"doubling food production by 2012"*will require a multi-pronged approach consisting of improved high yielding variety seeds, mechanization and balanced agronomic practices. The use of *cutting edge technologies* will play an important role in developing improved seeds. Productivity of agriculture has to dramatically increase in the wake of reduced availability of arable land. A balanced and multidisciplinary effort is absolutely crucial and every opportunity of crop productivity maximization has to be explored. Along with variety improvement which is the key to make use of the full potential of investment, simultaneous development of efficient *pest management solutions* - weeds, insects and diseases should be built into the programme. While insect and disease control are being taken care of, weed control seems to have not received the attention that is commensurate with the magnitude of its negative impact on productivity of crops.

Impact of weeds on India agriculture

Weed control has been a *perennial challenge* to the cultivators. Weeds not only compete with crops for water, nutrients, sunlight, and space but also are the abode of insect and disease pests. The *proliferation* has many times led to clogging irrigation and drainage systems; resulting in poor crop quality and in depositing weed seeds into crop harvests. This has resulted in crop damage which in *extreme cases* have been reported to be up to 100per cent.

There have been *various studies* conducted by scientists in many crops showing that losses caused by weeds are huge and in some cases as high as 90 percent. One study conducted by *International Maize and Wheat Improvement Centre (CIMMYT) entitled "Maize in India"* by Joshi et al, 2001, has clearly pointed out that the value of loss due to weeds in selected states with respect to maize crop alone was to the tune of Rs. 1000 crores. Therefore, in this scenario, *effective and timely weed management* is the most important consideration for maximizing the yield in the crop protection system. The returns on weed free cultivation are enormous, justifying the adoption of all the latest technologies.

Traditional weed management

Farmers have been managing weeds by the *traditional* means of tillage, manual weeding, hoeing and use of mechanical inter-cultivators. These techniques have *always* not produced the desired results. Tillage has led to valuable topsoil exposure to wind and water *erosion* causing adverse environmental consequences. Manual weeding practices have also led to disturbance of soil and pruning of root tips during active crop growth period.

Generally, farmers cultivate their land before planting to reduce the number of weeds present in the field. A very few farmers apply broad-spectrum or non-selective herbicides (one that can kill all plants) to further reduce weed growth just before their crop germinates. Weeds that emerge during the growing season can be controlled using narrow-spectrum or selective herbicides. In reality, different types of weeds (grasses, sedges, broad leave, annual and perennial weeds etc) germinate in the field at various time during crop growth period. This requires either many time hand weeding or application of different type of herbicides, which leads to ineffective weed control with additional cost burden on farmers and can also leads to environmental pollution.

The other disadvantages faced by the farmers have been:

1. Increase in *cost of tillage* operations to the tune of around 10-15 %. (More than 50 percent of tillage cost is accounted for by weed control measures).
2. Use of mechanical inter cultivations also involves utilization of *non-renewable source* of energy like Diesel.
3. Increase in *irrigation* requirements and costs
4. Decline in *quality* of produce
5. Increase in insect, pests, pathogens and parasites causing *health hazards* to animals and humans.

The farmers have also been facing difficulties in pursuing traditional practices due to substantial increase in *cost of labour, non-availability of work-force* for agricultural operations with increasing rural incomes and because of a lack of assured and timely availability of labour at critical times of the crop. Excess rains during monsoon months, labourers have also found it difficult to enter the field to undertake de-weeding operations. Chemical herbicides have offered a very *remunerative option* for weed control. The use of chemical herbicides is gaining ground not only in *labour scarce* states like Punjab and Haryana but also in labour surplus states like Madhya Pradesh (MP), West Bengal, Bihar and Uttar Pradesh.

Emergence of chemical pesticides and its spread

The use of herbicides has been increasing over the last few years as they are selective, cost effective, fairly easy to apply and offer flexibility in application time. In general, herbicides account for the largest proportion of crop protection chemicals sold on a world wide scale. Globally herbicides constitute 50 per cent of the total pesticides sale and in some countries like USA, Germany and Australia are as high as 75 percent. In India however the herbicide consumption is

only 15 percent of total pesticide consumption. However the consumption of herbicides in India has increased rapidly from 4100 metric tones (MT) in 1988-89 to 11,000 MT in 2001-02 and it is likely to further increase in future.The herbicide market has expanded in respect of crops like *Wheat, Rice, Soybeans, Vegetables, Tea, Cotton, Maize and Sugarcane* mainly in the irrigated areas. There are however certain limitations in herbicide usage practices.

Limitations of present herbicide practices

Generally, the farming community tills the soil before planting to reduce the number of weeds present in the field. Then *broad-spectrum or non-selective herbicides* (one that can kill all other wild plants) to further reduce weed growth just before the crop germinates is applied. This is to prevent the crops from being killed together with the weeds.

Weeds that emerge during the growing season are controlled using *narrow-spectrum* or selective herbicides. Unfortunately, weeds of different types emerge in the field, and therefore, farmers have to use several types of narrow-spectrum herbicides to control them. This weed control method can be very costly and can harm the environment. Farmers in India are currently having very *limited choice* and are using predominantly *pre-emergence herbicides* i.e. at the time of sowing, to manage weeds only in few crops namely, Maize, Soybean, cotton, rice and wheat. In these crops, the application is irrespective of the presence of weeds in the field or otherwise.

The pre emergent herbicide needs to be applied during very *limited period* of time i.e. 2-3 days of planting the crop. Any weed control measure taken after the critical weed control period leads to *unrecoverable loss* to productivity. The critics also argued that the heavy use of herbicides has led to groundwater contaminations, the death of several wildlife species and has also been attributed to various human and animal illnesses.Under such conditions use of an *effective post-emergence herbicide* is a good option for the farmer to control the weeds during the critical stages of the crop. Several weed scientists also suggested that weed management could be simplified by spraying a single broad-spectrum herbicide over the field anytime during the growing season. The best candidate for post emergence herbicides should be having no or minimal residual activity in the soil.

Development of herbicide tolerant crops

Alternate new technologies using latest *biotech approaches* like *herbicides tolerant crops* with broad spectrum non-selective and non- residual herbicides have proved to be better and more cost effective solutions in many countries. According to *International Service for the Acquisition of Agri-biotech Applications* (ISAAA), during the 10-year period 1996-2006, globally, herbicide tolerance technology has consistently delivered *excellent* benefits to farmers. The safety of this technology has also been well documented and established with *globally 12 countries* having approved its use as well as imports for food and feed. In 2006, herbicide tolerance traits, deployed in *Soybean, Maize, Canola, alfalfa and Cotton* were planted on 69.9 million hectares, which constitute 68 per cent of global biotech crop area.Herbicide-tolerant (HT) crops offer farmers a vital tool in fighting weeds and are compatible with no-till methods, which help preserve topsoil. They give farmers the flexibility to apply herbicides only when needed, to control total input of herbicides and to use herbicides with preferred environmental characteristics.

How do these herbicides tolerant technology work?

These herbicides target key enzymes in the plant metabolic pathway, which disrupt plant food production and eventually kill it. So how do plants elicit tolerance to herbicides? Some may have acquired the trait through selection or mutation; or more recently, plants may be modified through genetic engineering.

Glyphosate-tolerant crops

Glyphosate herbicide kills plants by blocking the EPSPS enzyme, an enzyme involved in the biosynthesis of aromatic amino acids, vitamins and many secondary plant metabolites. There are several ways by which crops can be modified to be glyphosate-tolerant. One strategy is to incorporate a soil bacterium gene that produces a glyphosate-tolerant form of EPSPS. Another way is to incorporate a different soil bacterium gene that produces a glyphosate degrading enzyme.

Other methods by which crops are genetically modified to survive exposure to herbicides including: 1) producing a new protein that detoxifies the herbicide; 2) modifying the herbicide's target protein so that it will not be affected by the herbicide; or 3) producing physical or physiological barriers preventing the entry of the herbicide into the plant. The first two approaches are the most common ways scientists develop herbicide tolerant crops. The ability of crops to tolerate broad-spectrum herbicides such as glyphosate which will control most other green plants will give flexibility to achieve effective weed control. These herbicides are useful for weed control and have minimal direct impact on animal life, and are not persistent. They are highly effective and among the safest of agrochemicals to use.

Advantages of herbicide tolerant technology

Herbicide tolerant crops will allow India to skip the *"selective product phase"* and thus leapfrog into a more advanced practice. Post-emergence herbicides would allow farmers *flexibility* of use based on the weed pressure in the field. The technology will be very useful in agriculture even for *small/marginal* farmers. Economic growth would also lead to *migration* of labour from rural areas to urban areas because of more remunerative job opportunities offered by the urbanization, industrial growth and growth in the service sector.

Herbicide tolerant crops behave similar to their *non-transgenic counterparts* and are genetically modified to tolerate non- selective, post-emergent herbicides like *Glyphosate and Glufosinate.*

The major benefits that would accrue include:

1. Greater *economic and effective* season long weed control choice adding to the existing options of manual weed control and selective pre and post emergence herbicides.
2. *Flexibility* to farmers for over the top application (wider application window) and better weed control with outstanding *crop safety*
3. *Environment protection* as these herbicides recommended and used for the technology are non residual in nature.

4. Adoption of "*conservation tillage* which helps in preventing soil erosion and reduces turn around time between harvests to planting of next crop.

Safety aspects of herbicide tolerance technology

Toxicity and allergenicity

Government regulatory agencies in several countries have ruled that crops possessing herbicide-tolerant conferring proteins do not pose any other environmental and health risks as compared to their non-GM counterparts.

Introduced proteins are assessed for potential toxic and allergenic activity in accordance with guidelines developed by relevant international organizations. They are from sources with no history of allergenicity or toxicity; they do not resemble known toxins or allergens; and they have functions, which are well understood.

Effects on the plants

The expression of these proteins does not damage the plant's growth nor result in poorer agronomic performance compared to parental crops. Except for expression of an additional enzyme for herbicide tolerance or the alteration of an already existing enzyme, no other metabolic changes occur in the plant.

Invasiveness of crops

A major environmental concern associated with herbicide-tolerant crops is their potential to create new weeds through out crossing with wild relatives or simply by persisting in the wild themselves. This potential, however, is assessed prior to introduction and is also monitored after the crop is planted. The current scientific evidence indicates that, GM herbicide-tolerant crops are no more likely to be invasive in agricultural fields or in natural habitats than their non-GM counterparts (Dale et al., 2002).

The herbicide-tolerant crops currently in the market show little evidence of enhanced invasiveness.

Current Status of herbicide tolerant crops

In 2006, herbicide- tolerant crops occupied the largest planting area with over 69.9 mha of the 102 mha total planted to GM crops (James, 2006). The most common are the glyphosate and glufosinate tolerant varieties. The following table shows countries that have approved major HT crops for food use.

Crop	Countries
Canola	Canada, Japan, United States, Korea, Australia, European Union, Philippines
Cotton	Australia; Canada; Japan; Philippines; South Africa (SA); US, Korea, Mexico
Maize	Argentina, Australia; Canada; EU; Japan; Korea; Philippines, South Africa, Taiwan and US
Rice	United States (US)
Soybean	Canada and United States

Source: Agbios GM Database (2006): http://www.agbios.com/database

A recent literature review conducted by the Council for Agricultral Science and Technology concluded that the environment benefits from the use of HT crops. In the US, for example, no-till soybean acreage has increased by 35% since the introduction of HT soybean. A similar trend is observed in Argentina where soybean fields are 98% planted with HT varieties. The CAST paper entitled "Comparative Environmental Impacts of Biotechnology-derived and Traditional Soybean, Corn and Cotton Crops" is available at http://www.cast-science.org

Conclusion

Adoption rates for transgenic crops which includes predominantly herbicide tolerant crops and Insect tolerant crops are unprecedented and are the highest for any new technologies by agricultural industry standards. High adoption rates reflect grower satisfaction with the products that offer significant benefits ranging from more convenient and flexible crop management, higher productivity and/or net returns per hectare, and a safer environment through decreased use of conventional pesticides, which collectively contribute to a more sustainable agriculture.

During the past five years, Herbicide tolerance has consistently been the dominant trait followed by insect resistance trait and stacked genes for herbicide tolerance and insect resistance. In 2000, herbicide tolerance trait deployed in soybean, corn and cotton occupied 80% of global area under transgenic crops followed by Bt crops occupying 20 % and stacked genes for herbicide tolerance and insect resistance occupying 8 % of global transgenic area. There are evidences from many case studies that transgenic crops are delivering significant economic benefits to farmers deploying herbicide tolerant crops. Several studies have also confirmed that there are also significant indirect benefits to others in society.

Herbicide tolerant crops offer the farmer greatly improved weed control options. Under some circumstance, a single application of one herbicide to a herbicide tolerant crop can replace multiple applications of mixtures of two or more herbicide. The herbicides used for herbicide tolerant crops usually control a broad spectrum of weed species. The advent of these herbicide tolerant crops has allowed farmers to control weeds more effectively usually with only one herbicide application at a significantly lower cost. Before the introduction of herbicide tolerant crops, farmers had to apply several pre- and post- emergence herbicides which required significant re-

sources with limited management flexibility. Thus the major gain to farmers has been less expensive, more effective and more flexible weed control. These transgenic crops can also make a very important contribution to sustainable farming systems. The use of these crops is compatible with farming systems that reduce or eliminate the need for tillage or cultivation, which in turn are helpful in reducing soil erosion, conservation of moisture, nutrients and soil structure. The use of herbicide tolerant crops are one of the powerful and important components of Integrated Pest Management (IPM) farming systems that enable farmers to implement long term sustainable systems of crop production.

Experience in some countries reveal that introduction of herbicide tolerant crops in conjunction with no-till has resulted in significant benefits and management flexibility. The herbicide tolerant crops are fully compatible with no-till systems and encourage soil conservation. The yield of a crop is most directly affected by the efficacy of the herbicide that precludes yield reduction due to competition from weeds and by the level of herbicide toxicity or the damage caused by removing weeds mechanically. The use of herbicide tolerant varieties of crops also results in increased adoption of conservation tillage farming. Low-till or no-till conservation tillage significantly reduces the need for land preparation and conserves moisture and nutrients and significantly reduces erosion of topsoil.

There are critics of biotechnology who maintain that the transnational developers of transgenic crops are the sole or major beneficiaries from transgenic crops. However, there is no evidence to support this perception. Whatever studies have been conducted till date confirm that not only are farmers significant beneficiaries but they are also usually the major beneficiaries, taking on average from one-third to one-half of the total economic surplus generated by transgenic crops.

In this context we need to understand that any new technology has its own advantage. We need to focus on proper evaluation and if it provides value to our farmers and country as a whole, we should not hesitate to accept and manage the same for longer period of tine. We believe that this is the right time to discuss and debate more about transgenic crops and evaluate these crops for their benefits to farmers of our country to remain self reliable in future to feed increasing population.

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Herbicide residues in soil, water and food chain: an Indian perspective

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The present day agriculture can be considered sustainable if it ensures that today's developments are not at the cost of tomorrow's prospects. Over the years herbicides have emerged as an important tool in the management of weeds. Herbicides represent a large chemistry with different mode of action to control variety of weeds. Due to intensive research in herbicide discovery and mode of action, many new molecules are available at g/ha level to cater the farmers need.

Large quantity of herbicides are applied annually create a need to study the fate of these herbicides in soil, crop produce and ground water. The recognized persistence of several sulfonylureas, substituted ureas, uracil, s-triazines, the benzoic acid derivatives, picloram and other herbicides in soils has received detailed study in India and abroad. It is being recognised that some persistence is necessary property of all herbicides; with no persistence soil applied herbicide would not control weeds. Thus data on residual toxicity of recommended herbicide become indispensable for approving a herbicide for large scale commercial use, environment safety and human health.

In India, the herbicides market has grown many folds in the last two decades. Under this situation excessive and repeated use of herbicides may pose problems such as phytotoxicity to crop plants, residual effect on susceptible inter-crops, succeeding crops or non-targets organisms and ultimately health hazards due to accumulation of residues in the soil, crop produce and ultimately ground water contamination due to runoff and leaching. Regardless of the methods of application approximately 80 % of herbicides ultimately reach the soil not only making them unavailable to the targets but also polluting the soil ecosystem in a number of ways by leaving residues. The fate and behaviours of herbicides in soil is influenced by the biotic and abiotic process including adsorption, movement/leaching, decomposition etc. Under tropical, subtropical and high rainfall conditions herbicides rapidly degrade by chemical and biological process, and hence residues are generally not detected at harvest in crop produce and soil and hence contamination due to herbicide can be considered as negligible. Moreover, herbicides are applied either as pre-plant incorporation, pre-emergence or post-emergence, this longer interaction between application and crop harvest will result in the dissipation of herbicides in the plant system and soil.

Fate and persistence of herbicides in the soil

As soon as a herbicide is applied a number of processes immediately begin to remove the compound from the original site of application. For the herbicide which is intercepted by plants, the chemicals may be taken up by the plant itself may be washed off by precipitation onto the soil, may undergo photodegradation on plant surface or may volatile back into the air. Herbicides persistence in the soil is expressed as half life or time required to degradates fifty percent of the original

molecule (Table 1). However, the half life is not absolute because it depends on the soil type, temperature, and concentration of the herbicide applied. The persistence varies with the nature of a chemical, soil properties and climatic conditions. The herbicide should persist long enough to check weeds until the end of critical period of weed competition but should not persist beyond the crop harvest, as it would be injurious to the sensitive crops grown in rotation. Very rapid loss of herbicides from soil will cause insufficient weed control, which is considered as unsatisfactory as their unduly long persistence within soil. Beside herbicides structure, soil conditions prevailing during and after the application of a herbicide as well as herbicide application methods influence the fate of the herbicides in the soil. Heavy rainfall in monsoon will cause greater leaching and runoff. Sandy soil would have a higher leaching potential than a clay soil due to larger pore spaces and lower CEC (Sondhia 2001; Sondhia and Yaduraju 2005, Sondhia 2007) .Higher humidity enhances the soil microflora proliferation. Similarly the persistence of herbicides in dry soil is greater as compared in wet soil.

Table 1: Half-lives of some herbicides in soil

Herbicides name	Half lives (Days)	Herbicides name	Half lives (Days)
Atrazine	13-58	Metribuzin	23-49
Butachlor	5-24	Metolachlor	8-27
Fluazifop-p-ethyl	8-24	Oxyfluorfen	19-29
Fluchloralin	12-13	Pendimethalin	15-77
Imazethapyr	57-71	Sulfosulfuron	3-8
Isoproturon	13-21	2, 4 D	7-22

*Source: (Sondhia 2007)

A herbicide is said to be persistent when it may be found to exist in soil in its original or a closely related but phytotoxic form longer than one crop season after its original application (Sondhia 2005). Herbicide residues in crop produce above the safe level can cause health hazards to man and animal (Table 2). Ultimate fate of herbicide in soil depends on number of processes such as volatilization, leaching, runoff and degradation by microbes, chemical processes and photodecomposition

Table 2 : Residues of some important herbicides in the soil, food grain and straw

Herbicides	Crop	Dose (g/ha)	Residues*		
			Soil	Grains	Straw
Butachlor	Rice	1000	0.005	0.012	0.029
Sulfosulfuron	wheat	25	BDL	0.010	0.004
Fenoxaprop-p	Wheat	100	0.089	0.0024	0.0013
Metsulfuron-methyl	Rice	4	BDL	BDL	BDL
Isoproturon	Wheat	1000	0.032	0.035	0.065
Oxyfluorfen	Rice	150-250	BDL	BDL	BDL
Imazethapyr	Soybean	100	0.016	0.210	BDL
Imazosulfuron	Rice	30-40	BDL	BDL	BDL
		50-60	BDL	0.006-0.009	0.009-0.039

*Source: (Sondhia 2007)

Effect of herbicides on microflora and fauna

Nowadays soil health and microbial diversity have become vital issues for the sustainable agriculture. Loss of microbial biodiversity can affect the functional stability of the soil microbial community and soil health. Generally, negative effects of herbicides on the population level or composition of species are decreased for a while but subsequently improves. Beneficial organism known to be affected negatively by specific herbicides includes nitrogen fixing bacteria (Rhizobium) and some mycorhizal fungi. Actinomycetes are relatively resistant to herbicides and affected at high concentration only. Fungi are probably the more sensitive to the majority of herbicides than are bacteria.

Apart from soil microflora, herbicide may have adverse or stimulatory effects on some beneficial soil fauna. Earthworms are perhaps the most important soil organisms in terms of their influence on organic matter breakdown, soil structural development, and nutrient cycling, especially in productive ecosystems. Harmful effects of herbicides on earthworm are rarely reported. In a study it was found that isoproturon did not cause lethal effects at 1.4 g/kg soil on mature earthworm (*Lumbricus terrestris* L.) after 60 days.

Effect of herbicides on succeeding crop

Herbicide persistence in soil may injure succeeding crop. From example, injury to pea from sulfosulfuron is noted in field treated with sulfosulfuron in the previous year (Sondhia and Singhai 2006, 2007). Several substituted ureas, sulphonylureas, dichlobencil and 2, 3, 6-TBA often pose phytotoxic residues problems on crop land. Even a short residue herbicide like glyphosate has been reported to damage tomato transplants. Sometimes non-phytotoxic residues of previously applied herbicides may damage the rotation crop by interacting with the herbicide applied to the present crop.

Most of the herbicides are absorbed through plant roots and underground absorptive sites besides they undergo number of degradation processes. At the recommended dose of herbicide application the problem may not arise and they selectively kill the weeds. But when the dose is more than the recommend rates that happens due to indiscriminative use and improper calibration and method of application, there is possibility of residual hazards in soil particularly in persistent herbicides such as triazines and uracils. Repeated application of the same herbicides in a mono crop sequence may cause accumulation of residues in soil, which in turn will affect the sensitive crops. Leaching of herbicides can cause crop injury due to transport of herbicide into the absorption zone of susceptible crop plants and accumulation of herbicides in toxic level in tolerant crop plants.

In some experiments it was found that pre-emergence herbicides such as thiobencarb, butachlor, pretilachlor and anilofos applied at recommended doses continuously for four seasons in rice crop did not influence the germination and yield of urdbean raised subsequently (Balasubramanian *et al.*, 1999). Pretilachlor at 0.50 to 1.00 kg /ha, 2, 4-D at 1.50 to 2.50 kg/ha, anilofos 0.40, to 0.60 kg/ha and pendimethalin 1.50 to 2.00 kg/ha applied as pre-emergence to transplanted rice did not affect succeeding wheat and peas crops but cucumber germination was reduced by 28 % in 2.5 kg/ha dose but 2, 4-D showed a greater level of persistence in soil (Gupta *et al.*, 2000). Sulfosulfuron

applied at 25, 50 and 100 g/ha in wheat crop did not show any adverse effect on succeeding maize and sorghum crop however significantly affected the growth of lentil and pea (Sondhia and Singhai 2007). Toxic and nontoxic effects of some important herbicides are given in Table 3.

Table 3 Effect of some important herbicides on succeeding crop

Crop	Herbicides	Dose (Kg/ha)	Toxic	Nontoxic	Reference
Wheat	Sulfosulfuron	0.25-100	Pea, lentil	Sorghum, maize	Sondhia (2006, Sondhia and Singhai 2007)
Wheat	Pendimethalin	1-1.5	-	Sorghum	Kulshrestha and Yaduraju, (1987)
Sorghum	Atrazine	0.25-1.0	-	Fingermillet Cotton	Jayakumar (1987)
Cotton	Fluchloralin Oxadiazon Oxyfluorfen Pendimethalin	1.0 0.5-1.5 0.1-0.2 1.25	Cucumber	Fingermillet Foxtail millet Mungbean	Jayakumar *et al.* (1988)
Sunflower	Fluchloralin Butachlor Alachlor Pendimethalin	1.0 1.0 1.0 1.0	Mungbean	Groundnut Cowpea Cucumber	Basavarajappa and Nanjappa (1994)

Conclusion

In India, use of herbicides is increasing at a faster rate as compared to other pesticides. Newer molecules are added each year. Due to environmental and health concern, the regulatory requirements have been made longer. Herbicides have lower residue concern than other pesticides in view of their lower mammalian toxicity. Further contrary to other pesticides, herbicides are applied at planting or during early stages of crop growth, thus giving more time for degradation of the chemical in the plant and environment. Further the soil and climate conditions prevalent in the country enable faster degradation of the chemical. The fate of herbicides in the soil is a concern of many segments of society. The soil acts as an important buffer governing the persistence and fate of most herbicides in the environment. As long as soil system remains healthy, possible adverse effect from herbicides in the environment probably can be minimized. Herbicides in most instances when applied at recommended doses have not been detected in food chain or in soil at level that should cause concern. Thus the chances of residues at harvest become negligible. Our results and literature reveal that at harvest residues are either not detected or found at below the maximum residue limits set by EPA or CODEX and thus herbicides can be considered as safe to sustainable food production and environment. However, if any of the herbicide applied continuously in the same field for a long time, there are possibilities of buildup of herbicide residues at toxic level in the soil. Therefore, judicious use of herbicide with proper scientific principles is advisable so there is no adverse effect on the succeeding crop and soil microbes.

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Weeds and their management in Tea

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India is the largest producer and consumer of tea in the world. Assam is the major tea producing state in India accounting for 55 per cent of the country's total production. India holds the first rank as the producer and consumer of tea in the world. Its unique tea industry produces about 840 million kg from an area of 5,10,492 ha. Out of total tea production in India, 75 per cent comes from North Eastern region. Total tea produced in Assam comes from an area of about 2,28,260 ha comprising 1000 major tea estates and thousands of small tea gardens. The total turnover from tea industry in India is more than Rs. 6000 crores. It provides direct employment to 1.2 million people out of which 50 per cent is women and indirect employment to millions involved in various activities. The major export of tea from India takes place to the European Union, U.S.A. and Russia.

Nature and extent of weed problem

Type and intensity of weeds in tea varies with stage of the crop, season and management conditions. Major weed flora comprises *Ageratum houstanianum, Axonopus compressus, Borreria articularis, Chromolaena odorata, Cleodendrum viscosum, Cynodon dactylon, Digitaria setigera, Mikania micrantha, Paspalum longifolium, Scoparia dulsis, Setaria palmifolia, Sida acuta etc.*

Weeds are the number one pest and can reduce the productivity of tea by about 10-50 per cent (Rao *et al.*, 1977) depending on the intensity of weed growth, extent of competition, weed species and the competitive ability of cloning. Reduction of both quantity and quality of production is caused due to weeds by virtue of restricted branching and frame development in young tea, as alternate host harbouring of important pests of tea, decreased plucking efficiency, contaminating plucked shoots,

Weed problem is most severe during the young stage till the bushes develop a strong frame touching each other and providing enough of ground cover to suppress the weeds. This stage is reached in about five years after plantation. The intensity of weed also increases in the years of light pruning, medium pruning and deep skiffing.

On an average, grassy weeds reduce the productivity of tea by about 21 per cent while broad-leaved weeds accounts for 9-12 per cent.

Critical period of competition

The hot humid rainy period between April to September is most favourable for weed growth resulting in the highest competition of crop-weed competition. Effective weed management during this period is very essential for achieving the optimum yield from the crop.

Weed management options

Weed management is the second most expensive item of tea production, the cost for which ranges between Rs.1500 to Rs.4500/ha depending upon the severity of weed problems, crop stage and management strategy adopted by the planter. Manual weeding/uprooting of weeds is mostly followed in tea nurseries and young tea plantations. Manual removal is also followed to control weeds like *Mikania, Setaria, Melastoma* etc. Cheeling, sickling, hoeing or forking are the common mechanical methods to control weeds but these are expensive, time consuming and occasionally injurious to feeder roots of young tea plants.

Acute shortage of labourers, increasing labour wages and facilities to labourers besides other advantages has caused extensive use of herbicides in tea plantations. Herbicides worth Rs.7 crores are alone consumed by the tea industry in North Eastern India alone. In Indian context, 20 per cent or more of the total amount of herbicides used in the cropped area goes to the tea plantations only (Chakravartee and Borbora, 1993).

There are various effective pre and post emergence herbicides for weed control in tea but choice is entirely dependent upon the type of weed flora, their growth behaviour, type of herbicides, age of the plantation and cost-benefit ratio. However, a herbicide application schedule is necessary involving herbicide mixture, herbicide rotation etc. Recommended herbicides are diuron, oxyflourfen, simazine, 2,4-D, dalapon, glyphosate, glufosinate ammonium etc.

The dose of the herbicide required for spraying varies depending primarily upon the type of herbicide, type and intensity of weed infestation, stage of weed and crop, weed control efficiency.

Integrated weed management strategy

Increasing concern in major tea consuming countries in the world for herbicide residues left in the product and also the residues in the soil and water in and around the tea gardens have invited the attention of the weed scientists towards evolving integrated weed management modules comprising all the alternative means of weed control without any adverse impact on the quantity and quality of produce.

Weed management in medicinal and aromatic crops

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The demand of raw drug material and aroma compound is increasing world over at the rate of 10-20% per annum due to increasing awareness regarding use of natural herbs and after effects of allopathic medicines. This resulted in over exploitation of medicinal and aromatic plants from the natural habitats and availability is reduced to fulfill the demand of drug manufacturing companies. Hence, the cultivation of those medicinal and aromatic plants which are required in larger quantities has been started in many parts of India. In view of the above research organizations are developing the agro technologies for successful and economic production of the drug material. The Department of Health and Family Welfare and Indian Council of Agricultural Research have started the Research Projects on Medicinal and Aromatic Plants (M&AP) to develop location specific agro technologies for M & A P of a particular region through SA Us and other Research Institutes. Central Institute of Medicinal and Aromatic Plants Lucknow and NRC on M & AP have also under taken the basic and applied research work on M & A P. Consequent upon many varieties are identified having high active principle, processing and agro techniques are developed for more than 50 species (Table 1-2). However the detailed investigations on weed competitional stress and techniques for weed management are very meager.

The major weeds found in M& A P crops in Kharif comprised of *Echinochloa crus-galli, Dactiloctenium aegyptiacum, Digitarea adscendens, Cynodon dactylon, Cyperus rotundus, C. iria, C. dicotoma, Commelina bengolensis, Commilina communis* etc amongst mono cotyledonous. While among dicotyledonous *Celosia argentia, Corchorus olitorious, Euphorbia geniculata, Parthenium hysterophorus, Acanthospermum hispida, Amaranthus viridis, Amaranthus spinosus, Alternanthera sessilis, Ageratum conyzoides* etc. During Rabi season the major weeds consisted of *Melilotus indica, M. alba, Lathyrus aphaca, Vicia sativa, Convolvulus arvensis, Rumex dentatus, Medicago denticulata, Cichorium intybus ,Cynodon dactylon* etc. The parasitic weed *Cusctta trifoli* also attack the M& AP

The weeds found in crop ecosystem also have medicinal values and some are highly used for medicinal purpose *Eclipta alba, Cassia tora, Solanum nigrum, Xanthocerpum surratens, Achyranthus aspera, C. rotundus, Phyllanthus amarus, Tribulis terristeris* etc. have higher medicinal values.The farmers should collect, clean and dry these weeds while weeding which will provide the income. These weeds are required by the pharmaceutical companies in truck loads.

The weeds which are found in the crop fields they also had nutritive food and fodder values. The leafy vegetables are prepared from *Chenopodium album, Portulaca oleracea, Trianthema portulacastrum, Corchorus oletorius, Ipomoea aqquatica* etc. The grassy weeds viz. E.*crusgalli, D.adscendens,D.aezyptiacum* during Kharif and major Rabi weeds viz. *Avena fatua, P. minor,*

Melilotus spp., Vicia sativa, Rumex dentatus etc. constitute nutritive fodder. The weed competitional stress due to weeds is as high as 95% in Isabgol, 55-78% in Citronella, 58% in Japanese mint and 50-70% in Lemon grass. The critical period of weed competition has been found to be first 105 days after transplanting in Japanese mint, 30-60 days after sowing in Isabgol and Citronella and up to 90 days in Pachouli.

Cultural method

In medicinal and aromatic crops, the cultural methods particular hand weeding is more prevalent. However, the studies on different cultural methods of weed control are also not carried out to decide their relative efficacy for control of weeds and resulting in economic production over weedy check. In general 2-3 hand weeding are recommended in KhasiKateri, Liquorice, Senna, Ashwagandha, Dill seed, Henbane, Ocimum, Chamomile, Palmrosa and other short duration crops. Whereas, in Sarpagandha, Bach (*Acorus calamus*) 5-6 H W are reported. In long pepper weeding and earthing are recommended. The crop rotation are reported for weed control viz. Senna-Mustard or Senna-coriander and Isabgol-Chandsur.

The intercropping of Lemon grass in plantation of *Gmelina arbrea* and *Oroxylum indicum* was found effective. In Palma rosa inter cropping of pigeon pea two rows was found economical. Inter cropping with smother crop like soybean was found effective in Sarpagandha.

Mulching has been found very effective and economical in weed control in roses, lemon grass and patchoali. Rose beds may be mulched with straw, black polyethylene film, sawdust and well decomposed FYM. It helps conserving soil moisture, suppress weeds and produce more flowers of better quality. In Jasmine mulching is the best method to control weeds after the first rains, the plant basin are mulched thoroughly. Mulching followed by 2-3 hand weeding a year control the weeds.

Other cultural methods like application of high seed rate, pure seed ,sowing in rows, high density, stale seed bed preparation, use of well decomposed manures and application of fertilizers in rows, following drip irrigation etc. are effective to reduce the weed competition. Soil solarisation can be a effective method for weed control in nursery of M &A P.

Weed management in organic cultivation of M & Ap

The practicing of organic cultivation which eliminate chemical fertilizers, herbicides and pesticides in M & A P is the demand of exporters of raw drug material. However, the use of FYM or wormi compost commonly infest more weeds and increases the weeding cost. Hence, well decomposed FYM free from weed seed must be used. Generally where berseem is fed to cattle, *Cichorium intybus* and *Cuscuta trifolii* become as the major problem through FYM.

Mechanical weeding

In wide row planted medicinal trees, shrub and herbs the mechanical weeding is prevalent. In planting of tree species viz. *Emblica officinalis, Santalum album, Gmelina arborea, Oroxylum indicum, Pterocarpus marsupium, Cassia fistula, Bixa orellana* etc., the tractor drawn implements like duck foot harrow or cultivator are used to manage the weeds at initial 4-5 years. The inter

cropping of herbaceous species of M &A P is recommended to smother the unwanted weed growth. The lemon grass or palma rosa as inter crop was found effective to curve the weeds and provided additional income at J.N.K.V.V. Jablpur in planting of *Gmelina* and *Oroxylum*.

The bullock drawn implements locally called dora and dori (blade harrow of different size according to row spacing) are also used, particularly in Malva tract of Madhya Pradesh to control weeds in *Rauvolvfia serpentina, Withania somnifera, Aloe vera* and *Abelmoschas moschatus*. The double wheel hand hoe developed by CIAE, Bhopal are very common to manage the weeds in *Chlorphytum borivillianum, Andrographis paniculata, Isabgol,* etc. which are planted at narrow row spacings. However, the experimental data comparing the benefits over other methods viz, H W or chemical weeding are not available in M &A P , yet the mechanical weeding will be more economical as compared to H W or chemical weeding and the problem of residues if any is over come.

Chemical weeding

In Aswagandha (*Withania somnifera*) isoproturon 0.75 kg/ha PE+ one H W at 45day stage was found best method to control weeds at Udaypur, Rajsthan. At Indore, one hand weeding 30 DAS and one inter-culture 50 DAS reduced the weed density as compared to weedy check. However, application of Trifluralin 2 kg/ha + one inter-culture 50 DAS gave effective weed control and net return (Rs. 37160/ha) as compared to weedy check (Rs 24,000). At Mandsaur, isoproturon 0.5 kg/ha PE/1HW 45 DAS, Glyphosate 1 kg/ha PE to crop and post to weeds +1HW 45DAS, were as good as weed free check in controlling weeds and in giving quality root and seed yield of Aswagandha.

In Opium poppy(*Papaver somniferum*), isoproturon 0.25kg/ha PE and 1 HW at 30 DAS was found appropriate method at Udaipur. At Mandsaur, isoproturon 0.375 kg/ha PE + 1 HW 30 DAS gave comparable seed husk and latex yield and net profit to weed free check.

In Isabgol (*Plantago ovata*) critical period of weed competition is first 20-25 days after sowing. Pre sowing application of isoproturon 0.5 to 0.75 kg/ha in 500 L. water is recommended by NRC, MAP. Application of isoproturon 0.375 kg/ha PE +1 HW at 45 DAS was found effective at Udaipur, Rajsthan. isoproturon POE was found phytotoxic. At Anand, Gujrat isoproturon 0.5kg/ha at 2 days before or after sowing was found effective for control of weeds. At Mandsaur, M.P. the application of isoproturon 0.5kg/ha pe +1 HW 40 DAS and isoproturon 1.0kg/ha pe alone gave comparable seed yield and net profit to weed free check. Herbicides viz., isoproturon, pendimethalin, fluchloralin, alachlor and 2-4-D Na salt applied to Isabgol did not cause residual effect on succeeding crops of cowpea, soybean, sorghum and maize grown in Kharif. At Hisar, Haryana, trifluralin 0.5 and 1.0 kg/ha ppi Imazy thapyr PE, and POE 50,75,100 and 150 g/ha were phytotoxic to crop except imazythapyr 50 g/ha PE which was better than other herbicidal treatments. The major weeds were *Melilotus alba, Chenopodium album, Spergula arvensis, Anagallis arvensis,* and *Convolvulus arvensis, Circium arvense, Cynodom dactylon* and *Cyperus rotundus*. The pre emergence application of imazythapyr was more effective than post emergence to control the weeds. Pendimethalin 0.75 to 1.5kg/ha PE totally inhibited Isabgol germination, Trisulfuron 10-30 g/ha, imazythapyr 75-125 g/ha, 2-4-D400 and 500 g/ha and metsulfuron 3 and 4 g/ha applied at 40 DAS were phytotoxic to the crop.

The medicinal shrubs viz. *Embelia ribes* (Baividang), *Berberis aristata* (Daruhuldi), *Aloe vera* (Ghritkumari), *Commiphora wightii* (Guggul), *Lawsonia enermis* etc., climbers viz., *Gymnema sylvestre*, *Gloriosa superba* (Kalihare), *Asparagus racemosus* (Sataware), *Tinospora cordifolia* (Giloe), *Piper longum* (Pipplamul) and medicinal trees which are planted at wider spacing, the weeds can be controlled effectively by directed and protected post emergence spray of glyphosate 1.0-2.5 kg/ha as per weed flora.

A field study conducted in peppermint (*Mentha pipertita Linn.*) during Kharif at PAU, Ludhiana revealed that the application of isoproturon 0.75 kg/ha PE gave significantly the highest fresh herbage (340.5q/ha) and essential oil (98.98l/ha) during 1999 and during second year yields were maximum under diuron 0.4 kg/ha follwed by pendimethalin 0.75 kg/ha. The major weeds were *Coronopus Linn.*, *Rumex aspera*, annual grasses, *Chenopoelium album* and *Cyperus rotundus*. Weeds caused reduction in green herbage yield up to 68.7 and 66.4% .

Pre emergence application of diuron 2 kg/ha or protected post em spray of dalapon 2.5 kg/ha or paraquat 1.0kg/ha could be done in between rows. In Japanese mint simazine, artrazine 1.0-1.5kg, diuron 0.6-0.8 kg, metribuzin 0.3-0.5 kg/ha, methabenzthiazuron 2.0kg/ha, isoproturon 2.0 kg/ha , pendimethalin 1.0-1.5 kg/ha and the combination of isoproturon + pendimethalin all as PE application were found effective and selective. In pepper mint (*M. piperita*), prometryn 2.0-2.5 kg PE was effective. In established piper mint crop combined application of prometryn+ simazine was effective.

In rose generally hand weeding is preferred. Annual monocot and dicot weeds can be effectively controlled by oxyfluorfen 0.5 kg/ha PE or by a solution of simazine 1 kg and 2-4-D 0.2kg/ha PE. The application glyphosate 1-2 kg/ha POE directed spray controls the annual and perennial weeds including Cynodon dactylon and Cyperus rotundus. For control of weeds up to 2-3 months POE directed spray of paraquat or glyphosate is very effective. In Geranium alachlor 1-2 kg/ha was found effective.

In Patchouli-diuron 2-3 kg/ha PE was the best herbicide. In *Curcuma aromatica* application of oxyfluorfen 0.1kg/ha PE was found effective in managing weeds at Trichur, Kerala. In *Aloe vera* atrazine 0.5 kg/ha pp was effective.

Utilization of weeds for handmade paper and board

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The raw materials used in handmade paper are generally the waste product of the textile industry, different bast fibers extracted from waste lingo cellulosic bio-mass including the annual grasses/shrubs besides the recycled secondary fibers. The bast fibers, leaf fibers extracted from the locally available annual grasses/shrubs have found to contain higher quantities of cellulosic contents with favourable morphobological characteristics like fibers length/dia thereby making them a suitable raw material for handmade paper & board making.

In view of the rising demand of handmade paper in domestic and global market and increased efficiency of the textile mills, the availability of the hosiery waste being used by the industry has come to a sharp focus. This has resulted in increased cost of the traditional raw materials used by the handmade paper industry thus effecting the competitiveness of the sector.

Kumarappa National Handmade Paper Institute (KNHPI) an autonomous body under Khadi & Village Industries Commission – Ministry of Micro, Small and Medium Enterprises has been engaged in applied research for the development and sustainability of handmade paper sector. One of the major issue confronting with the Indian handmade paper sector has been the availability of good quality of cellulosic raw material at competitive and reasonable price. To address the above said issue, KNHPI has identified raw material and process research as one of the priority area of its research and development activities so that growing demand of the Indian handmade paper industry could be met without disturbing the environment, social and community harmony.

Role of new herbicide molecules in modern weed management

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Herbicides usage has revolutionized agriculture in developed nations where chemical control forms single most important weed management practice. In the world pesticide trade today herbicides with 43% sales lead other pesticides.

The use of herbicides is now a good farming practice. For every rupee wisely invested in herbicides, the farmer either saves several rupees in reduced production costs or gains by improved crop yield and quality. In many crops, herbicides can eliminate hand hoeing; often they can replace much of the mechanical cultivation. The full potential of herbicides can be achieved only through their proper use.

Herbicides use has increased to 30% during the last 10 years in the country. Out of total herbicide usage, about 90 per cent farmers in India make use of recommended herbicides like butachlor, pretilachlor and anilofos in rice and isoproturon, 2,4-D, fenoxaprop, clodinafop and sulfosulfuron in wheat. Continuous use of these herbicides over the years, may result in weed shifts. Moreover, with the extensive use of same herbicides, there are chances of development of resistance in weeds. The excessive use of herbicides may pose problems such as phytotoxicity to crop plants, residual buildup on soil, crop produce and ground water. Continuous usage may also cause loss of efficacy of herbicides.

Testing of new molecules under different crops in different locations giving wider choice for weed control through chemicals. The main aim is to generate data on bioefficacy and make suitable recommendation under different ecological regions. The data on bioefficacy is used for registration purposes to CIB before commercialization. Thus there is a strong need for developing new herbicide molecule which can offer broad spectrum weed control.

The various new molecules have been evaluated based on its performance in various crops. In rice, pyrazosulfuron,bisbyribac, azimsulfuron, ethoxysulfuron, penoxsulum, cyhalofop, fenoxaprop and oxadiargyl; in wheat, pinoxaden, carfentrazone,triasulfuron and flufenacet etc. have shown their feasibility to a greater extent, combining grass herbicides with broad leaf killer at their reduced doses.

Weed management in *Orchards*

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India's diverse agro-climatic regions facilitate production of wide variety of fruits and vegetables. According to FAO statistics, India produces nearly 160 million tonnes of fruits and vegetables, and ranks second in the global map. In the year 2003, India produced nearly 45 million tonnes of fruits and over 110 million tonnes of vegetables, from over 12 million hectares area and accounted for nearly 10 per cent of global production in each category. Over the past decade, the increase in area and production is around 30 per cent and 54 per cent, respectively (Chadha, 2001). Major fruits grown in Indian include bananas, mangoes, citrus, apples, grapes, pineapples, and papayas. Horticultural Crop is a mainstay in Indian economy. Variety of agroclimatic conditions prevailing in India not only provides ample opportunities for fruits cultivation but also present an abundance of wide range of weed species. Optimum productivity of fruits crops can be obtained only when all the aspects of production technology including weed management are given due consideration. Vigorous weed growth particularly during rainy season poses 'serious' problem to the fruits orchards as the weeds compete with main crops for water, nutrients and interfere with cultural practices. They harbour insects, disease and rodents, which attack trees. In some instances weed competition directly reduces both quality and yield of harvested fruits. Their eradiation for better growth and productivity is very essential either by direct plant destruction or by prevention of consideration. Losses from water and fertilizer used by weeds are undoubtedly substantial. The yield loss due to unchecked weeds varies from 34.0 to 71.7 percent in fruit crops. In a report of the agricultural research service of the United States, Department of Agriculture, estimates indicate that weeds reduce citrus production in the United States by approximately 5 per cent of the total crop. It is estimated that the citrus orchards treated with herbicides are about 50% in North America, 25% in the Mediterranean area, 15% in the Far East and 5% in the Southern Hemisphere. Weed control represents a major cost items in horticultural crop production and has now become a part of modern agricultural Technology. For centuries, man fought weeds with his hands, hoes, animal power cultivar and mechanical power. Recently, control using herbicides has assume great significance and is being adapted all over the world.

Accurate identification of weed species is necessary before selecting and implementing a control programme. Weeds are classified on the basis of their structure, life cycle and seasonality. Grasses (monocotytledons with strap-Shaped leaves) that cause problems in orchards are generally perennials e.g. Bermuda sedge and torpedo grass etc. The major narrow and broad leaved weed species were: *Paspalum conjugatum Berg., P. distichum L., Cynodon dactylon L., Imperato cylindrica L., Axonopus compressus L., Cyperus rotundus L.,* C. *iria L.,* and *Ageratum conyzoides L., Borreri hispida L., phylonntbus nintri L., Euphorbia hirta L., Sida acuta Brum., Urena lobata L. and Mimosa pudica L.*

Many factors including temperature, rainfall, wind, soil type and stage of development of weed species influence herbicide efficiency. Establishment and maintenance of a weed control programme. is an essential part of orchard practices. Well-designed programmes rely on a combination of methods and materials, rather than a single strategy.

Chemical weed control has become a common practice in many citrus growing regions. While chemical is very effective if used properly, improper selection of materials, variations in environment, and improper application may result in either poor weed control or damage to citrus trees. Most important to any herbicide programme is to understand the chemical properties and limitation of the product. Herbicides may be broadcast over an entire area, in a specific area, or directed to a particular region.

Chemical weed control in some of the important fruit crops of temperate, tropical and sub-tropical

Temperate fruits

(a) Apple pears and peaches : Darak (1966), while experimenting on the sensitivity of fruit trees to simazine, found that pome fruits withstood simazine upto 29 kg/ha. A rate of 30 kg/ha slowed the growth of peaches. Dalapon was recommended for control of couch grass in established apple and pears. Herbicides evaluation for use in peach orchards has been worked out by Aitken (1972) and simazine applied preemergent to weeds were the most effective against annual weds. Repeated application of dalpon at 3.0 lb/ac. Were effective against young weeds. In nurseries, trifluralin at 0.5 lb/ac gave satisfactory results. Ghosh *et al.* (1981) achieved good control of narrow leaved weeds with dalapon/dowpon at the rate of 10 kg/ha in apple and poear orchards in Meghalaya. Simazine applied at 8-10 kg a.i. or caragard at 6-8 kg a.i./ha to apple nurseries decreased weed population by 93-96% and had no adverse affect on seedlings.

(b) Stone fruits : Ministry of Agriculture London (1967) do not recommend simazine for stone fruits. They recommend paraquat and diquat of controlling annual grasses and broadleaved weeds and may be applied as directed spray under stone fruits. Dhuria *et al.* (1980) conducted a weed control study in apricot. They found that simazine or diuron @ 2,4 and 6 kg a.i/ha checked the emergence of monoct and dicot weeds effectively for 90 days. Oxyfluorfen was quite safe when applied 30 days or more after petal fall to almonds, stone fruits, walnuts and pistachios. Oxyfluorfen + glyphosate of paraquat provided excellent short-term broad spectrum weed control (West *et al.*, (1985) reported that application of oxyfluorfen rate of 0.5 and 2.lb/acre gave good wed control in nut orchards.

Tropical and sub-tropical fruits

(a) Banana : Many herbicides like paraquat, dalapon, 2,4-D simazine, linuron (Kashian and Kassion, 1962 & 1968) and gramoxone (Anon. 1959) diuron, monuron, diquat, paraquat, simazine, atrazine and dalapon (Dhooria *et al.*, 1971) have been tested for controlling weeds in banana plantations. Kassian (1962) reported that gramoxone controlled grasses upto 3-6 weeks a mixture of agral 90 and simazine. Mishra *et al.* (1984) reported that diuron (2-6 kg/ha), paraquat (1-3 litres/

ha) or simazine (2-6 kg/ha) when applied on first and 30th days after planting Covandish banana gave good weed control of 15 monocotyledonous and 14 dicotylendonous weeds especially at higher rates.

(b) Grapes : Chemical control of weeds in grapes is assuming importance in India on in recent years (Bankapur, 1969; Dhillion, *et al.,* 1974; Jawanda, 1967 and Phadnis *et al.,* 1968) although large amount of work on this aspect is available from all over the world. Dhuria and Leela (1974) observed that diuron at all concentrations was found effective in controlling both monocots and dicots. All the treatments increased yield with no change in the quality of berries. Most effective control of weeds in vineyard was reported by Cantele *et al.* (1985*)* when they applied terbuthylazing + ternbumeton @ 3, 9 + 3 .9 kg/ha in lato winter.

(c) Guava : The work on chemical weed control in guava is very mearge, Ishierly *et al.* (1967) found that guavas treated at 2 week intervals with 1:1 mixture of butoxy esters of 2, 45 – T were more susceptible during wet season. A similar pattern of defoliation response was caused by dicamba and picloram. In a 12 years old guava orchards CV.LAC-4 the best control was obtained with diuron + oryzalin @ 1.6 kg/ha + 1.67 litres/ha (Martinez *et al., 1985*).

(d) Mango : In mango CV "Pair" nursery beds 4 to 5 week old seedlings showed leaf scorch and leaf fall when treated with tribunil and terbacil @ 2.0-3.9 kg. Singh (1984) obtained good control of monocot and dicot weed with application of dalapon + grammoxone at the rate of 5.0 kg/ha applied during August in ber orchards.

(e) Citrus : In nursery most common method is the hand weeding but it is necessary to make use of chemical weedicides. Tabacil @ 2.5 kg/ha sprayed in nursery gives effective complete control of all seedling weeds and most grasses including nut grass *(Cyperus spp.)* for 5-6 months (patil, 1976). Diuron @ 2 kg/ha is also effective fu controlling weeds in nursery (Dhillon *et, al.,* 1975). Herbicides should be used with caution so as to guard young nursery seedlings against possible Phytotoxic effects. Application of Atrazine and Diuron each at 0.5 Kg/ha. resulted in maximum decreased in weight of weeds with increase in stem girth and seedling height after 10 months of serving in acid lime nursery. The most commonly employed pre-emergence herbicides in citrus are diuron, monuron, simazine and dalapon. Glyphosate and glufosinate are the two promising post-emergence weedcides which is being used in paraquate orchards. For more effective control of both grasses and other weeds a mixture of gramaxone plus 2-3 kg/diuron/ha was found to be better. In an study Diuron @ 3 kg/ha controlled the weeds beyond 300 days when applied two times as pre-emergence, first before commencement of monsoon in the first week of June and Second after 120 days of first spray in September and this economical over hand weeding. The weed control efficiency of weedicides was found to be more in black soils having cation exchange capacity of 56.2 meq/100g compared to clay loam ml soil (38.1 meq/100g). (Lallan Ram *et al.,* 1995).

Study indicated that the effectiveness of herbigation in order to reduce application costs of bromacil and chlorotriazine methoxytriazine through drip irrigation systems in lemons. The application of the herbicides through drip irrigation system must be divided into monthly doses. **Biological** methods may have potential for future integrated control of weeds. *Phytophthora pa/*

mivera has been shown to control milkweed vine in Florida if applied at the early seedling stage. **Allelopathy** may also have a role. For example, several compounds in extracts from *Lantana camara,* a weed itself, suppress the growth of rye grass plant. Insects that feed on specific weeds like *Lantana* may also have promise for future biological control. Similarly use of plant pathogens, especially fungi to control weeds **"mycoherbicides"** is gaining important in recent years.

Conclusively, adequate and finally suppression of weeds is essential to harness full potential of given genotype of any economic plant species, as well as of the various modern inputs that go into its production. It is now planned as scientifically as the crop management itself, based on certain ecological principles of plant community and good crop husbandary procedures, including the prevention of weeds. Other methods of weed control involving the use of physical, chemical and biotic stresses on weeds are suitably combined with these. In recent years several herbicides have been made available to deal with the weeds in varied situations, both before and after their appearance on the ground. Many of these are so selective that they prove superior to the human eye in distinguishing between the similar looking weed and crop plants. However, their judicial use requires an insight into their selective behaviour, their residual effects in soils and different non-target organisms and the required precautions essential in their safe use. Further, in any kind of agricultural field the use of herbicide is to be considered as supplement to the other options available for weed management, rather than as means to replace these, particularly in the developing nations.

Current status of parasitic weeds and their management in india

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Parasitic weeds are those plants which require growth stimulants for germination and host plant to support growth and development and to complete their life cycle. Parasitic weeds are gaining importance in recent times in view of their wide spread occurrence or host-specific occurrence and difficulty in managing them. Parasitic weeds have certain specific characteristics like prolific seed production potential, competitiveness and aggressiveness with the host plants, prolonged seed viability, troublesome and very difficult to control by normal weed control measures. Parasitic weeds depend on host plant for stimulants for germination, physical support, draw nutrients, water, photosynthates, minerals, etc.

Parasitic weeds are two types based on dependence on host plants – complete parasite which depends on host plants entirely for its survival and semi-parasite which depends on host plants for physical support, nutrients, water, minerals for its survival. The former does not have green leaves and hence depends on host plants for photosynthates, while the latter have green leaves and synthesize photosynthates on its own for its survival. Parasites are of two types based on occurrence on – a) root parasite like *Striga* being partial parasite occurring on sorghum, maize, sugarcane, and *Orobanche* being complete parasite occurring on tobacco, tomato, brinjal, potato, mustard, etc; and b) stem parasite like *Cuscuta* being complete parasite occurring on Lucerne fennel, niger, bengal gram, plantation crops, hedge plants, etc. and *Dendropthae* being partial parasite occurring timber crops, fruit trees, plantation crops, etc. The brief status of these parasitic weeds in crops, losses caused by them and management strategies to be adopted to contain the menace of the parasitic weeds area as follows.

***Orobanche* spp. (broomrape)** belongs to family Orobanchaceae, is a complete root parasite with about 130 species occurring only on varied broad leaf crops world over. It is concentrated in Mediterranean countries, Europe, Africa, Australia, Asia and North America. Broomrape parasitizes wide range of hosts comprising food leguminous crops, oilseed crops, solanaceous crops and medicinal plants belonging to families – Solanaceae, Chenopodiaceae and Asteraceae. The four virulent species are O. *cernua* on tobacco, sunflower, tomato, brinjal; O. *ramosa* on carrot, cabbage, cotton, sunflower, tomato, *Brassica* crops; O. *aegyptiaca* on tomato, cotton, cucurbits, brinjal, potato, tobacco; and O. *crenata* on carrot, tomato, peas and broad beans *(Vicia faba)*. In India, O. cernua and O. aegyptiaca is occurring on crops – tobacco, cumin, mustard, Plantago, Lentil, potato, brinjal and tomato and cause losses from 30-35% in tobacco to more than 80% in solanaceous vegetables. As the broomrape entirely depends on host plants, at times it will be devastating where mono-cropping of solanaceous vegetables are grown in succession. The broomrape is distributed in Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Maharashtra, Rajasthan, and Haryana states causing greater concern among farmers.

Broomrape is an annual, host specific parasitic herb propagated by seeds and gets germinated if the host root exudates reaches the seed for one week and if the seeds lie with in 10 mm distance from host fibrous roots. The parasite seedlings then infect the nearby host roots forming haustoria on them. Soon thereafter the broomrape emerges through the soil as pale shoots, devoid of chlorophyll around 45 to 55 days after planting host crops. It starts flowering a week after emergence, fleshy shoot grows up to 20 to 30 cm and dries up in 30 to 40 days. Each shoot can produce as high as 6.0 lakh seeds and as high as 30 to 40 shoots/plant of tobacco or tomato crops can be seen. The broom- rape seeds disseminate by wind, birds, farm animals, implements, water, seeds, etc. They can remain dormant in soil for 2 - 20 years.

The broomrape can be managed by following suitable preventive, cultural, physical, biotechnological, biological and chemical methods. Suggested control measures that can be adopted in India are avoiding the use of seeds from infested areas and of clean seeds; deep plowing incorporates seeds well below root zone and prevents the contact of the stimulants of host crops with the parasite seeds; soil solarisation with the use of 0.05 mm thick white polyethylene sheets for 30 to 40 days during hot summer, though expensive can lower the menace by 60 to 80%; flooding of the field during germination of parasite (i.e., around 20-25 days after planting); physical removal of emerged shoots of parasite and burning them; repeated directed application of 1 to 2 drops of mineral oils – diesel, kerosene or plant oils – coconut, neem, caster, cottonseed, gingili or linseed on emerging shoots before flowering would desiccate them and prevent seed formation; passing spear or iron blade below the host plant would cut young shoots of parasites followed by manual removal of shoots with in the rows, collecting and burning them; use of trap crops – pepper *(Capsicum annum* L.), Amaranthus, cowpea, green gram, black gram, pigeon pea, Dhaincha for 3 to 4 seasons before taking up main host crops in sick fields; use of suitable intercrops in areas having lower infestation of parasite; soil application of analogue of Strigol – GR-24 or GR-7 at 0.3 kg/ha in acid soil to 1.5 kg/ha in alkaline soil about 6 weeks before sowing of host crops induce suicidal germination of the parasite; use of pre-emergence herbicides relevant to the host crops will delay and lower the emergence of broomrape; use of ammoniacal or urea based fertilizers at 2 mg/ liter of water lowers the emergence and length of the radicals of the parasite; directed spraying of glyphosate at 0.1 to 0.2% on the lower side of the host plants around 50-55 days after planting, use of neem cake at 150 to 200 kg/ha in rows at planting, soil drenching with 5% copper sulfate around host crops between 45 to 55 days will lower the emergence of broomrape. Other options are use of Agromyzid shoot borer – *Phytomyza orobanchaia* lowers seed production by 30 to 80%; use of *Fusarium* specific to broomrape species can lower the menace of broomrape by 60 to 80%; while biotechnological approach of developing glyphosate resistant lines of host crops would also lower the menace of the parasite.

Broomrape being infesting crops also infests weeds like *Parthenium hysterophorus*, *Solanum kasianum* and *Physalis minima* and thus perpetuate by forming numerous seeds. Therefore, integrated efforts of preventive, physical, cultural and chemical approaches should be adopted to destroy these weeds before they set seeds.

Striga, Witch weed, Scrophlariaceae, an annual, partial root parasite propagated through tiny dust like seeds with 41 species having wide distribution. Of these, 11 species occur on important

tropical cereals (maize, sorghum, pearl millet, finger millet, upland rice and sugarcane) and many grasses. Of these, only four species are considered noxious inflicting greater losses to the cultivators. These are i) *Striga asiatica* (= *S. lutea*), wide spread in Africa, Asia occurring on sorghum, bajra, maize, sugarcane, rice, millets and grasses; ii) *S. hermonthica,* wide spread in Africa, North and South Yemen, Madagascar and Saudi Arabia occurring on sorghum, maize and other grasses; and iii) *S. gesnerioides*, wide spread in Africa, South Yemen, South Arabia, Oman, India and USA, exclusively occurring on dicotyledonous crops -cowpea, tobacco; and iv) *S. densiflora* wide spread in India and Indonesia occurring on sugarcane and cereals. Striga inflicts yield losses 15 to 75% in India in sorghum, pearl millet, maize and sugarcane depending on the severity of infestation. The stimulants secreted from the host plants which causes germination of Striga are kinetin, zeatin, ethylene, Strigol, scopoletin, thiourea, allylythiourea, sulphuric acid and sodium hypochlorite. If the striga seeds lying with in a few millimeters of host roots and receiving stimulants continuously for 24-28 hours, will germinate and have attachment with host roots through haustoria. Striga emerges after 50 – 55 days of sowing of host crops and continues growth for another 50 to 70 days coinciding with harvest of crops. Each shoot may produce seeds up to 50,000 to 75,000/- having seed dormancy up to 15- 20 years.

Suggested control measures: Non chemical methods such as deep plowing to place witch weed seeds below the root zone of host crops, uprooting and burning shoots of striga, use of clean seeds, avoid using seeds from areas infested with Striga, crop rotation, use of trap crops or inter cropping, and use of resistant crops/ varieties may be useful in preventing and reducing the menace of Striga. It is generally agreed that for the subsistence farmers of the tropics, the development of resistant varieties of sorghum (N-13, No. 148/168 (CSV-5), Farmida, BH4-1-4), sugarcane (CO-290, CP-36-13, CP-36-105, CP-48-103), maize and pearl millet will be the final answer to the striga menace. For instance, the new hybrids of pearl millet seem free from striga.

Catch crops (striga susceptible, short duration crops to be planted and destroyed before planting the main crop) and trap crops (striga germination stimulating crops with inherent attachment barriers), are often suggested as possible means to reduce striga populations. *Cotton,* sunflower, cowpea, gram, redgram, Sesamum, groundnut, castor and melons are considered suitable trap crops of striga. Catch crops – Setaria, maize, may be taken up before main crop and destroy the germinated Striga and host plants before Striga set seeds. Growing of inter crops of groundnut, cowpea and red gram along with sorghum will also lower the menace of Striga. Even repeated hand-pulling around 50 – 55 days onwards before flowering and burning will help in lowering the menace of Striga, but it is impracticable and costly in situations of severe infestations. Striga's infestation is usually less in the wet season, in adequately N fertilised plots, and in densely sown crops. Improving soil fertility through manures and fertilizers (application at higher than recommended level) also lowers the menace of Striga owing to higher osmotic concentrations of the host plant cell sap. Use of herbicide - directed applications of 2,4-D Na salt at 1.50 to 2.0 kg ai/ha is a very practical alternative to this for breaking future populations of Striga. Its amine salt is applied at 0.5-0.75 kg/ha, 2-3 times during the crop season to destroy flushes of Striga in its vegetative phase. Use of stimulants like Strigol, GR 7, GR 45, ethylene and like compounds as pre-plant, incorporated treatments at 0.1 to 1.0 kg/ha on the sorghum infesting striga in India, found to lower 50% reduction in striga population. The stimulants will be effective on moist soil for at least for 3

to 4 weeks and when the temperature is about 20° C. A successful ethylene and methyl bromide fumigation treatment achieve 90% reduction in striga seed population of the plough layer of the soil, but it is not practicable for the arid farmers. Further researches to develop chemical stimulants of varied strains of striga are needed. Thus, the timing of soil treatment with the stimulants and the planting of crops must be worked out properly. Isolated infestations of striga growing on some host weeds species, outside the field boundaries, should also be destroyed with any contact herbicide to prevent its seed production.

Suitable legislation is required to restrict the movement of seeds of crops grown in these parasite infested areas to other areas, where the parasite menace is not observed. In the United States, "Witch weed" is the only weed seed whose movement is prohibited in every state.

***Cuscuta*, dodder**, family Convolvulaceae, is an invasive, obnoxious, complete stem parasitic weed that attaches itself to stem and leaf of wide varieties of host plant species. There are about 100 species of genus *Cuscuta*, among them *Cuscuta chinensis*, *C. reflexa*, *C. compestris* and *C. trifolii* are more common in India. The *Cuscuta* is widely distributed in our country in cropped and non cropped areas. This parasite poses a serious problem in niger in Orissa, Chattisgarh and parts of M.P., and pulses in Andhra Pradesh, Tamil Nadu, Orissa, Chhattisgarh and parts of Madhya Pradesh where rice-fallow cropping system (also known as *Utera* or *Paira* cropping) is followed. It is also a major weed of lucerne and berseem in Gujarat and some parts of M.P. Other crops plagued by *Cuscuta* are linseed, lentil, chickpea, onion, sugar beet, carrot, *hina* and citrus. In non-cropped areas, the weed is mostly found on hedges and shrubs.

C. reflexa also transmits tomato leaf curl virus from infested plants to healthy plants of tomato following establishment with haustorial connections. They also transmit the diseases to host plants. The yield reductions due to *Cuscuta* are reported to the tune of 30% in green gram and black gram to 70% in chillies and alfalfa depending upon its intensity of infestation.

Seeds usually germinate on or near the soil surface. Germination of seed is completely independent of any influence from a host plant. Seedlings are rootless, leafless stem. After emergence, the seedlings twin around the leaf or stem of a suitable host plant. In the absence of suitable host, *Cuscuta* seedlings die within a week time. Haustoria from the *Cuscuta* penetrate the host and establish a parasitic union. Once the *Cuscuta* is attached to a host plant, it remains parasitic until harvest. A well-established single plant of *Cuscuta* produces more than one lakh of seeds, which remain viable for many years. It reproduces mainly by seeds and to a lesser extent by shoot fragments.

Non chemical methods such as deep ploughing, burning, use of *Cuscuta* free crop seed, use of resistant crops/varieties, crop rotation and inter cropping, mechanical weeding, etc., may be useful in preventing/reducing *Cuscuta* infestation. *Cuscuta* is one of very few weeds that can be controlled completely by crop rotation with members of the Poaceae, forage grasses or cereal grains. Without a host plant near by, *Cuscuta* seedlings emerge and die. There are genotypic differences with regards to tolerance to *Cuscuta* infestation. Lucerne variety T9 was found to be highly sensitive, whereas LLC 6 and LLC 7 were moderately tolerent to *Cuscuta* infestation. Greengram cv. M2 and blackgram cv. T9 are tolerant to *Cuscuta*. The shade from dense crop foliage sup-

presses *Cuscuta* sufficiently to control it almost completely. The pulse crops can be partially protected from *Cuscuta* parasitism by growing the *Cuscuta*–resistant cluster bean along with green gram or black gram in a mixed cropping system.

Non-selective herbicides like paraquat (1% spray) and glyphosate (1%) and others like 2,4-D kill *Cuscuta* effectively in areas where Cuscuta occurs in patches. Use of pre-emergence herbicides fluchloralin, trifluralin or pendimethalin at 0.75 to 1.50 kg ai/ha (relevant to crops) will lower the menace of Cuscuta in addition to other weeds in niger, linseed, chickpea and lentil. In lucerne, early post-emergence (10 days after sowing) of pendimethalin at 0.50 kg/ha was also effective killing the emerging Cuscuta.

Dendrophthoe (= Loranthus), Loranthaceae, is a semi stem parasite of certain tropical and subtropical trees and bushes like teak, rosewood, sandalwood, tea, fruit crops -Mango, Citrus, Sapota, Jackfruit. In India, about 60 species of *Dendrophthoe* have been recorded on various trees and plantations. Of these *D. longiflorus var. falcatus* is the most damaging and occurring on various trees. The seeds of parasite are spread by birds to fresh tree branches. In Karnataka, it occurs on all most all forest trees, high value timbers – Teak, Rose, sandalwood; Eucalyptus, Casuarina, Neem, Mango, Citrus, Sapota, pomegranate, except Tamarind.

Control : The only control measure of Loranthus on record is to bore two rows of holes down the infected tree, reaching the sap wood. In each hole a mixture of 8 g copper sulphate and 1 g 2,4-D powder is pushed in. The treatment is supposed to free the trees from Loranthus for a period of up to 4 years. Other method is to lop off the branch infested with *Dendrophthoe* to prevent further growth and spread in the initial stage itself.

Weed management under moisture stress conditions

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There is a good reason to control weeds in crop land. Low soil moisture increases the competition for water between the weed and the crop, therefore, weed control is even more important when water is scare. Generally, when moisture is limiting, there may be fewer and less vigorous weeds and weed emergence may be delayed until rainfall occurs. Drought tolerant weeds such as thistle an field bind weed develop extensive root systems early and take advantage of limited water, making them more competitive and germination leading to decreased weed abundance.

Weeds respond under moisture stress by thickening their leaf cuticle and reducing their vegetative growth. Some of important dominant weeds found in rainfed areas on farmers field as follows:

1. *Cyperus rotundus*	2. *Cynodon dactylon*	3. *Chenopodium album*
4. *Chenopodium murale*	5. *Convolvulus arvensis*	6. *Argemone maxicana*
7. *Eleucine indica*	8. *Euphorbia spp.*	9. *Trianthema spp.*
10. *Digiteria spp.*	11. *Orobanche spp.*	12. *Cuscuta spp.*
13. *Striga spp.*	14. *Opuntia spp.*	15. *Cirsium arvense*
16. *Polygonum spp.*	17. *Tribullus terrestris*	

These weeds are able to survive even under extreme drought conditions. Some of special adaptations were observed in these weeds i.e. presence of extensive root system, waxy substance on the leave, thick and fleshy leaves and presence of awn. In arid region of Rajasthan where moisture is a limiting factor in crops like *pearl millet and sesame, the weed species observed are cenchrus setigarus, cenchrus biflorus, convolvulus microphyllus, corchorus tridens, crotolaria, medicagivea, cucumis, callosus, cyperus rotundus, dactylictenium, aegyticcum, digera muracata, ipomeas* pp.

Perennial weeds i.e. cyperus rotundus and cynodon dactylon cause a serious problem because they are very competitive and difficult to control. Similarly, broad leaved perennial i.e. *convolvulus arvensis* is also difficult to control.

Among parasitic weed *orobanche spp.* is major weed in semi arid region while *striga spp.* found more in hot arid regions affecting pearl millet, maize an sorghum.

Weeds and crop seed germinate almost simultaneously, weed produce more foliage than crop plants and compete with crop plants for moisture, nutrient and space. Weeds absorb nutrient and moisture from the soil rapidly and in large amount than crop plant. For producing equal amount of dry matter weeds transpire more water than crop plants. Transpiration coefficient of weeds

ranged from 221 (*Tribulus terristris*) to 1402 (*Tridax procumbens*) while for maize it is 352 and for sorghum it is 394. Hence, effective weed control in dryland agriculture leads to more availability to soil moisture to crop. Generally initial stage 4-6 weeks period is more sensitive period to competition from weeds. Weed control during this period helps to minimize the loss in crop production.

Methods of weed control

Various weed control practices like manual, mechanical soil solarization and chemical aim to minimize the weed growth and maximize crop growth and yield.

1. Tillage

Under mechanical managed weeds, tillage reduces soil moisture and when soils are dry, tillage could result in seed bed desiccation and reduced crop establishment. if we can minimize moisture loss by applying a shallow tillage and using a harrow to fill in and seal the ground. In most cases, adopting minimum tillage or no tillage may be the best solution to conserve soil moisture but care should be taken to reduce the proliferation of perennial weed species. Tillage practices immediately after harvest of the crop are more effective in controlling weed population. This would help in two ways, Firstly, seed bed preparation in such condition become very easy and quick and farmer can sow their crops early i.e. first showers of rain. Secondly, off season tillage also checks the multiplication of weed seed.

2. Dryland practices

By using timely dry land practices such as stale seed bed techniques, selection of crops / variety, timely planting, maintaining plant density, using dry land weeder, using timely appropriate fertilizer application, intercropping and crop rotation etc. One can reduce the weeds in dry land conditions.

3. Chemical weed management

Drought and heat not only complicate weed management but they also increase crop susceptibility tyo pre-emergence and post-emergence herbicides. Dry weather reduces microbial and chemical degradation of soil applied herbicides increasing carry over injuries. High temperature and low humidity increases herbicide volatilization and degradation reducing the effectiveness of pre-emergence herbicide particularly of those that have not been mechanically incorporated. A shallow mechanical incorporation, 24 hour after application will reduce loss of soil applied herbicides. Unfortunately, when soils are too dry, it is very difficult to achieve uniform herbicide incorporation. Also, as soil moisture decreases, herbicide molecules tend to bound more tightly with soil particles reducing the effectiveness of soil applied herbicides. Drought stress weeds are more difficult to be controlled with post-emergence herbicides because of reduced herbicide absorption and low physiological activity. Contact foliage applied herbicide, such as paraquat, bromoxynil, oxyflurofen are usually less affected by drought stress than the translocated herbicides such as 2,4-D, glyphosate, dicamba, chopyralid, fluroxypyr, triclopyr and their combinations. Do not akimp on herbicide rates when treating water stressed weeds. Generally more herbicide is needed to control drought stressed weed. Also, certain herbicide formulation may be more effective on

drought stressed weeds for example, ester formulation of 2,4-D generally perform adjuvant can improve control of drought stressed weeds by improving herbicide coverage, retention and uptake.

The complete weed control through adoption of any single method is highly doubtful. The concept of integrated weed management is more suitable for dry land agriculture to save the cost and get efficient control of weeds. Normal weeding or interculture operation required to control weeds are not possible under certain situation. Further, initial weeds population which is very small in growth is sometimes ignored for sometime to make enough growth. Such very early growth can be effectively controlled by pre-emergence application of herbicide in cereals as well as legumes.

4. Solarisation

This is another method of utilizations of solar energy for the desiccation of weeds. In this method, soil temperature is further raised by 5-10^{0}C By covering thin and transparent plastic sheet. In stress conditions, weeds are controlled with this method.

Biological control of terrestrial and aquatic weed in India

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Introduction

Weeds play an important role in all spheres of human activities. Their capacity to adopt, prosper and dominate in any environment combined with the problems they cause to agriculture and health have made them as key targets to control by mankind globally. Irrespective of the ceaseless and non tedious measures adopted by mankind since ages, weeds still remain as the major competitive factor to man.

The increase in the costs combined with the health and environmental problems involved in herbicides application to control weeds has led to look for alternate control measures such as biological control. Biological control is an effective self-sustaining, eco-friendly and economically cheap method of suppressing the target organisms. Among the biological control agents employed for weed control world wide, insects rank foremost, followed by pathogens, mites and vertebrate agents such as plant feeding fishes and mites.

Biological control is however perfect to situations where exotic weeds become aggressive and dominate large areas that are uncontrollable by the other methods. At relatively low cost, it can permanently reduce such weeds to scattered plants and isolated clumps. Without biological control there is usually no economical method of solving this type of weed problem (Andres, 1977). However, the specificity of biological weed control agents is a disadvantage in monocultured crops, most of which harbour a complex of weed species.

Classical, conservation and augmentation approaches are generally employed in biological control. However, classical biological control of naturalized weeds by the introduction of exotic control organisms from the native range is the most frequently used method in biological control of weeds. Augmentation approach using periodic releases and or redistribution of native natural enemies has attained certain importance, particularly using native pathogens. The conservation approach involving environmental manipulation to enhance the effect of existing native or exotic control organisms has not received much attention in biological control of weeds.

Historical overview:

The earliest record of biological control of a weed was the large scale destruction of *Opuntia vulgaris* in central and northern India by *Dactylopius ceylonicus* (Green), introduced from Brazil in the mistaken belief that it was *D. coccus* Costa, a species cultured as a source of carmine dye. The intentional introduction of the same insect during 1836-1838 into southern India is the first successful intentional use of an insect to control a weed. The subsequent introduction of *D. ceylonicus* to Sri Lanka about 1865 and the successful control of *O. vulgaris* there constituted the first international transfer of a natural enemy for biological control of weeds (Goeden, 1988).

The first spectacular success in a biological weed control project was reported from Australia, where the Argentinean moth *Cactoblastis cactorum* (Berg.) released in 1925, brought about virtual complete control of *Opuntia inermis* and *Opuntia stricta* from 24 million hectares of formerly infested land by 1935 and restoring the same to agricultural use (Goeden, 1988). The spectacular success achieved in the biological control of cactus in Australia aroused interest in utilizing this method against other weeds.

Although several well known alien weeds occur in India, only a few sporadic biological control attempts were made until 1980. After the spectacular success achieved against *Opuntia* spp. releases of exotic natural enemies were only made against *L. camara*, *Ageratina adenophora* and *Chromolaena odorata.* With the initiation of the All India Coordinated Research Project on Biological Control of Crop Pests and Weeds concerted efforts were made for the biological control of water hyacinth (*Eichhornia crassipes*), water fern (*Salvinia molesta*), *C. odorata* and *Parthenium hysterophorus*, starting 1982.

Biological control of exotic weeds

Biological control trials against *L. camara* were initiated in 1921 with the introduction of the seed fly *Ophiomyia lantanae* Froggatt from Hawaii in 1921. Although establishment was obtained the insect failed to control the weed. *Teleonemia scrupulosa* Stal. Imported from Australia in 1941, is reported to cause defoliation of *L. camara* in some parts of the country, without bringing about control (Muniappan and Viraktamath, 1986). Various abiotic and biotic factors such as temperature, parasitoids, predators, rainfall, were reported to be the limiting factors.

The tephritid gall fly *Procecidochares utilis* Stone was introduced in 1963 and released for biological control of *A. adenophora*. Although the insect has established its effectiveness is hampered by attack of parasites (Sankaran, 1973). This insect is reported to have spread into Nepal, where it has become well distributed (Kapoor and Malla, 1978).

Biological control trials against *C. odorata* were initiated in 1973 with the introduction of Pareuchaetes *pseudoinsulata* Rego Barros (Lepidoptera: Arctiidae). As repeated field releases failed to result in establishment, a culture of the same was obtained in 1984 from Sri Lanka, where it had established after released made in 1973. This strain got established in many parts of South India. However, the insect was able to cause sporadic defoliation in pockets. Various reasons such as temperature, parasitism, rainfall, predation are considered as the causative agents. Recently a gall-forming insect Cecidochares Connexa is imported to India. The insect is reported to have established in many released areas (Annual report, PDBC, 2006)

The leaf feeding beetle *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) imported from mexico established readily under field conditions in Bangalore. The insect started building up damaging population levels from July 1988, causing large-scale defoliation of the weed in Bangalore and surrounding areas. Defoliation by the beetle was found to cause up to 98% reduction in flower production and also encourage the growth of vegetation formerly suppressed by this weed (Jayanth and Geetha Bali, 1994). The insect has dispersed to many parts of the country and is considered as a major suppressing factor.

A summary of the bioagent so far introduced in India is given in the Table-1.

Table-1: Exotic insect enemies introduced in India naturally or deliberately for the biological suppression of some exotic terrestrial weeds. Imported,widely established and controlling weeds in India.

Weed and its origin	Bioagent and its origin	Introduced/released in India	Current status
Cactus (prickly pear), *Opuntia monocantha* Haw (=*O. vulgaris* Miller (Cactacae); native of Argentina, Brazil	Cochineal *Dactylopius indicus* Green (=*D. celonycus* (Green) (Hemiptera: Dactylopidae); native of Brazil	1795,18311836	Eradicated this weed from India
	D. confusus (Cockerell); native of South America.	1926	Not established
	O. dillenii (Ker *D. tomentosus* Lam. Gawler);USA,West (=*D.opuntiae*) (Cocke	1926 from Sri Lanka	Eradicated weed from India.
O. elaitor Miller (=O. nigricans); Panama, Columbia.	--do--	--do--	--do--
Lantana (*Lantana camara*)			
	1.Plume moth *Lantanophaga (Platyptilia) pusillidactyla* (Lepidoptera:Pterophoridea); native of Central and tropical South America.	Introduction obscure perhaps naturally by air current	Established but efficiency is not of high merit
	2.The scale insect *Orthezia insignis* Dougles (Homoptera)	Probably got entry from Sri Lanka	Established but feed on many other hosts hence
	3.Seed fly *Ophiomyia lantanae* (Frog.) (Diptera;Agromyzidae); native of Mexico.	In 1921 from Hawaii	Established but not effective.
	4.*Teleonemia scrupulosa* .,(Hemiptera: Tingidae); native of Mexico	In 1941 from Australia	It was though to become a pest of teak hence culture was destroyed but insect accidentally escaped from laboratory and established hrouthut India; partially effective during raingy season
	5.Leaf minor *Octotoma scabripennis* (Coleoptera: Chrysomelidae);native of Mexico.	In 1972 from Australia	Several releases were made but could not established
	6.Beetle *Uroplata girardi* Pic. (Col.:Chrysomelidai): native of Mexico.	--do--	--do--
	7.Stem and root borer *Plagiohamus spinipennis* (Thoms)(Col.:Cerembycidae); native of Mexico.	In 1972 from Sydney	Imported pupae failed to yield beetle.
	8.Tingid bug *Leptobyrsa decora* Drake (Hemiptera: Tingidae); native of South America.	In 1976 from Australia	Declared unsafe hence whole culture was destroyed
	9.Fruitborer,*Epinotia lantanae* (Busk) (Lepidoptera: Tortricidae); native of Mexico	First recor ded in 1986	Not effective ; introduction obscure.
Carrot weed, *Parthenium hysterophorus* L.;	1.Weevil *Smicronyx lutulentus* Dietz (Colloptera; Curculionidae); native of Mexico, Argentina and Trinidad.	In 1983 from Mexico	Could not breed in laboratory
	2 Beetle *Zygogramma bicolorata* Pallister (Col.;Chrysomelidae); native of Mexico.	In 1993 from Mexico	declared safe, emerged controversy about its status on sunflower but declared safe by Govt. of India; established throughout south India and some states in north India; achieved spectacular success in many areas.

	3.Moth *Epiblema strenuana* (Walker); native of Mexico.	In 1985 from Australia	Completed life-cycle on Niger hence culture was destroyed
Siam Weed *Chromolaena odorata* (L.) Robinson,(=*Eupatorium odoratum* Compositae);	1.*Apion brunneionigrum* Chromolaena odorataB (Col.; Apionidae); King & Robinson; native of West Indies.	In 1975 from Trinidad.	Not established
	2.Moth *Pareuchatus pseudoinsulata* Rego Barros (=*Amalo insulata* native of Central tropical America. Walker) (Lepidoptera: Arctiidae)	In 1981 from Trinidad	Trinidad strain failed but Sri Lankan strain established.
	3.Moth Mescinia parvula Z. (Lep.; Pyralidae);native of West Indies.	In 1986 from Trinided	Failed to breed in laboratory
Crofton weed *Eupatorium aden ophorum* Sprengel (Compositae); native of America	Gall fly *Proceicidochares utilis* Stone (Diptera; Tephritidae); native of Mexico	In 1986 from New Zealand	Established and spreading naturally, got entry into Nepal, partially effective.
Waterhyacinth (*Eichhornia rassipes*); native of south America	1.Weevil *Neochetina eichhorniae*	1983	Ex-released in Bangalore, established, spectacul;ar success achieved in many lakes and aquatic weeds throughout India
	2. Weevil *N. bruchi*	1983 from USA	-Do-
	3.Mite *Orthogalumha terebrantis* (Hyacinth mite)	1982 from USA	-Do-
Water Fern *Salvinia molesta* D.SMitchell; South America (Water fern)	1. Weevil *Cyrtobagous salviniae* Calder & Sand. (Coleoptera : Curculionidae)	1982 via Austalia	Released in Bangalore (Karnataka) and Kerala; establieshed and caused spectacular success
	2. Paulinia acuminata (De Geer) (Orthoptera: Acriditae)	1974 from Trinidad	Could not established

Two exotic weevils *Neochetina eichhorniae* Warner and *N. bruchi* Hustache (Coleoptera: Curculionidae) and a leaf mining mite *Orthogalumna terebrantis* Wallwork (Acarina: Galumnidae) were imported in 1982 for biological control trials against water hyacinth. Releases were made after host specififcity tests in mnay parts of banglore. Studies carried out over many years indicated that the weevils are self sustaining and could keep the weed under check (Jayanth, 1987; 1988b and jayanth and Ganga visalskhy,1991Promising results are being obtained in other parts of the country. success ful control of water hyacinth in 286 sq. km Loktak Lake in Manipur, in assam were reported. 75% of which was under water hyacinth cover (Jayanth and Ganga Visalakshy, 1989a). as well. *O. terebrantis* has established in Bangalore (Jayanth and Ganga Visalakshy, 1989b) and Kerala.

Releases of *Cyrtobagous salviniae* Calder and Sands (Coleoptera: Curculionidae) has brought about spectacular control of *S. molesta* in Kerala. Most of the water bodies in southern Kerala, which were choked by Salvinia are now free of the weed. In the case of paddy cultivation, where Rs. 250-750 had to be spent per hectare for manual removal, the annual savings on account of labour alone are estimated to be about Rs. 6.8 million annually (Singh, 1989). Some of the successful examples of biological control agtaisnt aquatic weed are given in Table 2.

A plant of exotic origin ***Orobanche spp.*** (Broomrape) is a parasitic weed of tobacco, brinjal, tomato, sunflower, etc. A culture of Phytomyza orobanchiae puparia imported for Yugoslavia could not be established. However the insects were later reported from Anand but heavy parasitism was found to inhibit their population build up.

Table-2 - Successful examples of insect/fish bioagent against aquatic weed in world

Aquatic weed controlled	Insect bioagents	Remarks
Alligator weed (*Alternanthera hiloxeroides)*	*Agasicles hygrophila* (Flea beetle)	Successfully used in many countries. Urgent need to import in to India
Waterhyacinth (*Eichhornia crassipes*)	*Neochetina eichhorniae* *N. bruchi (Hyacinth weevils)* *Mite Orthogalumha terebrantis* (Hyacinth mite) *Sameodes albiguttalis* (Hyacinth moth)	Successfully used in many countries. Spectacular success achieved in India.
Salvinia (Salvinia molesta)	*Cyrtobagus Salvinae.* (Curculionid weevil) *Paulinia acuminata* (Grass hopper)	Successfully used in many countries. Spectacular success achieved in India.
For many submerged and floating weed	*Ctenopharyngodon idella* grass carp	Native of China. Successfully used in many countries. Spectacular success achieved in India too.

Biological control by indigenous natural enemies

Two natural enemies pod borer *Nanophyes nigritulus* and a leaf feeder *Altica aerula* were reported to be keeping the weed *Ludwigia dcendens* . Similarly, Altica cynea, A.foveicollis and *Morphae ludwigiae* are reported to check the weed *L.perenis* and *L.adcendens* infesting paddy fields under check in north eastern parts of India (Gangag visalakshy and jayanth , 1995).

A plant of exotic origin, it is considered as a problematic crop weed of banana orchards, vineyards and vegetable fields in addition to being an alternate host to pest and diseases. Two curculionid weevils were recorded, a leaf miner *Ceutorhynchus portulacae* and stem borer *Hypurus portulacae* as potential biocontrol agents of the weed (ganga visalskhy,2001).

Future

The science of biological control of weeds has made significant contribution to the control of alien weeds in India . many countries around the globe. However, not all weeds are amenable to biological control and unfortunately we still cannot predict the impact of introduced biological weed control agents.

The success rate in the utilization of host-specific plant pathogens for weed control has been 66.6% compared to 25% for insects (Julien, 1989). Though some efforts are made on this methodology in India, more empahsis is to be made in future.

In addition of introduction of insects for weed management, importation of vertebrates such as fishes especially in the management of aquatic weeds may be initiated.

The role of weeds in conservation of natural enemies especially in crop system is very scanty in India. More information on this aspect could help us to view management of crop weeds differently.

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Integrated weed management in direct seeded upland rice in Chhattisgarh

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An experiment was conducted during wet seasons of 2003 and 2004 to evaluate the effective methods of weed control in upland rice at IGKV, Raipur, Chhattisgarh. The treatments consisted of various means of weed control either alone or in different combinations of manual, mechanical, herbicidal weed control as well as intercropping and incorporation of green fodder/ manure. The seven treatment combinations were laid out in randomized block design replicated thrice. The rice variety MTU-1010 was sown in rows at 20 cm distance and was fertilized with 80:50:30 kg N:P:K ha^{-1} in inceptisol under upland bunded situation.

Echinichloa colona, Cyprus iria, Fimbristylis miliacea, Cynotis axillaries, Alternanthera triandra, Caesulia axillaries, Commelina communis and *Ischaemum rugosum* were the dominant weeds in the experimental field. Dry matter of weeds recorded at 60 DAS revealed that hand weeding twice was effective and produced minimum dry matter, while under other weed management practices, application of pendimethalin 1.0 kg ha^{-1} fb one hand weeding at 40 DAS reduced the weed dry matter-m^2. Similarly, grain yield under hand weeding twice as well pre-emergence application of pendimethalin 1.0 kh ha^{-1} fb one hand weeding were comparable to each other and proved significantly superior over rest of the treatments. The mean yield of two years also followed the similar trend. Weed control efficiency was also maximum under hand weeding twice (74.37%) followed by pre-emergence application of pendimethalin 1.0 kh ha^{-1} fb one hand weeding (69.02%). Maximum reduction in yield to the extent of 58.17% was recorded under unweeded control.

Herbicide resistance in *Phalaris minor*

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The resistance in *P. minor* against isoproturon was reported from Punjab in 1996. After that three herbicides namely clodinafop, sulfosulfuron and fenoxaprop-*p*-ethyl were recommended against *P. minor*. A field experiment conducted for eight years where *P. minor* was subjected to alternate herbicides year after year indicated that the weed has also developed resistance against fenoxaprop-*p*-ethyl and the herbicide was no more effective against this weed. The GR_{50} value of this herbicide was more than the recommended dose of 100g ha^{-1} indicating its ineffectiveness. The GR_{50} value for clodinafop and sulfosulfuron were less than their recommended doses. In clodinafop and sulfosulfuron the percentage of yellow seeds was higher than fenoxaprop-*p*-ethyl and isoproturon. The germination in yellow seeds from clodinafop treatment was lower than other herbicides.

Effect of fertility level and weed management on the weed and yield of wheat

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A field experiment was conducted during 2005-2006 and 2006-2007 to study the effect of fertility levels and weed management on the weed and yield of wheat at Sardar Vallbh Bhai Patel University of Agricultur & Technology Meerut. The soil of experimental field was loam in texture and heaving available nitrogen, phosphorus and potash 268.7, 18.9 and 224.3 kg/ha, respectably. Fifteen treatments consisting 3 fertility levels (75,100 and 125% of recommended NPK) and 5 weed management practices ie. weedy check, two hand weeding, Isoprotuorn + 2,4- D (0.75+0.50 kg a.i./ha.) POE, pendimethalin 1.0 kg a.i./ha PE fb one hand weeding, clodinafop 60 gm a.i./ha + MSM 4.0gm a.i./ha POE. The predominant weeds of wheat crop were *phalaris minor, Chenopodium album, Fumaria parviflora, Melilotus alba* Result revealed that application of 125% NPK reduced the weed population and weed dry matter accumulation than 75% NPK level. Panicle length, number of grains/panicle, test weight and grain yield of wheat was significantly increased in 125% NPK over 75% NPK level. Weed management practices lead to significant reduction in weed population and weed dry matter as compared to weedy check. Application of pendimethalin 1.0 kg a.i./ha PE fb one hand weeding controlled weed population effectively and also reduced the weed dry matter. The highest grain yield of wheat was also recorded in the same treatment followed by isoprotuorn + 2,4- D (0.75+0.50 kg a.i./ha.) POE.

Allelopathic effect of prominent weed species on important crops

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A pot experiment was conducted to assess the allelopathic potential of *Commelina benghalensis, Cyperus rotundus, Parthenium hysterophours* and *Prosopis juliflora* weed leaf residue (5, 10 and 20 kg of soil). Observations on plat height, leaf area and dry matter production and partitioning in sorghum, soybean ad groundnut were recorded. The weed residue of *Commelina* and *Cyperus* significantly reduced plant height, leaf area and dry matter production and partitioning at 30 days in all the crops studied particularly at higher concentration. Sorghum and groundnut were relatively less susceptible.

Bio-efficacy of herbicides in french bean (*Phaseolus vulgaris* L.) grown for seed

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A field experiment was conducted to study the bio-efficacy of herbicides on yield of french bean during spring season of 2005-2006 at Vegetable Research Centre of G.B.Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand. Sixteen weed control treatments were tested in a randomized block design with 3 replications.

Pendimethalin, metribuzin and chlorimuronethyl at their respective doses, were sprayed within 2 days of sowing as pre-emergence application. Fluchloralin at 1.0 kg ha^{-1} was incorporated in to the soil before planting the crop. Isoproturon at 1.0 kg ha^{-1} was applied at two stages (just after planting and 15 days after planting). French bean variety 'Pant Anupama' was sown on January, 15, 2006 and was harvested on May 5, 2006. Seeds were sown @ 100 kg ha^{-1}, 50 cm apart in rows. The crop was fertilized uniformly with 120 kg N, 80 kg P_2O_5 and 60 kg K_2O ha^{-1} through urea, SSP and MOP, respectively. Recommended package of practices other than weed control was adopted to raise the experimental crop.

The major weeds of the experimental field were *Phalaris minor, Chenopodium album, Anagallis arvensis, Melilotus indica, Gnaphalium indicum, Cyperus rotundus, Medicago denticulata,* and *Eleusine indica*. All the weed control treatments significantly reduced the weed density and their dry matter accumulation as compared to weedy check at 60 days after sowing (DAS). Pendimethalin at all the doses, post-emergency spray of isoproturon at 1.0 kg ha^{-1}, metribuzin at 0.25 kg ha^{-1} along with hand weeding at 40 DAS and hand weeding twice (20 & 40 DAS) being on par with weed-free treatment produced significantly higher seed yield as compared to rest of the treatments. On an average, the uncontrolled growth of weeds resulted in to 77.9 per cent reduction in seed yield of french bean when compared with weed-free treatment.

Bio-control efficacy of *Zygogramma bicolorata* Pallister (Coleoptera : Chrysomelidae) after field release in district Saharanpur

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Z. bicolorata Pallister is a biocontrol agent of *Parthenium hysterophorus*. It is an obnoxious weed which is commonly called as congress grass, carrot weed, white top and hydra headed grass. It has been spreaded like a wild fire in district Saharanpur and adjacent area. Field trials were made of the release of this Maxican beetle in Saharanpur district at different sites. After the release of beetles, its population was established very rapidly. After 25 days of release all stages of *Z. bicolorata* (eggs, larvae and pupae) were observed at each site. Firstly, beetle and their larvae ate only soft part of leaf and buds after that hard and main stem was eaten. It was also observed when half plants were damaged, most of adult beetles migrated to near by vicinity while larvae fed on the left over parts of the plants till these were fully damaged. Beetle damaged seed formation ability of the plants by feeding on inflorescence and flower. After about a month of release, 50 to 90 percent plants were damaged and after 35 to 85 days of release all the plants were found fully damaged at different sites, leaving behind no trace except stubs. Both adults and their larvae are voracious feeder. A group of 5 adult beetles and 5 larvae took only a week to damage a healthy caged potted plant. The weed is spreading in the near by forest area of Uttarakhand so release of this beetle in these areas is needed.

Integrated weed management in mustard (*Brassica juncea*)

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The treatments consistent of herbicides such as isoproturon, oxydiargly, oxyfluorfen and pendimethalin in three different rates, fluchloratlin, weed free, one hand weeding and weedy check were tested in randomized block design with three applications. The experiment was sown on 3rd week of October during both the year and variety Pusa bold was used. The soil was sandy loam neutral in reaction. The major weed flora observed in the experiment field were *Cyperus rotundus, Asphodelus tenuifolius, convolvulus arvensis, Anagllis arvensis, Chenopodium album, Phalaris minor, Aspergula arvensis* and *Melilotus* spp.

Results revealed that the application of oxyfluorfen @ 0.150 and 0.180 kg/ ha yield much higher gave as compared to other treatment and of these treatments was almost similar to than of weed free treatment. All the herbicides caused reduction in dry. Lowest dry weight of weed was produced in weed free plot and maximum in weedy check. Uncontrolled weeds resulted in to nearly 30 per cent reduction in seed yield of mustard as compared to weed free plot. Higher WCE was observed under weed free plot and herbicides Oxyfluorfen @ 0.120 kg/ha and pendimethalin at all the rates were next in order.

Integrated weed management in rice-rice cropping system in east and south eastern coastal plain zone of Orissa

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A field experiment was conducted consecutively for these years (2002-03 to 2004-05) in East and South Eastern coastal plain zone of Orissa at Research Farm, OUAT, Bhubaneswar taking tow treatments in main plot for *Kharif* rice, Farmers practice (2 HW at 30 and 45 DAP), pretilachlor 0.75 kg/ha at 3 DAP and five weed control measures in sub-plot for second rice crop (unweeded control, one HW at 40 DAP, 2, 4-DEE 0.8 kg/ha (3 DAP), butachlor 1.25 kg/ha (3 DAP) + almix 4g/ha (3 DAP), narrow spacing (15×10 cm) + 1 HW (30 DAP) in split plot design. The soil of the experimental site was low in available N and medium in P and K with pH ranging from 5.3 to 5.7 Both the rice crops were fertilized with 80 40 40 kg N, P_2O_5 and K_2O/ha. The treatments were imposed in time during both the seasons. The results indicated that farmers practice of 2 HW in *Kharif* + 1 HW (40 DAP) in *rabi* registered the highest grain yield of 8803 kg/ha in rice-rice system. Application of pretilachlor 0.75 kg/ha in *Kharif* and butachlor 1.25 kg/ha + almix 4g/ha in *rabi* was found to be better with respect to grain yield (8733 kg/ha) and cost of weeding (Rs. 1550/ha). The highest B'C ratio of 1.48 was obtained with application of pretilachlor @ 0.75 kg/ha in *Kharif* rice significantly reduced the weed density and weed biomass during the initial stages of *rabi* rice. Butachlor 1.25 kg/ha + almix 4g/ha in *rabi* rice recorded the lowest weed density (11.3/ m2) and weed biomass (4.3 g/m2). A deceasing trend in weed densities and weed biomass was observed in herbicide treated plot from the years of initiation.

Chemical control of *Pluchea lanceolata*- a non crop weed

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Pluchea lanceolata (Baisuri) has become a problematic weed in light soil of semi-arid tracts of Uttar Pradesh, Rajasthan, Madhya Pradesh and Maharashtra. In Uttar Pradesh this weed has occupied an area of 4000 ha in Agra region. A field experiment were conducted at Students' Instructional Farm of C.S.A.U&T Kanpur during two consecutive years (2005 and 2006) to develop effective weed management practices. Six treatments viz., unweeded check glyphosate (10 ml/l), glyphosate (10ml/l) + 2,4-D (1g/l.) once, glyphosate (10ml/l) + 2,4-D (lg/l)twice, Excel 71% (4ml\l), Excel 71% (6ml\l) and Excel 71% (9ml\l) were compared with untreated in a randomized block design with 3 replications. Plot size was kept $15m^2$. The herbicides dissolved in water were sprayed on foliage before flowering. Visual injury on the *P. lanceolata* were recorded after 55 days of herbicidal applications. Effect of the herbicides was quite evident. Glyphosate alone did not bring pronounced effect on this weed. Tank mix application of glyphosate (10ml/l) + 2, 4-D (1g/l) once, recorded 82 to 85% mortality of *P. lanceolata*. Application of Excel 71% @ 4ml\l, 6ml\l and 9ml\l alone were found in effective against *P. lanceolata*.

Integrated weed management in maize

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To find out the integrated effect of intercropping, manual and mechanical and chemical weed control methods to manage weeds in maize, a field experiment was conducted at Palampur during the two consecutive *kharif* seasons of 2004 and 2005. Twelve treatments consisted of intercropping of soybean in between two rows of maize (1:1) in combination with unweeded check, pendimethalin (1.0 kg/ha), metolachlor 1.0 kg/ha and one hand weeding, solid maize in combination with unweeded check, handweeding 30 DAS fb atrazine 1.0 kg/ha, atrazine 1.5 kg/ha fb atrazine 0.75 kg/ha, atrazine 1.0 kg/ha fb atrazine 0.75 kg/ha, mechanical weeding at 20 DAS fb atrazine 1.0 kg/ha, tank mix application of pendimethalin 0.75 kg/ha + atrazine 0.75 kg/ha, maize-closer row spacing 30 cm (harvesting of one row for fodder purpose) + mulch for 30 DAS fb 1 hand weeding and maize closer row spacing 30 cm (harvesting of one row for fodder purpose) + mulch for 30 DAS fb atrazine 1.0 kg/ha. Maize variety Kanchan Hybrid KH-101 was sown on June 8, 2004 and June17, 2005 and was harvested on September 25, 2004 and October 10, 2005. Intercropping of soybean with maize resulted in significant reduction of all the weeds except *Echinochloa* and *Ageratum* over unweeded solid maize and increased the grain yield of maize. Intercropping of soybean with maize (1:1) in combination with metolochlor 1.0 kgha^{-1} (Pre) resulted in significantly higher grain yield of maize with additional yield of soybean by reducing the population and dry weight of weeds. Application of atrazine 1.5 kg fb atrazine 0.75 kg ha^{-1} and atrazine 1.0 kg fb atrazine 0.75 kg ha^{-1} behaving statistically similar recorded significantly lower total weed count and total weed dry weight of were the next best treatments in increasing grain yield of maize. These two treatments provided season long control of weeds particularly that of *Ageratum* which in other treatments increased the total weed count as well as total weed dry weight. Weeds in unweeded solid maize reduced the grain yield of maize by 36.4 and 40.0 per cent over unweeded maize + soybean and by 59.7 and 61.5 percent over best treatment of maize + soybean in integration with metolachlor 1.0 kg/ha during 2004 and 2005, respectively. Intercropping of soybean with maize (1:1) in combination with metolochlor 1.0 kgha^{-1} (Pre) resulted in gross and net returns over unweeded control and was followed by intercropping of soybean with maize (1:1) in combination with hand weeding.

Degradation pattern of pretilachlor in soil and its residues in rice

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Degradation behavior of pretilachlor under the trade name Rifit, 50% EC, a new selective pre-emergence herbicide for transplanted rice was studied during kharif, 2006 at college farm, Rajendranagar, Hyderabad. Pretilachlor was applied 4 days after transplanting of paddy at two levels i.e. recommended rate of 1.0 kg/ha (x) and double the recommended rate of 2.0 kg/ha (2x). Soil samples were collected from 0- 15 cm depth at 0, 15, 30, 60 days after herbicide application and at harvest.

The representative soil and grain samples were extracted with 250 ml of acetone : hexane. The samples were filtered and the extract was evaporated. The soil and grain extracts were cleaned by passing through florosil- activated charcoal and anhydrous sodium sulphate and elution with hexane. The eluate obtained was concentrated and analyzed on Shimadzu Gas chromatograph equipped with electron capture detector (ECD) using nitrogen as carrier gas with ZB-5 column. The authenticity of this method was checked by conducting recovery experiments at the fortification levels of 0.5 ppm and 1 ppm.

The recovery of pretilachlor in samples spiked at 0.5 and 1 mg /kg level was 82 and 84%. The retention time for pretilachlor was found to be 22. 4 minutes. The initial deposits of pretilachlor ranged from 0.541 to 2.140 mg/kg following application @ 1 kg and 2 kg a.i/ha . The half life of pretilachlor was 11.98 days at lower rate of 1.0 and 16.8 days at higher rate of application of 2.0 kg/ha. The half life of pretilachlor when applied at recommended rate was shorter than when applied at double the recommended. The residues of pretilachlor in rice grain collected at harvest was below detectable level (BDL). The residues of pretilachlor were not found in grains or in soil at harvest time and were below the detectable limit and does not pose any residual problem or environmental polluation. Like grain samples, the soil samples at harvest were free from pretilachlor residues there by indicating that pretilachlor can safely be applied to rice crop as pre-emergence herbicide for controlling weeds.

Production and weed control of baby corn – ground nut crop sequence in soil solarization with tillage and moisture regime

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A field experiment was conducted for two consecutive years (2003 & 2004) to study the effect of soil solarization with tillage and moisture regimes on weed dynamics and yield of baby corn - groundnut crop sequence at the Agronomy Field Unit, Main Research Station, UAS, Bangalore under irrigated conditions. The experiment consisted of solarization during Apr – May followed by baby corn and ground nut crop sequence and has 18 treatments *viz.* three tillage treatments in main plot (one ploughing + harrowing, thorough land preparation and unploughed control) and six moisture regimes with solarization in sub plots (irrigation up to FC, 40 mm, 20 mm and control-dry for solarization with non-solarized weedy and weed free check) in split plot design with three replications. After harvest of baby corn, land was prepared with shallow digging and each plots were divided into two to study the residual effect of solarization on ground nut. These were super imposed with one hand weeding and unweeded control treatments.

Husked baby corn and fodder yield were superior with thorough land preparation (112.9 q ha^{-1} and 47.20 t ha^{-1}) followed by one ploughing + harrowing which were significantly superior over unploughed control. Among the sub plot treatments, significantly lower husked baby corn and fodder yield was noticed in non-solarized weedy check (93.8 q ha^{-1} and 36.73 t ha^{-1}) as compared to all other treatments. Solarization with irrigation up to FC recorded higher husked baby corn and fodder yield (116.8 q ha^{-1} and 49.89 t ha^{-1}) followed by 40 mm irrigation for solarization and weed free check. In groundnut, pod, kernel and haulm yield were significantly superior with residual effect of solarization with thorough land preparation (25.54, 18.06 and 28.39 q ha^{-1}, respectively), solarization with irrigation up to FC (26.40, 18.64 and 28.46 q ha^{-1}, respectively) and with one hand weeding treatment (24.14, 16.89 and 26.65 q ha^{-1}, respectively) among tillage, moisture regimes and weeding treatments.

Soil solarization with unploughed control treatment recorded significantly higher number (81.7 m^{-2}) and dry weight (6.91 g 0.25-m^{-2}) of weeds at harvest in baby corn than thorough land preparation and one ploughing + harrowing. Among moisture regimes with solarization, non-solarized weedy check recorded significantly higher number (135.4 m^{-2}) and dry weight (13.05 g 0.25-m^{-2}) of weeds over all other treatments. Weed free check recorded the lowest number of weeds followed by solarization with irrigation up to FC and 40 mm. Similar results were also noticed in ground nut.

It was inferred from the above study, that thorough land preparation and irrigation up to field capacity are essential before solarization. Under extreme conditions one ploughing + harrowing and 40 mm of irrigation are required for effective solarization to enhance the productivity in baby corn – ground nut crop sequence.

Studies on emergence profile of weeds and critical period of crop weed competition in summer sesame (*Sesamum indicum* L.)

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The field investigations were conducted during summer 2003 and 2004 under irrigated conditions in a sandy loam with pH 5.3, low in organic carbon, total nitrogen and available P and K at the Agricultural Farm of the Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal, to study the emergence profile of different categories of weeds as well as critical period of weed competition in sesame. The critical period of weed competition was determined taking ten treatments *viz.* weedy and weed free for first 15, 30 45, 60 DAS and upto harvest. The results revealed that the emergence of grassy weeds in sesame commenced first followed by broadleaved in both the years. The grassy weeds started to appear from 5 and 4 DAS whereas the broadleaved weeds from 10 and 6 DAS in 2003 and 2004, respectively. Two and three peak period of emergence occurred in grassy and broadleaved weeds, respectively. It appeared that the emergence of grassy weeds was more depended on soil moisture but that of broadleaved weeds were influenced both by soil moisture as well as temperature. *Digitaria sanguinalis* among the grasses and *Spilanthes acmella* among the broadleaved weeds remained most dominant through out the crop-growing period. It was revealed that the critical period of weed competition in sesame was between the periods from 15 to 45 DAS. However, the extrapolated critical period of weed competition was determined to be 19-40 DAS in 2003 and 20-42 DAS in 2004 respectively.

Does Triton X 200 surfactant behave like nano molecule in releasing of glyphosate into the cuticle?

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Triton X 200 having more hydrophilic head holds more glyphosate molecule having high water solubility nature. Further, this surfactant separates, disperse the molecule and release it for cuticle loading. More density of fine drops (750 micron) than single coarse drop (1750 micron) increased the surface contact area. Fine drops formation by narrow orifice nozzle with triton X 200 enhanced uptake of ^{14}C-glyphosate by 54- 190 percent in different weed species than coarse drop with glyphosate alone. Fine droplets known to dries out fast and triton X 200 form micelle, thus dried particle chemically react and micelle leads to nano-particle formation. Importance of fine particles increased uptake was discussed.

Utilisation of parhenium vermicompost as a nutrient source for irrigated maize - sunflower cropping system

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Parthenium hysterophorus, the obnoxious weed is widely distributed. It is found to be a rich source of nutrients. The thermoinsensitive herb is a prolific seed producer with seeds having long storage life and can quickly disperse through wind. Hence composting is recommended, as the seeds lose their viability due to the higher temperature during composting. To evaluate the efficiency of *Parthenium hysterophorus* as a source of nutrient to maize, an experiment was carried out in Tamil Nadu Agricultural University farm during 2005-2006. Four different composts of parthenium namely pit aerobic parthenium compost, pit anaerobic parthenium compost, heap anaerobic parthenium compost and parthenium vermicompost were evaluated for their efficiency on the productivity of maize. parthenium vermicompost at 5 t ha^{-1} with recommended NPK (135-625-50 kg NPK / ha)increased the yield attributes and yield in maize. Conjoint application of organics and inorganics (100 %NPK) sustained the soil fertility and improved the crop productivity. Among the organics greater increase was observed in parthenium vermicompost applied plots. The succeeding sunflower also responded well to the residual effect of parthenium vermicompost. The recommended dose of fertilizer (40:20:20 kg NPK /ha) nutrients applied to the succeeding sunflower resulted in higher productivity in parthenium vermicompost applied maize fields.

Effect of different planting geometry and weed management in transplanted rice

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A field experiment was conducted during *kharif* season of 2001, 2002 and 2003 at Rajendra Agricultural University, Pusa to find out the effect of different planting geometry and weed management on weeds and yield of transplanted rice. Weed management treatments reduced the weed density and weed try weight significantly than weedy check. Higher plant density (10 x 15 cm) recorded lower weed density and weed dry biomass, which was significantly superior to lower plant population. Significantly lower weed indices were recorded in all the weed control treatments over weedy check and gave higher grain yield than the weedy check. Higher weed control efficiency was recorded in higher plant geometry (10 x15 cm) and hand weeding treatments.

Effect of phosphorus and weed control measures on growth and yield of chickpea (*Cicer aeritinum* L.)

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A field experiment was carried out during *Rabi* season of 2005-06 at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology. The soil of the experimental field was silt loam in texture with pH 8.1, available N, P and K content was 165, 18 and 244 kg ha^{-1}, respectively. The experiment comprising 16 treatment combinations was laid out in randomized block design with 3 replications. The treatment consisted of 4 phosphorus levels (0, 20, 40 and 60 kg ha^{-1}) and 4 weed control measures (weedy check, hand weeding at 30 DAS, pendimethalin @ 1.0 kg ha^{-1} and rice straw mulch). Chickpea variety 'Udai" was sown on 11th October, 2005 with the spacing of 30 cm apart using 80 kg seeds ha^{-1}. A common dose of nitrogen at 20 kg ha^{-1} was applied through urea as basal and phosphorus applied as per treatment. Increasing level of phosphorus up to 60 kg ha^{-1} significantly increased all the growth characters, yield attributes and seed and straw yield, however, weed density and weed dry weight were decreased significantly with increasing levels of phosphorus up to 60 kg ha^{-1}. Among the weed control measures, hand weeding at 30 DAS significantly reduced the weed density and weed dry weight. Hand weeding at 30 DAS proved its superiority over other methods of weed control in respect of all the growth characters, yield attributes, seed and straw yield followed by pendimethalin @ 1.0 kg ha^{-1}.

Weed management in cropping sequence based on single and mixed crops

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An experiment was conducted during 2003-05 with single crop sequence of maize-wheat and soybean-Indian mustard, and with mixed-crop sequence of maize + soybean – wheat + Indian mustard under different weed control methods. The mixed-crop sequence proved most effective in reducing population of weeds (36.9 and 29.7%) and dry matter accumulation by weeds (43.8 and 39.1%) and increased net profit (128.3 and 29%) compared with single crop sequence of maize-wheat and soybean – Indian mustard, respectively. Application of metolachlor @ 0.75 kg ai/ ha pre-emergence in rainy season crops and pendimethalin @ 0.75 kg ai/ha pre-em. + isproturon @ 0.75 kg ai/ha post-em. in winter season crops showed 9.4% more control of weeds than the use of fluchloralin @ 1.25 kg ai/ha pre-plant incorporation in rainy-season crops and isoproturon @ 1.25 kg ai/ha post-em. in winter-season crops in all the years of experimentation. The treatment was comparable with that of weeding by grubber (15& 30 DAS) in minimizing density and dry weight of weeds and in increasing net profit.

A report on survey and biology of new occurrence of *Elatine triandra* and *Oryza rufipogon* in Gangetic Inceptisol

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A field survey was conducted in 15 villages of Inceptisol region during 2006-07 through farmers' participatory method by the research workers engaged in weed science. The survey revealed that *Elatine triandra* Schk. var *pedicellata* Krylov, Family Elatinaceae, in aerobic ecosystem and *Oryza rufipogon,* Family- Poaceae in anaerobic ecosystem have already invaded in this region alone with few other weed species like *Fimbristylis aestvalis, Cyperus microiria, Cyperus serotinus* (anaerobic) and *Sagittaria trifolia, Miscanthus sinensis, Conyza bonariensis, Bonnaya tenuifolia* etc. (aerobic) in this Inceptisol region of West Bengal.

According to farmers' opinion the *Elatine triandra* locally called BJP weed was occurred first during 2002 at village Kantabelia of district Nadia, West Bengal and the main source of occurrence was the soil of a branch canal of the river Jamuna which they were used during summer time in their field to increase fertility of soil. This is commonly found in vegetables plot and now has spread in nearby 8 villages. *Elatine triandra* is a dicotyledonous broadleaf annual with root length varies 3 cm to 6 cm. The stem 3-15 cm long, dichotomous, prostate, reddish purple in colour, succulent, soft and short internodes 4 - 6 mm; number of branches is varied from 3 -10 and each branch has 15 - 35 leaves. Leaves are lanceolate, opposite with short petiole and stipules, small flowers at axils. Moisture helps to propagate this plant by both seed and plant parts. The average fresh and dry weights are 12. 96 g and 5. 23 g , respectively. The wild rice *Oryza rufipogon* has been observed first during 2007 at Viswavidyalaya Farm, Kalyani, Nadia. It is almost phenotypically similar to cultivated rice. The former is now creating serious problems in different countries of Asia. If the infestation rate of a crop is 35% or more the average yield losses is to the tune of 60%. The scourge is commonly known by different names in various Asian countries, *viz.* Khao Nok (Thailand), Sharei (Korea), Jhora dhan (Bangladesh), Lua Lon (Vietnam), Padi Angin (Malaysia) or Akamai (Japan), etc. *Oryza rufipogon* , the identified wild rice has 15 tillers, average 12 panicles/ tiller , height 155 cm , length of panicle 22.5 cm and 86 grain per panicle. It is a host of rice bug, a serious insect pest in flowering stage of rice. In depth research study has been started with these species at both on station and on farm for details observation on competition and environment safe management practices.

Integrated weed management in brinjal

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A field experiment was conducted during rabi seasons of 2002-2004 at Marathwada Agrilcultural University, Parbhani to find the comparative performance of various methods of weed control in brinjal. The experiment was laid out in a randomized block design with three replications comprising of eight weed management treatments i.e., un-weeded control, 2 HW at 3 & 6 WAT, PE pendimethalin 1.0 kg/ha, PE pendimethalin 0.75 kg/ha + HW at 6 WAT, pre-planting application of fluchloralin 1.35 kg/ha, pre-plant application of fluchloralin 0.90 kg/ha & HW at WAT, PE oxyfluorfen 0.125 kg/ha & PE oxyfluorfen 0.100 kg/ha + HW at 6 WAT. The highest fruit yield of brinjal was observed with the application of pendimethalin @ 0.75 kg/ha + HW at 6 WAT. The lowest dry weed weight and highest weed control efficiency for grassy weeds and broad leaved was obtained under pendimethalin 0.75 kg/ha + HW at 6 WAP. The highest monetary returns were observed due to application of pendimethalin 0.75 kg/ha + HW at 6 WAT.

Considering pooled yield and higher net monetary returns for economic and efficient weed control in brinjal the PE- Pendimethalin 0.75 kg/ha followed by HW at 6 WAT or PE - Alachlor 1.5 kg/ha supplemented with HW at 6 WATP under labour shortage can be followed. Two hand weedings at 3 & 6 WATP can also be undertaken in easy availability of labourers.

Studies on herbicides applied with and without FYM on physico-chemical properties of soil and its residues in potato

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A field experiment was conducted at AICRP on Weed Control Farm, Anand to know persistence of fluchloralin and metribuzin applied with and without farm yard manure in sandy loam soil under potato crop. The soil of the experimental field was sandy loam having pH 8.18 with 0.020 % nitrogen, 68 kg P_2O_5/ha and 360 kg K_2O/ha. Fluchloralin (1.00 kg/ha) and metribuzin (0.35 kg/ha) were applied as pre-plant in potato field. Fluchloralin residues were lower at all the intervals under the fluchloralin applied with 10 t FYM/ha as compared to fluchloralin applied alone. Total population of bacteria and fungi were higher in fluchloralin applied at 1.00 kg/ha enriched with 10 t FYM/ha as compared to fluchloralin applied alone. Bacterial population was significantly suppressed by application of herbicides at one and seven days after spraying, while fungal population was significantly suppressed upto fifteen days after application. Soil pH, electrical conductivity, available phosphorus and available potassium were not significantly influenced by application of fluchloralin or metribuzin applied alone or with 10 t FYM/ha. The nitrogen content was recorded significantly highest with application of fluchloralin enriched with 10 t FYM/ ha. The tuber yield of potato was not significantly influenced by various weed management practices.

Economical and sustainable weed management of graminaceous weeds in mango and cashew nut orchards

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Mango and cashew nut are commercial rainfed crops of *Konkan* region, which saw significant area expansion by 3.2 and 2.6 times during the decade ending 2001 due to successful implementation of EGS. After establishment of orchards and destruction of perennial weedy vegetation, an annual graminaceous weed *Themeda quadrivolus* grows vigorously during every *Kharif* season and is generally cut by farmers as dry fodder during winter months. However, due to scarcity of labours for covering extensive areas and high recurring costs, grass cutting delayed to summer when many cases of fire hazards to orchards occur all over *Konkan* damaging large areas of orchards and forests every year. Moreover, grass weeds compete for applied nutrients and pose problem in picking up matured cashew nuts.

Therefore, to find out effective and economical weed control method various chemical and mechanical measures as also animal grazing as one of the treatments were tried at the College of Agriculture, *Dapoli* Dist. *Ratnagiri* and Agricultural Research Station, *Phondaghat* Dist. *Sindhudurg*. Three years pooled results of this investigation revealed that, mechanical methods of weed control were most effective exhibiting WCE of 74.5-81% followed by animal grazing (70%). Amongst chemical measures, *glyphosate* spray @ 1 kg ha^{-1} 3 months after onset of monsoon exhibited higher WCE (54%) as compared to parquat sprays (45%). Though herbicides suppressed growth of grasses, it was accompanied with simoultaneous increase in growth of BLWs like *Hyptis suaveolens*, *Mimosa pudica*, *Urena, lobata*, *Triumfetta rhomboidea Impatiens balsamina* which are not browsed by cattles and thus cannot be used as fodder. It is thus evident that animal grazing is effective, economical, sustainable and socially acceptable method which can be used for unmanageable areas where timely grass cutting cannot be followed.

Pusa protocol for Parthenium management-2008

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Pusa Protocol for Parthenium Management-2008 (PPPM-2008) is an outcome of Department of Biotechnology, Govt. of India's sponsored project developed and executed at the Indian Agricultural Research Institute, commonly known as Pusa, which is located at Delhi. It comprises simple operational bio-intensive strategies incorporating the blend of effective and possible integrated Parthenium Management options aimed for non-cultivable land. These options are self-perpetuating in nature, ecologically safe, sustainable and provide fuel for the poor as well as feed for the animals, besides suppression of *Parthenium hysterophorus*. Integration of two biological control agents *viz;* botanical (*Kochea indica*) and insect (*Zygogramma bicolorata*) along with judicious mix of cultural and mechanical control methods are recommended in such a way that these become complimentary to each other for effective *P. hysterophorus*. Nucleus of both biocontrol agents have been shared with several biologists/ environmentalists in the country interested for the containment of exotic and pernicious weed. Survey conducted during 2007 reveals that all the Parthenium affected areas are under the pressure of *K. indica* and *Z. bicolorata* while weed is reduced to less than 15 per cent as against 2004.

The details will be discussed during the presentation in the symposium based on the opportunity and the poster will be presented depicting the major components and activities detailed below:

Pusa Protocol for Parthenium Management -2008

Months	MAJOR ACTIVITY	REMARKS
January	Conservation of beetles at moist sites	Parthenium may be planted
February	Mechanical uprooting of Parthenium	Mainly scanty plants
March	Monitoring bioagents (*Kochea* & *Zygo.*)	Documentation of story
April	Shifting of beetles from moist places	Parthenium may be planted
May	Multiplication of beetles in Entocool	On Parthenium biomass
June	Training to Parthenium activists	Commun.health check up
July	10-15% Na Cl (salt) spray, uprooting	In absence of bioagents
August	Shifting of beetles from hot spots-new	Community involvement
September	Harvesting of *K. indica* seed	Nucleus may be obtained
October	Harvesting/spread of *K. indica* seeds	On un used land
November	*Kochea* transplanting if seedling is available	On borders/channels, dry stem collection for fuel
December	Training: Parthenium menace, *Zygo* & *Kochea* conservation & enhancement	Through IARI/trained person on module

Management of Monocot weeds by Targa Super 5 EC (Quizalofop ethyl) and Wrap-up 10 EC (Cyhalofop butyl) - post emergence herbicides

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Monocot weeds are a serious problems in most of the crops, specially of Kharif crops like Soybean, Pulses, Oilseeds, Rice, etc. and these weeds, because of congenial agro-climatic conditions for growth, reduce yields considerably. Dhanuka Agritech Limited, dealing in plant protection chemicals, have introduced two post emergent, systemic herbicides, Targa Super 5 EC and Wrap-up 10 EC for the control of monocot weeds in different crops.

Targa Super 5 EC containing Quizalofop ethyl has been introduced by Dhanuka Agritech Limited in technical collaboration with M/s. M/s. Nissan Chemical Industries Ltd., Japan, for the control of monocot weeds in different crops and vegetables. Targa Super 5 EC is a selective, post emergence, systemic herbicide, which can be used after 15 to 30 days of sowing for the control of dreaded monocot weeds like Echinocloa sp., Digitaria sp., Dinebra sp., etc. Targa Super 5 EC successfully controls tough perennial weeds also like Hemarthria compressa, Sorghum halepense, Saccharum sp., etc. Because of its strong systemic action, Targa Super 5 EC have even successfully kills roots of perennial weeds. For the control of annual weeds Targa Super 5 EC should be used @ 750-1 l/ha and for the control of perennial weeds it should be used @ 1.5-2 l/ha. Targa Super 5 EC can be used on most of the crops, except graminaceous crops like Wheat, Rice, Maize, Sorghum, Barley and Sugarcane. Our in-house research experiments showed a strong synergy between Quizalofop ethyl (@ 750 ml/ha) and Oxyfluorfen (@ 190 ml/ha) for the control of both types (narrow and broad leaf) weeds in Onion and Garlic and Quizalofop ethyl (@ 750 ml/ha) + Chlorimuron ethyl (@ 37.5 g/ha) for the control of narrow and broad leaf weeds in Soybean.

Dhanuka Agritech Limited also introduced Wrap-up 10 EC containing Cyhalofop butyl for the control of monocot weeds like Echinocloa sp., Digitaria sp., Dinebra sp., etc. in Rice. Wrap-up 10 EC should be used in nursery to control the monocot weeds @ 5 ml/l of water and also in direct sown Rice @ 500ml/ha, 15-20 days after sowing or 3-4 leaf stage of grassy weeds. Wrap-up is a selective and systemic herbicide. The mortality of weeds normally occurs after 12-15 days of application of Wrap-up 10 EC.

Both the products, Targa Super 5 EC and Wrap-up 10 EC belongs to Aryloxyphenoxy-propionate'FOPs' group of herbicides and inhibit acetyl coenzyme A carboxylase (ACCase) enzyme resulting into the killing of monocot weeds.

P-1 Effect of weed management methods on weed flora density and dry matter production in wet seeded rice

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The field experiment was conducted in wet seeded rice to evaluate the efficacy of pre-emergence herbicides (pretilachlor plus and butachlor) applied in three different times (one week before sowing (WBS); two weeks before sowing and as pre-emergence after sowing) followed by two post emergence operations (one hand weeding on 40 DAS and post-emergence of 2,4-D on 30 DAS) in two seasons *viz.*, late *rabi* and *kharif*, 2004 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. The treatment consisted of three factors (herbicides, time of application and post-emergence operations) formed twelve treatments and compared with hand weeding twice (20 and 40 DAS) and unweeded control making total of 14 treatments. The treatments were replicated thrice in a randomized block design. The recommended fertilizer dose of 125:38:38 kg ha^{-1} were applied in all treatment plots.

The weed flora of the experimental field was dominated by grasses (56.50 and 53.34 %), the sedge weeds (35.30 and 38.10 %) and broad-leaved weeds (8.20 and 8.56 %). Among the herbicide treatments, pretilachlor plus 0.3 kg ha^{-1} at 3 DAS fb. HW at 40 DAS was very effective in reducing the density of *Echinochloa colona*, *Leptochloa chinensis*, *Echinochloa crus-galli*, *Cyperus rotundus*, *Cyperus difformis* and other weed spp. It markedly suppressed the total weed density (0.01 and 1.62 m^{-2}), weed DMP (0.01 and 1.78 g m^{-2}) at harvest with the highest WCE (99.95 and 93.46 %) during late *rabi* and *kharif* seasons 2004, respectively against unweeded control. Chemical weed control with pre-emergence application of either pretilachlor plus 0.3 kg ha^{-1} or butachlor 1.25 kg ha^{-1} even when followed by post-emergence application of 2,4-D (1.25 kg ha^{-1}) on 30 DAS also satisfactorily controlled the weed growth to certain extent in wet seeded rice. Promotion of growth and yield attributes was found superior by the application of pretilachlor plus 0.3 kg ha^{-1} at 3 DAS fb. HW at 40 DAS and it reflects on grain yield improvement by 98.1 and 95.6 per cent during late *rabi* and *kharif* seasons, 2004. The grain yield of rice was increased (4910 and 5325 kg ha^{-1}) followed by HW twice (4728 and 5111 kg ha^{-1}) during late *rabi* and *kharif* 2004, respectively. Significantly negative correlation was observed between weed attributes and grain yield, whereas, positive correlation was observed between crop DMP, yield attributes and grain yield in both the seasons. The pre-emergence application of pretilachlor plus 0.3 kg ha^{-1} on 3 DAS fb. one HW on 40 DAS is the most effective weed management practice for achieving higher grain yield through effective control of weeds in wet seeded rice under puddle condition.

P-2 Bio-efficacy of orthosulfamuron for weed management in lowland rice in southern Karnataka

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A field study was conducted on sandy clay loam soil at Kathalagere (Bhadra command area of Southern transition zone of Karnataka) during summer and *kharif* 2006 for bio-efficacy, phytotoxicity and yields of lowland rice in a broad spectrum new herbicide, orthosulfamuron (IR 5878 50% WG). Orthosulfamuron was evaluated at 35 to 150 g/ha as pre-emergence (3 DAP) and early post-emergence (12 DAP) in relation to hand weeding (20 & 40 DAP), butachlor 1.25 kg ai/ha – 3 DAP, oxadiargyl 80 g ai/ha at 6 DAS and unweeded control. The major weed flora observed in the experimental fields were, *Fimbristylis miliacea, C. difformis* and *Scirpus* sp (from initial stages), *C. procerus* (from 60 DAP onwards) (among sedges); *Panicum tripheron, E. colona* (from initial stages), *Echinochloa glabrascens* (nearing harvest) (among grasses); *Ludwigia parviflora, Rotala verticillaris, Dopatrium junceum, Glinus oppositifolius* (from 30 DAP), *Spilanthus acmella* (60 DAP onwards), *Eclipta alba,* (from 60 DAP onwards) (among broad leaves weeds). Use of orthosulfamuron at 60 to 75 g ai/ha as pre-emergence and at 75 to 120 g/ha as early post-emergence at 12 DAP lowered the dry weight of sedges, grasses and broad-leaved weeds considerably and compared similar to hand weeding (20 & 45 DAP) and butachlor 1.25 kg ai/ha. The new molecule did not show phytotoxicity at doses of 60 to 75 g/ha as pre-emergence and early post-emergence.

Use of Orthosulfamuron at 60 to 120 g/ha was effective against sedges (*Cyperus iria, Scirpus* sp, *C. difformis* and *F. miliacea* initially), grasses (*E. glabrascens, E. colona*) and broad leaf weeds (particularly *Ludwigia parviflora, R. verticillaris, D. junceum*) in rice. Orthosulfamuron at 60 to 75 g/ha as pre-emergence at 3 DAP was very effective in controlling sedges, grasses and broad leaf weeds and resulted in rice yields (4570 to 5151 kg/ha) similar to hand weeding twice (4882 kg/ha), and other herbicide- butachlor 1.25 kg/ha at 3 DAP (4523 kg/ha) and oxadiargyl 80 g/ha – 6 DAP (4303 kg/ha). Unweeded control lowered the rice yield by 48% as compared to hand weeding twice. Thus, orthosulfamuron 50% WG at 60 to 75 g/ha as pre-emergence at 3 DAP can be recommended for broad spectrum weed control in lowland rice.

P-3

Long term effect of herbicides on weed shift and sustainable yields of rice – rice system under lowland conditions in southern Karnataka

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A field study was conducted on sandy clay loam soil at Kathalagere (Bhadra command area of Southern transition zone of Karnataka) during 1999 to 2006 in lowland rice – rice system to know the effect of continuous use of weed control treatments on weed shift, crop growth and yields. Three weed control treatments namely butachlor 0.75 kg + 2, 4-D EE 0.4 kg ai/ha (3 DAP, applied in sequence) both during *kharif* and summer, butachlor 0.75 kg + 2, 4-D EE 0.4 kg ai/ha (3 DAP) during Kharif and pretilachlor 0.75 kg ai/ha (3 DAP) during summer, and farmers' practice of hand weeding twice (20 and 45 DAP) during both the seasons of Kharif and summer were compared at two sources of fertility levels – 100% NPK supplied through fertilizers only (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) and combination of 75% NPK + FYM (10 t/ha). Major weed flora observed in the experimental plots was *Cyperus iria*, *Scirpus* sp (from initial stages), *C. difformis*, *Fimbristylis miliacea* (from 60 DAP), *C. procerus* (nearing harvest) (among sedges); *Panicum repens, Echinochloa colona* (from initial stage), *Panicum tripheron* (from 60 DAP) (among grasses); *Ludwigia parviflora, Lindernia veronicaefolia, Alternanthera sessilis* (from initial stage), *Eclipta alba, Lobelia olecinoides* (from 60 DAP), *Glinus oppositifolius* and *Spilanthus acmella* (nearing harvest, among broad leaf weeds). Continuous use of butachlor + 2, 4-D EE during *kharif* and summer paved way for increase in the density of sedge (particularly *Fimbristylis miliacea* and *Cyperus iria,* three times higher (in 2002 summer as compared to 1999 Kharif), where as alternate use of butachlor + 2,4-D EE during Kharif and pretilachlor in summer lowered the density of sedges. While such increase was two fold in grasses' density in the former treatment as compared to latter treatment. This suggested that continuous use of butachlor + 2,4-D EE paved way for build up of sedges and grasses and rotation with pretilachlor lowered the density of both weeds' category.

Averaged over fifteen seasons, the rice yield in butachlor 0.75 kg + 2,4-D EE 0.4 kg/ha – 3 DAP during Kharif followed by pretilachlor 0.75 kg/ha -3 DAP during summer gave similar yield (4768 kg/ha) as that of hand weeding twice (4740 kg/ha), but slightly higher than the use of butachlor 0.75 kg + 2,4-D EE 0.4 kg/ha – 3 DAP both during *kharif* and summer (4594 kg/ha). This indicates that use of same kind of herbicide slightly lowered the rice yields owing to lack of control of weeds particularly during summer.

Thus study indicated that use of same kind of herbicide paved way for build up of weeds that are not controlled in rice – rice system. The beneficial effect of FYM on yield of rice was visualized in later seasons of the trial.

P-4 Bio-efficacy evaluation of combination of bensulfuron methyl + pretilachlor 6.6% granules for broad spectrum weed management in lowland rice

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A field study was conducted on sandy clay loam soil at Kathalagere (Bhadra command area of Southern transition zone of Karnataka) during summer and Kharif 2006 for bio-efficacy and phytotoxicity due to new herbicide mixture, bensulfuron methyl + pretilachlor 6.6% G for broad spectrum weed control yields of lowland rice. The herbicide mixture, bensulfuron methyl at 52.5 to 60 g + pretilachlor and at 525 to 600 g/ha (6.6% G mixture at 8.75 to 10.0 kg/ha) as pre-emergence (3 DAP) was compared with hand weeding (20 & 40 DAP), butachlor 2.0 kg ai/ha – 3 DAP, pretilachlor 600 g/ha – and bensulfuron methyl 60% DF at 60 g/ha (all as pre-emergence, 3 DAP) and unweeded control. The major weed flora observed in the experimental fields were *Cyperus difformis, Fimbristylis miliacea* and *Scirpus* sp (from initial stages), *Cyperus procerus* (from 60 DAP onwards) (among sedges); *Echinochloa colona* and *Panicum tripheron* (from initial stages), *Echinochloa glabrascens* (nearing maturity) (among grasses); *Ludwigia parviflora, Spilanthus acmella, Rotala verticillaris, Lindernia veronicaefolia, Glinus oppositifolius* (from initial stages), *Eclipta alba* (nearing maturity) (among broad leaf weeds).

The study indicated that use of bensulfuron methyl 52.5 to 75 g + pretilachlor 525 to 750 g/ha (6.6%G) at 3 DAP was found effective against sedges, grasses and broad leaf weeds and resulted in rice yields (5424 to 5604 kg/ha) which was similar to hand weeding twice (5371 kg/ha), and other standard herbicides- pretilachlor 600 g ai/ha (5296 kg/ha) and butachlor 2.0 kg ai/ha at 3 DAP (4911 kg/ha). Use of bensulfuron methyl alone at 60 g/ha was effective against sedges (*Cyperus iria, C. difformis* and *Scirpus* sp initially) and broad leaf weeds (particularly *Ludwigia parviflora*) in rice, but gave slightly lower rice yield (4682 kg/ha) owing to lack of control of grasses. Combination of bensulfuron at 52.5 to 75 g + pretilachlor 525 to 750 g/ha (6.6%G) was good against broad leaf weeds like *Glinus oppositifolius, Ludwigia parviflora, Spilanthus acmella* and *Lindernia veronicaefolia*; grasses *(Echinochloa colona)* and sedges (*Cyperus difformis, Fimbristylis miliacea* and *Scirpus* sp) from initial stages. The crop did not show phytotoxicity due to the use of herbicide mixture at 8.75 to 10.0 kg/ha in lowland rice. Unweeded control lowered the yield of rice by 46% owing to competition from weeds particularly sedges and broadleaf weeds.

P-5

Bio efficacy evaluation of doses of anilofos 30% granules for weed management in transplanted rice

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A field study was conducted on sandy clay loam soil at Kathalagere (Bhadra command area of Southern transition zone of Karnataka) during Kharif 2006 for bio-efficacy, phytotoxicity and yields of lowland rice with the use of anilofos 30% G. The new formulation of anilofos 30% Granules at 300 to 600 g/ha with and without emulsifier was compared to work out the optimum dose for its bio-efficacy in transplanted rice in relation to standard herbicide – anilofos 30% EC and farmers' practice of hand weeding. The major weed flora observed in the experimental fields were *Cyperus difformis, C. procerus* and *Scirpus* sp, *Cyperus iria* (among sedges); *Echinochloa colona, E. glabrascens* (among grasses); *Ludwigia parviflora, Glinus oppositifolius, Eclipta alba, Rotala verticillaris, Lindernia veronicaefolia, Spilanthus acmella* and *Dopatrium junceum* (among broad leaves weeds). Use of anilofos 30% G at 300 to 600 g/ha (both with and without emulsifier) lowered the density of sedges, grasses and broad-leaved weeds considerably and comparable equal to that of hand weeding and anilofos 30% EC at 300 to 450 g/ha.

Rice yields in plots treated with anilofos 30% G with emulsifier at 300 to 450 g ai/ha (4658 to 5483 kg/ha), anilofos 30% G without emulsifier at 300 to 450 g ai/ha (4422 to 4913 kg/ha) gave paddy yields similar to plot treated with hand weeding twice (5188 kg/ha) and anilofos 30% EC at 300 to 450 g ai/ha (4717 to 4795 kg/ha). Thus, use of anilofos 30% G at 300 to 450 g ai/ha was effective against sedges (*Cyperus iria, C. difformis* and *Scirpus* sp initially), grasses (*Echinochloa colona*), and broad leaf weeds (particularly *Ludwigia parviflora, Glinus oppositifolius* and *Lindernia veronicaefolia*) in rice and compared similar to anilofos 30% EC at 300 to 450 g ai/ha. Unweeded control lowered the yield by 53.8% owing to competition from weeds particularly sedges and broad leaf weeds. The anilofos 30% G with and without emulsifier at 300 to 450 g ai/ha did not cause epinasty and hyponasty symptoms expressed on the plants, necrotic symptoms on the leaves, vein clearing, and wilting and resetting symptoms in the rice plants.

P-6

Effect of seeding methods and weed control practices on weed growth and yield of direct seeded rice under upland situations

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The productivity of upland rice in Assam is very low (974 kg ha^{-1}). Heavy weed infestation is one of the major factor limiting the productivity of upland rice. Herbicides alone many a times failed to give satisfactory control of weeds. Integration of cultural methods with herbicides may provide effective control of weeds. Field experiments were conducted during summer 2005 and 2006 at the research farm of the university, Jorhat. Treatments comprised of seeding methods viz., direct seeding 80 kg ha^{-1}, direct seeding 80 kg ha^{-1}+ sesbania and broadcasting 100 kg ha^{-1} and weed control practices viz., fenoxaprop 70 kg ha^{-1}, pretilachlor 0.75 kg ha^{-1} + safener and control (Weedy check). Rice variety 'Luit' was sown as per treatment. The treatments were arranged in a split plot design replicated thrice.

The major weed flora observed in the experimental field were grasses -*Eleusine indica, Isahcne himalaica, Cynodon dactylon, Leersia hexandra* broad leaved- *Ageratum conyzoides, Commelina diffusa* and sedges *Cyperus iria, C. halpan* etc.

Results showed no significant influence of seeding methods on weed dry matter accumulation. All the weed control practices significantly reduced the weed dry weight over unweeded control. Among the weed control treatments pretilachlor 0.75 kg ha^{-1} + safener resulted in the lowest weed dry weight during both the years of study. Hand weeding twice (20 & 40 DAS) recorded significantly lower weed dry weight than fenoxaprop 70 g ha^{-1} in the first year of study while, it was statistically at par with fenoxaprop 70 g ha^{-1} during the second year of study. The highest grain yield during both the years of study was recorded with the application of pretilachlor 0.75 kg ha^{-1} followed by the treatment with hand weeding twice.

P-7 Effect of long term application of herbicides on soil microbial activity, enzyme activity, soil properties and nutrient availability in a rice-groundnut cropping system in coastal Orissa

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The field experiment in long term herbicidal trial on rice-groundnut cropping system was conducted at the Central Research Station, OUAT, during 2002-2005. The treatment allotted to the kharif rice (main plot) were : T1 – Hand weeding twice + organic matter + inorganic fertilizer, T2 – Hand weeding twice + organic matter + inorganic fertilizer (N adjusted), T5 – T3 rotated with pretilachlor 0.75 kg/ha, T6 – T4 rotated with pretilachlor 0.75 kg/ha. The treatments in rabi groundnut (sub-plot) were : H0 – hand weeding at 24 DAS + earthing at 40 DAS, H1 – alachlor 1.0 kg/ha at 3 DAS. The cultivars taken are Khandagiri in rice and Smruti in groundnut and the fertilizer doses in rice and groundnut were 60:30:30 and 20:40:40, respectively. *Sesbania aculeate* @ 6 t/ha has been incorporated as the source of organic matter before sowing of kharif rice. The soils of the study area are sandy loam in texture with pH of 5.4, low in available N, medium in available P and K. Application of herbicides to rice significantly reduced some of the microbial attributes like fungal and bacterial population by 6.1 to 10.0 per cent and 6.8 to 13.3 per cent, respectively. Addition of organic matter (*Sesbania aculeate* incorporation) enhanced the bacterial and fungal population by 15.1% and 10.4%, respectively. The treatments in respect of microbial population were in order : hand weeding (twice) > butachlor .75 kg/ha + 2, 4-DEE 0.4 kg/ha > butachlor + 2, 4-DEE in rotation with pretilachlor 0.75 kg/ha. Application of alachlor 1.0 kg/ha to groundnut however, enhanced the microbial population (bacteria 15.1% and fungi 10.4%). In general, an increasing trend in microbial population and enzyme activities were observed since the initial year of study (2002-03), particularly in the treatment with the incorporation of *Sesbania aculeate*, thereby indicating the stabilizing effects of organic matter on soil microbes. Addition of organic matter did not influence the BD, pH, OC and available nutrients. However, the available nutrient status of the soils showed an increasing trend over the years in treatments with organic matter, which justifies the role of organic matter in stabilizing soil properties. Application of herbicides in conjunction with organic matter improved soil fertility through better microbial activity.

P-8 Performance of different weed control measures in rice-groundnut cropping system in red and lateritic soil of coastal Orissa

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Field experiment was undertaken in rice-groundnut from 2002-03 to 2004-05 in the Research Farm of Agronomy, Department OUAT, Bhubaneswar, comprising of six main plot treatments to rice (T_1-ardweeding (twice)- organic matter incorporated @ 6 t/ha. of *Sesbania aculeatia* (OM) + inorganic fertilizers, T_2 – hardweeding (twice) + OM + inorganic fertilizer (N adjusted), T_3 – butachlor 0.75 kg/ha + 2,4 DEE 0.4 kg/ha – OM + inorganic fertilizer, T_4 – butachlor 0.75 kg/ha + 2, 4 DEE 0.4 kg/ha + OM + inorganic fertilizer (N adjusted), T_5 – T_3 rotated with pretilachlor 0.75 kg/ha and T_6 – T_4 rotated with pretilachor 0.75 kg/ha and three sub-plot treatments to groundnut (H_1 – Hand weeding at 25 DAS and hoeing at 40 DAS, H_2 – alachlor 1.0 kg/ha and H_3 – trifluralin 1.0 kg/ha. The rice (cv. Khandagiri) and groundnut (cv-smruti) was fertilized with 60:30:30 and 20 : 40 : 40 kg of N, P_2O_5 and K_2O per hectare, respectively. The soil was sandy loam with pH of 5.6. The available N,P,K of the soil was 170, 21 and 140 kg/ha, respectively. The results revealed that hand weeding (twice) coupled with integrated N nutrition to rice followed by hand weeding (25 DAS) + hoeing (40 DAS) in groundnut registered the highest REY of 11, 242, kg/ha as compared to other treatments, butachlor 0.75 kg/ha + 2,4 – DEE along with inorganic fertilizer (excluding O.M.) recorded reduced weed densities (48.0/m^2) as compared to the rest of the treatments. Application of organic matter to rice though increases weed population marginally was found effective in enhancing the pod yield of groundnut. A decreasing trend in weed categories were noticed in rice-groundnut system over the years irrespective of various weed control measures. Application of alachlor @ 1.0 kg/ha to groundnut was found to be superior to other weed control measures in terms of yield and weed control. *Celosia argentea* appeared regularly in trifluralin applied plots and conspicuously absent in alachlor treated plots during rabi season.

P-9 Integrated weed management in aerobic rice (*Oryza sativa* L.) in Cauvery command area

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A field experiment was conducted in farmer's field at Goravanahalli village, Maddur taluk, Mandya district during *kharif*, 2006 under irrigated condition on sandy loamy soil. There were 13 treatments laid out in randomized complete block design with three replication using KRH-2 Hybrid. Application of butachlor @ 1.0 kg ha^{-1} + two hand weeding at 20 and 40 DAS (7.00 to 8.66 m^{-2} and 2.73 to 5.28 g m^{-2}) significantly reduced the population and dry matter of weeds and was at par to weed free have to lec fille. A Higher grain yield and straw yield was recorded with weed free check (65.93 q ha^{-1} and 7.15 t ha^{-1}) which was followed by integration of butachlor @ 1.0 kg ha^{-1}+ two hand weeding at 20 and 40 DAS (63.98 q ha^{-1} and 7.05 t ha^{-1}). Combination of herbicides *viz.*, Butachlor @ 1.0 kg ha^{-1} at one DAS+ 2, 4-DEE @ 1.0 kg ha^{-1} at 20 DAS was intermediate in grain and straw yield. Higher grain and straw yield was attributed to increase in growth, yield parameters *viz.*, plant height , number of tillers, leaf area, leaf area index (LAI), total dry matter production, number of productive tillers $hill^{-1}$, panicle length, weight of panicle, filled spikelets per panicle, 1000 grain weight and lower sterility per cent . The highest net returns was obtained with the application of butachlor @ 1.0 kg ha^{-1}+ two hand weeding at 20 and 40 DAS (Rs. 29,265 ha^{-1}) followed by weed free check (Rs. 27,954 ha^{-1}). Maximum profit per rupee invested was achieved with butachlor @ 1.0 kg ha^{-1}+ two hand weeding at 20 and 40 DAS (2.88).

P-10 Efficiency evaluation of mechanical weedrs in wet seeded lowland rice

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Weed infestation continues to be a serious problem in wet seeded rice. Timely weed control is crucial to increase rice productivity. A field experiment was conducted during *kharif* 2006 to find the suitable hand operated weeders with combination of herbicide application in wet seeded low land rice as treatment. Hand weeding twice on 25 and 45 DAS, PE pretilachlor 0.45 kg/ ha on 3 DAS + HW on 40 DAS, Weeding with cono weeder finger type, single / double / three row rotary weeder, roto puddler, roto cylindrical weeder, rotao puddler with and without cutting edge on 25 and 45 DAS or in combination with herbicide on 45 DAS were compared in RBD with replications. All the weed control treatments significantly reduced weed density and their dry weight at 30 and 60 DAS. Pre-emergence application of pretilachlor 0.45 kg/ha on 3 DAS + rotoncylindrical weeder weeding on 45 DAS resulted in the least total weed density and weed dry weight at 30 and 60 DAS. Higher grain yield, net monetary return and B:C ratio was obtained in pre-emergence pretilachlor 0.45 kg/ha on 3 DAS + rotoncylindrical weeder weeding on 45 DAS in wet seeded rice.

P-11 Bio-efficacy and phytotoxicity of ethoxysulfuron in transplanted *kharif* rice

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Experiment was conducted on gangetic alluvial soil with nine treatments viz. (1-4) ethoxysulfuron 60WG @ (1) 15g/ha ; (2) 17.50g/ha; (3)20g/ha ; (4) 40g/ha ; (5) ethoxysulfuron 15WP @ 18.75g/ha ; (6) almix 20WP@ 4g/ha all at 15DAT (7) 2,4 –DEE 38EC@400g/ha at 20DAT(8) Hand weeding twice at 20 and 40DAT and (9) unweeded control replicated thrice to study the bio-efficacy and phytotoxicity of ethoxysulfuron in kharif rice - 2006. Predominant weeds were *Cynodon dactylon , Echinochloa crusgalli, E. colona , Cyperus iria, C. difformis,Fimbristylis littoralis, Alternanthera philoxeroides, Ludwigia parviflora, Ammania baccifera and Marselia quardifolia.*

Result revealved that hand weeding twice gave highest grain yield (5.08t/ha) which did not differ significantly with treatments almix 20 @ 4g/ha(5.01t/ha) and ethoxysulfuron at all doses except at 15g/ha and 17.50g/ha all applied as post-emergence. Minimum weed index (1.37) was recorded with almix 4g/ha treatment which proved its efficiency (90.44%) in controlling weeds and recorded less weed population (33.66/m^2) as well as less weed biomass (4.45g/m^2). Regarding benefit:cost ratio , highest value (1.41) was obtained with same treatment in comparison to hand weeding treatment. Though ethoxysulfuron at highest dose showed some injury like stunting growth and discolouration of leaves, it recovered however, later on. Hence, no phytotoxic effect on the crop for the applied herbicides was observed. So, almix 20WP @4g/ha as post-emergence can profitably replace the tedious, time consuming and expensive hand weeding practice. Even ethoxysulfuron except at 15g/ha and 17.50g/ha dose as post-emergence are also effective.

P-12 Efficiency evaluation of mechanical weeders in transplanted rice

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Weeds are considered to be one of the major yield limiting factors due to manifold harmful effects in rice. The study was conducted in transplanted rice with the objectives to evaluate the weed control efficiency of manually operated mechanical weeders in transplanted rice and to evaluate different mechanical weed control methods in lowland transplanted rice. Hand weeding twice on 20 & 40 DAT, PE butachlor 1 kg /ha on 3 DAT + HW on 40 DAT, weeding with conoweeder, finger type single / double / three row rotary weeder, roto puddler weeder, roto cylindrical weeder, roto puddler weeder without cutting edge alone on 20 & 40 DAT or in combination with chemicals on 40 DAT were compared with unweeded control in RBD experinment with three replication in transplanted rice during *Kharif,* 2006.

At 60 DAT, WCE was higher in plot applied with PE herbicide followed by weeders using finger type double row rotary weeder. Grain yield was higher in plots applied with pre-emergence herbicide butachlor 1kg/ha followed by weeding using finger type single row and double row rotary weeders. Among the different hand operated weeders evaluated finger type single and double row rotary weeders were found to be efficient in weed control, convenient to the operators, less labour involved and resulted in higher grain yield and net profit. If pre-emergence herbicide is to be avoided then finger type single/ double row rotary weeders can be used twice (15-20 DAT and 35-40 DAT). It is essential to remove the weeds left over in between the plants manually.

P-13 Effect of herbicides on population dynamics of soil microflora in direct seeded rice

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The field experiment was conducted during the *kharif* season of 2007-08 at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) to study the effect of herbicides on population dynamics of soil microflora in direct seeded rice. Soil at the test site was silt loam, with pH 8-10, 0.35% organic carbon, available NPK 168.5, 18.7 and 247 kg ha^{-1}, respectively. The experiment was laid out in a randomized block design with four weed management practices (weedy check, mechanical weeding (2), butachlor @ 1.5 kg ha^{-1} and anilofos @ 0.5 kg ha^{-1} + followed by one hand weeding at 40 DAS each. The treatments were replicated three times. The herbicides were applied as pre-em. at 3 DAS. Recommended dose of NPK (120:60:60) were applied. Maximum number of microbial population (bacteria, actinomycetes and fungi) in direct seeded rice soil were observed under mechanical weeding followed by butachlor, anilofos and weedy check but differences were non significant.

P-14 Efficiency of pretilachlor (Erijan 40 EW) on weeds and productivity of transplanted rice

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Field experiment was conducted during *kharif*, 2006 at Tamil Nadu Agricultural University, Coimbatore, to evaluate the bio-efficacy, method of application and compatibility of new herbicide formulation of pretilachlor (Erijan 40 EW) in transplanted rice ecosystem. The trial was laid out in a randomized block design with ten treatments in three replications. The treatments consisted of three doses (1250, 1500 and 1875 ml/ha) of new herbicide formulation Erijan 40 EW (pretilachlor) with two methods of application viz., splash pack and spray compared with recommended dose of Rifit 50 EC (pretilachlor), Machete 50 EC (butachlor) and Topstar 80 WP (oxadiargyl) @ 1250, 2500 ml and 125 g /ha respectively as well as with unweeded control.

Erijan spray at 1875 ml/ha was found to be effective in controlling weeds and it was followed by Erijan splash at 1875 ml/ha and Rifit spray at 1250 ml/ha. Between the two methods of application of Erijan 40 EW (pretilachlor), spraying method of application was more effective in containing weed density than splash method. Spraying method of application Erijan 40 EW (pretilachlor) at 1875 ml/ha reduced weed dry weight considerably with better weed control efficiency. No phytotoxic symptoms were observed even in the higher dose of Erijan 40 EW (pretilachlor) at 1875 ml/ha, in transplanted rice. Spraying method of application of Erijan 40 EW (pretilachlor) at 1875 ml/ha offered better weed control, enhanced the growth and yield components of rice and resulted in higher grain yield. Other alternative is splash method of application of Erijan 40 EW (pretilachlor) at 1875 ml/ha and spraying method of application of Topstar 80 WP (oxadiargyl) at 125 g/ha.

P-15 Evaluation of phytotoxicity and bio-efficacy of orthosulfamuron + butachlor in transplanted rice

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In transplanted rice, high weed infestation is a major constraint, which causes 30 to 50 per cent yield reduction. Continuous use of same herbicide results in resistant biotype of weeds and buildup of residue in the soil. Application of single herbicide alone may not control all the kinds of weeds. Keeping this in mind the filed experiment has been conducted in transplanted rice with the following objectives to asses the phytotoxicity and bio-efficacy of tank mix combination of orthosulfamuron (50% WG) + butachlor (50% EC) on weeds and transplanted paddy. The treatments comprising tank mix of orthosulfamuron + butachlor compared with orthosulfamuron and butachlor as single herbicide as well as with unweeded control in RBD experiment with three replication in transplanted rice during *kharif*, 2005.

Predominant weed flora were *Cyperus difformis* alone in sedge , *Echinochloa crus-galli*, *Panicum repens* among the grasses and *Ammania baccifera, Eclipta alba* and *Ludwigia parviflora* were dominant broad leaved weeds. Crop stand and growth were normal with herbicide mixtures at all the doses. However, with higher doses of herbicide mixtures slight yellowing symptoms were observed at 14 DAHS. But complete recovery of crops was observed at 21 DAHS. Lower weed density, dry weight and higher weed control efficiency with pre-emergence spray of tank-mix combination of orthosulfamuron 50% WG + butachlor (75+1250 or 75 + 900 or 60 + 1250 g a.i.ha^{-1}) on 3 DAT. Maximum grain yield of 5.64 t ha^{-1} was obtained with tank-mix application of orthosulfamuron + butachlor at 75 + 1250 g a.i. ha^{-1} on 3 DAT.

P-16

Integration of herbicidal and mechanical weeders in aerobic rice

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Yield losses as high as 46% caused by weeds have been reported in direct seeded rice. Undependable labour availability and escalating wages in many cases has given impetus to the development and use of herbicides and mechanical weeders for weeding would be advantageous as they require lesser labour. Keeping this in mind, the field experiment has been conducted in aerobic rice with the following objectives to evaluate the weed control efficiency of mechanical weeders alone and along with chemical weed management and to workout the economics of the different weed control treatments. PE pendimethalin1.0 kg/ha at 3 DAS, hand hoeing, wheel hoe, star or peg rotary, single tyne sweep weeder weeding alone or in combination with herbicide, twice at 25 and 45 DAS were compared with unweeded control in RBD experiment with three replications in aerobic rice during *rabi* 2006-07 and *kharif* 2007.

Predominant weed flora were *Cynodon dactylon*, *Echinochloa colona, Dactyloctenium aegyptium* and *Chloris barbata* among the grasses and *Alternanthra pungens*, *Portulaca oleraceae*, *Cleome chelidoni* and *Eclipta alba* were dominant broad leaved weeds. Weed density and weed dry weight were lower with pre-emergence application of pendimethalin 1.0 kg on3 DAS + single tyne sweep weeder weeding on 45 DAS or wheel hoe weeding on 45 DAS. Higher weed control efficiency could be obtained with pre-emergence herbicide application of pendimethalin 1.0 kg/ha on 3 DAS combined with either hand weeding or weeding with single tyne sweep or wheel hoe weeding on 45 DAS. Higher grain yield of aerobic rice could be obtained with pre-emergence application of pendimethalin at 1.0 kg/ha on 3 DAS + single tyne sweep weeder on 45 DAS which could further result in higher profitability of aerobic rice cultivation.

P-17 Influence of weed management practices in direct seeded rice

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Weed infestation is more pronounced in direct seeded than in transplanted rice. Weeds emerge at about the same time, as the rice seeds do and yield losses caused by weeds will be greater in direct seeding. During early establishment, weeds make 20 to 30 per cent of their growth while crop makes only two to three per cent of its growth. Field experiment was conducted to study the influence of weed management practices in direct seeded rice. The different method of seeding were taken in main plot and in subplot the early post-emergence cyhalofop-butyl on 15 DAS + hand weeding on 45 DAS, pre-emergence pretilachlor + safener on 5 DAS + hand weeding on 45 DAS, hand weeding twice on 20 and 45 DAS were compared with unweeded control in a split plot design with three replications in direct seeded rice during *rabi* 2004 - 2005.

The direct seeded rice was infested with composite weed flora comprising of grasses (48.1 per cent of total weeds), sedges (21.4 per cent) and broad leaved weeds (30.5 per cent) in all the stages. The pre-emergence application of pretilachlor + safener at the rate of 0.45 kg a.i. ha^{-1} on 5 DAS + hand weeding on 45 DAS registered lower weed density, weed dry weight, higher weed control efficiency and higher grain yield. This was followed by hand weeding twice and it was on par with early post emergence application of cyhalofop-butyl at the rate of 60 g a.i. ha^{-1} on 15 DAS + hand weeding on 45 DAS.

P-18 Weed management in upland rice

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A field experiment was conducted during rainy seasons of 2006 and 2007 to determine the most effective measure of weed management in upland direct seeded rice var. 'Vandana'. Application of butachlore @ 1.5 kg/ha pre-emergence followed by weeding by wheel hoe at 30 DAS recorded weed density (21.95/m^2), dry weight of weeds (10.40g/m^2) at 60 DAS similar to that of weed free up to 60 DAS as well as weeding by wheal hoe at 15, 30 & 45 DAS thereby recording higher weed control efficiency (81.24%) over rest of the treatments. Application of butachlore @ 1.5 kg/ha pre-emergence followed by weeding by wheel hoe 30 DAS recorded grain yield (2153 kg/ha) similar to weed free check up to 60 DAS (2350 kg/ha) , weeding by wheel hoe at 15, 30 & 45 DAS (2045 kg/ha) and oxyfluorfen @ 0.2 kg/ha pre-emergence followed by weeding by wheel hoe at 30 DAS (2020 kg/ha.)

P-19

Effect of nitrogen levels and weed management practices on productivity, nutrient uptake and nitrogen-use-efficiency of direct seeded rice (*Oryza sativa*) under upland rainfed conditions.

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A field experiment was conducted during the rainy season of 2002 and 2003 at Bihar Agricultural College Farm, Sabour, and Bhagalpur to study the effect of nitrogen levels and weed management practices on productivity, nutrient uptake and nitrogen-use-efficiency of direct seeded rice (*Oryza sativa*) under upland rainfed conditions. The soil of experimental field was sandy-loam with pH- 7.8 and organic carbon- 0.42, available N- 185, available P- 9.2 and K- 184.3 kg/ha. The experiment was laid out in split plot design replicated thrice. Three levels of nitrogen (40, 80 and 120 kg/ha) were put in the main plots and four weed management treatments viz. weedy check, two hand weeding (HW) at 20 and 40 days after sowing (DAS), pre- emergence application of butachlor at 1.5 kg /ha + one HW at 30 DAS and pre- emergence application of butachlor at 1.5 kg /ha + 2, 4-D @ 1.0 kg /ha at 30 DAS were allocated to sub-plots. The seeds of rice variety IR-36 were drilled in rows 20 cm apart on June, 22, 2002 and June, 24, 2003, using a seed rate of 60 kg/ ha.

The major weed flora of experimental field consisted of *Echinochloa crus-galli* (L.) Beauv, *Dactyloctanium aegyptium* (S) Richter, *Setaria glauca* (L.) and *Cynodon dactylon* (L.) Pers. among grasses; *Cyperus rotundus* (L.) and *Cyperus iria* (L.), among sedges and *Phyllanthus niruri* (L.), *Lindernia viscosa* and *Amaranthus viridis* (L.) among the broad-leaved weeds. Grain and straw yields of rice and N,P and K uptake by rice crop and weeds increased significantly with successive increase in nitrogen up to 120kg/ ha. Among the weed management practices, two hand weeding at 20 and 40 DAS and pre-emergence application of butachlor at 1.5 kg /ha + one hand weeding at 30 DAS were at par and significantly reduced the density and dry weight of weeds and nutrient depletion by weeds. These treatments significantly increased the nutrient uptake by the crop and gave higher grain yield (4.18 and 4.16 t/ ha) at 120 kg N/ha as a result of higher weed control efficiency (90.6 and 84.3%), N-use efficiency (33.5 and 32.9 kg grain/kg of N applied) and production efficiency (60.4 and 60.3 kg grain/kg N applied), respectively. However, Weeds in weedy check removed 28.7, 7.3 and 35.3 kg N, P and K/ha, respectively which corresponding to 67.5, 64.8 and 64.5% of total N, P and K removed by crop and weeds. Weeds in two hand weeding treatment removed 6.2 kg N, 1.7 kg P and 8.4 kg K/ha which were correspondingly 9.2, 9.0 and 8.9% of total N, P and K removal from the soil. Hence, this indicates that where the removal of nutrients by weeds was more the corresponding uptake by the crop was less and vice versa.

P-20

Effect of nitrogen and weed management on dry-matter accumulation and nitrogen uptake pattern in direct-seeded rice (*Oryza sativa*) under upland conditions

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A field experiment was carried out during rainy season of 2002 and 2003 on sandy-loam soil at Bihar Agricultural College, Sabour to study the effect of nitrogen and weed management on dry-matter accumulation and nitrogen uptake pattern in direct- seeded rice under upland conditions. The soil of experimental field was sandy- loam with pH 7.8 and organic carbon 0.42,available N 185, available P_2O_5 21.2 and K_2O 222 kg/ha. The experiment was laid out in split plot design replicated thrice. Three levels of nitrogen (40, 80 and 120 kg/ha) were put in the main plots and four weed management treatments viz. un weeded check, Two hand weeding (HW) at 20 and 40 DAS, butachlor @ 1.5 kg a. i. /ha + one HW at 30 DAS and pre- emergence application of butachlor @ 1.5 kg a.i./ha + 2,4-D @ 1.0 kg a.i. /ha at 30 DAS were allocated to sub-plots. The seeds of rice variety I.R.-36 were drilled in rows 20 cm apart on June, 22, 2002 and June, 24, 2003, using a seed rate of 60 kg/ha. Dry - matter accumulation, and concentration and uptake of nitrogen by crop as well as weeds increased with increasing levels of nitrogen at all the stages of crop growth. The differences in nitrogen concentration due to nitrogen levels were greatest at panicle initiation stage and started becoming narrower with the advancement in crop age. The crop, on an average, had accumulated nearly 16% of the total absorbed nitrogen up to tillering, 50% up to panicle initiation and 90% up to heading. Maximum dry-matter accumulation, and nitrogen concentration and uptake by crop were recorded with the plot receiving two-hand weeding at 20 and 40 DAS, which were comparable with the treatment of butachlor @ 1.5 kg /ha followed by one hand weeding at 30DAS. These treatments significantly reduced the dry weight and nitrogen removal by weed as compared to application of butachlor @ 1.5 kg /ha + 2, 4-D @ 1.0 kg at 30 DAS and un weeded check. It is apparent from the data that where the removal of nitrogen by weeds was more the corresponding uptake by crops was less and vice-versa. Therefore, for efficient utilization of applied nitrogen as well as to harvest a good yield, the weeds should be kept under control.

P-21

Effect of fertility level and weed management practices on productivity and profitability of scented rice (*Oryza sativa*)

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An experiment was conducted during rainy season of 2005 and 2006 at K.V.K. Farm, Bihar Agricultural College, Sabour, Bhagalpur to study the effect of fertility level and weed management practices on productivity and profitability of scented rice. The site of experimental plot was clay loam, 0.47% organic carbon, low in available N (196 kg/ha), medium in P_2O_5 (32.6 kg/ha) and K_2O (235 kg/ha) and neutral in reaction (pH 7.3). The experiment consisting 15 treatment combinations was laid out in factorial randomized block design, comprising three levels of N, P_2O_5 and K_2O, viz. 75% recommended dose of fertilizer (RDF) (60:30:15), 100 % RDF (80:40:20) and 125% RDF (100:50:25) kg/ha and five weed management practices, viz. pre-emergence application of anilofos @ 0.40 kg a.i./ha, pretilachlor @ 0.75 kg a.i./ha, butachlor @ 1.5 kg a.i./ha, two hand weedings at 20 and 40 days after transplanting (DAT) and a weedy check. The rice variety 'Rajendra Suwasini' was transplanted in 3rd week of July and harvested in 1st week of November during both the seasons. The dominant weed flora among grasses were; *Eichnochloa colonum*, *E. crusgalli*, *Ammania baccifera* and *Commelina benghalensis* among broad-leaf weeds; and *Cyperus rotundus* and *Cyperus difformis* among sedges. The intensity of grasses, sedges and broad-leaf weeds were 52.7, 36.1 and 11.2%, respectively.

The grain and straw yields as well as yield attributes increased significantly with increasing levels of fertility upto 100:50:25 kg/ha N, P_2O_5 and K_2O. Among the weed management practices, two hand weedings at 20 and 40 DAT registered the highest grain and straw yields, which, however exhibited statistical parity with the pre-emergence application of anilofos @0.40 kg/ha and these treatments were significantly superior to rest of the weed management practices. Interaction between fertility level and weed management practices revealed that maximum grain yield (50.60 q/ha) and nutrient uptake (97.3 kg N, 37.50 kg P and 133.4 kg K/ha) by rice were observed with two hand weedings at higher fertilizer dose of 100:50:25 kg/ha N, P_2O_5 and K_2O. However, higher net profit (Rs.20,028/ha) and benefit : cost ratio (1.41) were recorded with the application of 100:50:25 kg/ha N, P_2O_5 and K_2O and anilofos @ 0.40 kg/ha. The highest weed-control efficiency was observed with low fertility and two hand weedings followed by anilofos @ 0.40 kg/ha treatment. The maximum weed index was observed in weedy check plots. Under existing agro-climatic conditions, higher yield of scented rice can be obtained by adopting 100:50:25 kg/ha N, P_2O_5 and K_2O and two hand weedings at 20 and 40 DAT. However, pre-emergence application of anilofos @ 0.40 kg/ha at higher fertility level gave the maximum net profit.

P-22 Energy and nutrient budget of rice as influenced by weed management practices under different methods of crop establishment

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Field experiments were conducted during summer and *Kharif* seasons of 2001 at Agricultural Research Station, Honnaville, University of Agricultural Sciences, Bangalore. The experiment was laid out in a split plot design with three replications. The main plot consisted of three crop establishment practices *viz.*, broadcasting of seeds, direct seeding using drum seeder and transplanting of seedlings. Four weed management practices *viz.*, reduced tillage, pretilachlor + safener (Sofit 30 EC) pre-emergence application, two hand weedings at 20 and 40 DAS / DAT, pretilachlor + safener (Sofit 30 EC) as pre-emergence application + hand weeding on 30 DAS / DAT and an unweeded check were allotted to sub plots. Pooled data of two seasons indicated that total weed density and dry weight recorded in line transplanting system (19.27/0.25m^2 and 520.6 kg ha^{-1}) and direct seeding using drum seeder (20.15/0.25m^2 and 541.7 kg ha^{-1}) was at par and in turn were significantly lower compared to broadcast sowing (24.10/0.25m^2 and 644.1 kg ha^{-1}) resulting in grain yield of 5533 and 5429 kg ha^{-1}, respectively. Significantly higher energy use efficiency (7.87) was recorded in drum seeding followed by transplanting system (7.70). Application of herbicide followed by one hand weeding on 30 DAS/DAT recorded significantly lower total weed count (5.06/0.25m^2) and weed dry weight (51.4 kg ha^{-1}) compared to other treatments resulting in significantly higher uptake of nitrogen, phosphorus and potassium (138.1, 47.8 and 145.7 kg ha^{-1}, respectively) leading to significantly higher grain yield (6233 kg ha^{-1}) and energy use efficiency (8.64). Treatment combination of drum seeding with application of pre-emergence herbicide pretilachlor + safener at 1L ha^{-1} on 4 DAS followed by one hand weeding at 30 DAS recorded significantly lower total weed count (4.19 / 0.25 m^2) and total weed dry weight (35.1 kg ha^{-1}) resulting in superior grain yield (7061 kg ha^{-1}) and energy use efficiency (9.93).

P-23

Yield and yield attributes of rice as influenced by weed management practices under different methods of crop establishment

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Field experiments were conducted during summer and *Kharif* seasons of 2001 at Agricultural Research Station, Honnaville, University of Agricultural Sciences, Bangalore. The experiment was laid out in a split plot design with three replications. The main plot consisted of three crop establishment practices *viz.*, broadcasting of seeds, direct seeding using drum seeder and transplanting of seedlings. Four weed management practices *viz.*, reduced tillage, pretilachlor + safener (Sofit 30 EC) pre-emergence application, two hand weedings at 20 and 40 DAS / DAT, pretilachlor + safener (Sofit 30 EC) as pre-emergence application + hand weeding on 30 DAS / DAT and an unweeded check were allotted to sub plots. Pooled data of two seasons indicated that total weed density and dry weight recorded in line transplanting system (19.27/0.25m^2 and 520.6 kg ha^{-1}) and direct seeding using drum seeder (20.15/0.25m^2 and 541.7 kg ha^{-1}) was at par and in turn were significantly lower compared to broadcast sowing (24.10/0.25m^2 and 644.1 kg ha^{-1}) resulting in grain yield of 5533 and 5429 kg ha^{-1}, respectively. Significantly higher number of filled grains and thousand seed weight was recorded in transplanting system (92.7 and 21.8 g, respectively) followed by drum seeding method (88.4 and 21.1 g, respectively). Application of herbicide followed by one hand weeding on 30 DAS/DAT recorded significantly lower total weed count (5.06/0.25m^2) and weed dry weight (51.4 kg ha^{-1}) compared to other treatments which led to significantly higher grain yield (6233 kg ha^{-1}), productive tillers (536/ m^2) and filled grains panicle^{-1} (92.6). Treatment combination of drum seeding with application of pre-emergence herbicide pretilachlor + safener at 1L ha^{-1} on 4 DAS followed by one hand weeding at 30 DAS recorded significantly lower total weed count (4.19 / 0.25 m^2) and total weed dry weight (35.1 kg ha^{-1}) resulting in superior grain yield (7061 kg ha^{-1}) and productive tillers (673 / m^2).

P-24

Influence of seeding and weed control methods on the productivity of puddle seeded rice

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To study the effect of establishment methods in integration with weed control in puddle seeded rice, a field experiment was conducted at Palampur during the three consecutive *kharif* seasons of 2004, 2005 and 2006. Nine treatment combinations of three seeding methods {drum seeding (70-80 kg/ha), drum seeding (70-80 kg/ha) + green manuring (Sesbania) and broadcast seeding (100 kg/ha) of sprouted seeds}, and three weed management methods {cyhalofop-butyl 90 g/ha (15 DAS), butachlor 1.5 kg/ha (Pre) and hand weeding twice} were evaluated for weed control and yield. Rice variety 'HPR-957' was sown on 25 June 2004, 28 June 2005, 12 July 2006 and harvested on 29 October 2004, 5 November 2005 and 27 October 2006. Results of the study revealed that broadcast seeding resulted in significantly lower total weed count and dry weight during the first year. Total weed count and dry weight were not significantly inflenced owing to seeding methods in the second year. However, drum seeding remaining at par with drum seeding + green manuring gave significantly lower total weed count and dry weight during 2006. Drum seeding resulted in highest grain yield of wet seeded rice in 2005 and 2006 and was at par with broadcast seeding in 2004. Hand weeding twice resulted in significantly lower total weed count during 2005 and weed dry weight during 2004. Cyhalofop-butyl 90 g/ha was as effective as hand weeding twice in reducing total weed dry weight during 2005. Cyhalofop-butyl 90 g/ha resulted in highest grain yield of wet seeded rice in 2005 and 2006. On an average cyhalofop-butyl 90 g/ha increased puddle seeded rice yield by 12.1% over butachlor 1.50 kg/ha and 9.5% over hand weeding twice.

P-25 Effect of sowing methods and weed management in direct seeded rice (*Oryza sativa*)

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A Field experiment was conduct to see the effect of *Oryza sativa* L. on a sandy clay loam with pH 7.4 of Agricultural Research Farm, B.H.U., Varanasi during *Kharif* season of 2006-07. The soil of the experimental site was low in available N and medium in available P and K. The experiment was laid out in split plot design having three method of sowing (M1-DSR-Dry seeding, M2-DSR-Wet seeding, M3-DSR-Drum seeding) as main plot treatment and eight weed management treatment (W1-butachlor @1.25kg a.i./ha,W2- butachlor fb 2,4-D(1.25 fb0.5kg a.i./ha),W3-pretilachlor@ 0.75kg a.i./ha, W4-pretilachlor fb 2,4-D(1.25 fb0.5kg a.i./ha),W5- pendimethalin@1.0 kg a.i./ha,W6- pendimethalin fb 2,4-D (1.25 fb0.5kg a.i./ha), W7- hand weeding 25 and 45 DAS and W8- weedy check) as sub plot treatment.

Rice grain and straw yield were significantly affected by sowing methods and weed management treatments. Direct seeded rice sown by drum seeder produced significantly higher grain and straw yield than rice sown in wet seeding and dry seeding. In case of weed management treatment maximum grain and straw yield was noticed under hand weeding treatment which was found significantly superior over rest of the treatment except pretilachlor fb 2, 4-D (1.25 fb0.5kg a.i./ha) and minimum under weedy check. In case of herbicidal treatment maximum yield were recorded under application of pretilachlor fb 2, 4-D (1.25 fb0.5kg a.i./ha) which was found super imposed over rest of the treatments. Alone application of herbicide maximum yield were recorded under application of pendimethalin which was has not significant differences with application of butachlor@1.25kg a.i./ha and pendimethalin@1.0kg a.i./ha .This was due to increased number of panicles, grain per panicle and 1000 grain weight.

Sowing method and weed management treatment significantly influenced the total weed density and total weed dry weight at 60 DAS. Minimum weed density and weed dry weight was recorded under rice sown by drum seeder and maximum under dry seeding of rice, drum seeding of rice was found significantly superior over wet and dry seeding of rice. In case of weed management treatment total weed density and dry weight was maximum under weedy check and minimum under hand weeding. Application of pretilachlor fb 2, 4-D (1.25 fb0.5kg a.i./ha) reduced the weed density and weed dry weight and found significantly superior over rest of the treatment except hand weeding. Alone application of herbicide minimum weed density and weed dry weight were recorded under application of pretilachlor which has not significant differences with application of butachlor@1.25kg a.i./ha and pendimethalin@1.0kg a.i./ha.

P-26 Weed management in rice-rice cropping system in the lateritic belt of West Bengal

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Field experiments were conducted during the *kharif* seasons of 2002 and 2003 and summer seasons of 2003 and 2004 in the lateritic belt of West Bengal in a split plot design with three replications. During *kharif* seasons, only two treatments namely, farmers practice (2 Hand weedings) and pretilachlor @ 0.75 kg ai/ha as pre-emergence were included but in succeeding rice, 7 treatments were incorporated in each *kharif* treatments. Four herbicides namely, 2,4-D EE (0.8 kg/ha), butachlor (1.25 kg/ha), butanil (4 L/ha of trade product), metsulfuron methyl + chlorimuron ethyl (almix 4 g/ha) along with narrow spacing (15 X 10 cm), one hand weeding at 40 DAT and unweeded control were included in this investigation. The pre-dominant weed species were *Marsilea quadrifolia, Cyperus difformis* in summer rice. During *kharif* season farmers practice and pretilachlor were equally effective in reducing the number and dry matter of weeds. Application of metsulfuron methyl and chlorimuron ethyl (almix) @ 4 g ai/ha and butanil @ 4 L/ha (trade product) effectively controlled weed population in second rice. Highest grain yield (5283 kg/ha) of summer rice was recorded in aimix treated plots followed by that of butanil (5158 kg/ha). Pretilachlor @ 0.75 kg in *kharif* rice followed by almix 4 g/ha in summer rice was found most effective in controlling weed and recording higher grain yield in rice-rice cropping system of West Bengal.

P-27 Effect of weed management methods on nutrient uptake by crop and weeds in wet seeded rice

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The field experiment was conducted in wet seeded rice to evaluate the efficacy of pre-emergence herbicides (pretilachlor plus and butachlor) applied in three different times (one week before sowing (WBS); two weeks before sowing and as pre-emergence after sowing) followed by two post emergence operations (one hand weeding on 40 DAS and post-emergence of 2,4-D on 30 DAS) in two seasons *viz.*, late *rabi* and *kharif*, 2004 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. These treatments compared with hand weeding twice (20 and 40 DAS) and unweeded control making total of 14 treatments. The treatments were replicated thrice in a Randomized Block Design. A recommended fertilizer dose of 125:38:38 kg NPK ha^{-1} were applied uniformly in all the plots.

The weed flora of the experimental field was dominated by grasses, the sedge weeds and broad-leaved weeds. Among the treatments, pretilachlor plus 0.3 kg ha^{-1} at 3 DAS as pre-emergence fb. HW at 40 DAS markedly suppressed the total weed density, weeds DMP and recorded the highest WCE at harvest. Chemical weed control with pre-emergence application of either pretilachlor plus 0.3 kg ha^{-1} or butachlor 1.25 kg ha^{-1} even when followed by post-emergence application of 2,4-D (1.25 kg ha^{-1}) on 30 DAS also satisfactorily controlled the weed growth in wet seeded rice.

Pre-emergence application of pretilachlor plus 0.3 kg ha^{-1} at 3 DAS fb. HW at 40 DAS maximized the nutrient uptake of rice crop (159:12.5:202 and 186:12.8:228 kg NPK ha^{1} in both the seasons, respectively). Weed management significantly influenced P and K availability in soil. This treatment registered numerically less P (14.0 and 18.0 kg ha^{-1}) in late *rabi* and *kharif*, respectively and K (189.0 kg ha^{-1}) in late *rabi*. Whereas, butachlor 1.25 kg ha^{-1} at two WBS fb. HW at 40 DAS recorded less K of 189 kg ha^{-1} during *kharif* season. Both P and K recorded numerically higher values in late *rabi* (20.6 and 220 kg ha^{-1}, respectively) and P (20.4 kg ha^{-1}) at *kharif* in unweeded control. The available nutrient status of K was higher with butachlor at two WBS fb. 2,4-D at 30 DAS (216 kg ha^{-1}) followed by unweeded control and pretilachlor either applied at two WBS or as pre-emergence at 3 DAS fb. 2,4-D at 30 DAS in *kharif* season, registered the same value of 210 kg ha^{-1}. The grain yield of rice was also increased (4910 and 5325 kg ha^{-1}) followed by HW twice (4728 and 5111 kg ha^{-1}) during late *rabi* and *kharif* 2004, respectively.

P-28 Effect of varieties and weed control methods on rice (*Oryza sativa*) at farmers field

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The field experiment was conducted during *kharif* season of 2001 and 2002 at Krishi Vigyan Kendra adopted village Milawali (Gwalior). The experiment is divided in two sets. The treatment consisted of two rice varieties and four weed control methods. The treatments were replicated on eight farmer's field considering each farmers field as a separate replicate. The soil were clay loam, neutral in reaction, low in organic carbon (0.45%) medium in available phosphorus (14.5 to 18.2 Kg/ha) and medium in available potassium (230-239 Kg/ha) with pH of 7.3 to 7.8. The rice crop was transplanted in 2nd week of July during both the years at a spacing of 20 X 10 cm.. Recommended package of practices was adopted to raise the crop.

The major weed flora in the experimental field were *Echinochloa colona*, *Echinochloa crugalli*, *Commelina benghalensis*, *Cyperus iria*, *Cyperus rotundus*, *Setaria glauca*, *Eclipta alba* and *Phylenthus niruri* etc.

Results revealed that application of butachlor @ 1.5 kg a i/ha at early growth stage and removal of late emerged weeds by supplemented hand weeding at 30 DAT reduced the weed bio-mass significantly and recorded the lowest dry weight of weeds and highest weed control efficiency. Rice grain yield was significantly highest under all the weed control treatments than farmers practices. The highest grain yield and net return was obtained with pre-emergence application of butachlor @ 1.5 kg a i/ha + one hand weeding at 30 DAT. The rice varieties did not affect either weed density or dry matter production. However, the rice variety 'Kranti' recorded higher grain yield and net return over Madhuri. It is concluded that the highest grain yield and net return, lower weed population and weed bio-mass were obtained with pre-emergence application of butachlor @ 1.5 kg ai /ha + one hand weeding at 30 DAT.

P-29

Effect of trisulfuron, trisulfuron + pretilachlor and bensulfuron-methyl on weeds and yield of transplanted rice (*Oryza sativa* L.)

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The experiment was carried out with 12 weed control treatments following in a randomized block design with four replications at Crop Research Center, G. B. Pant University of Agriculture and Technology, during *Kharif* season of 2005. The objective was to find out the effective dose and time of application of trisulfuron, bensulfuron-methyl, pretilachlor and combination of trisulfuron and pretilachlor. The major weed species that infested the crop were *Echinochloa*, *Cyperus, Caesulia axillaries* and *Commenlina beghalensis*. Sedges (*Cyperus iria, C. difformis, Fimbristylis miliacea* and *Scirpus*) constituted the highest percentage (73.29 %) of total weed density. However highest dry weight (217.91g m^{-2}) was recorded with *Echinochloa*. This was followed *Caesulia axillaries* (6.14 %), *Commenlina beghalensis* (5.52 %) and other weeds (6.85 %). Weed infestation was found to be highest at 60 days stage, which reduced at later stages. The combination of trisulfuron and pretilachlor at 0.009 + 0.5 kg ha^{-1} (6 DAT), resulted 54 weeds m^{-2} and 32.8 g dry weight of weeds which was statistically at par with butachlor at 1.5 kg ha^{-1} + one hand weeding, pretilachlor at 0.75 kg ha^{-1} (3 DAT), butachlor at 1.5 kg ha^{-1} (3 DAT). Among the herbicides the lowest weed index was recorded with butachlor at 1.5 kg ha^{-1} and highest weed control efficiency was recorded with combination of trisulfuron and pretilachlor (0.009 + 0.5 kg ha^{-1}) applied at 6 days after transplanting.

The highest grain yield (6.02 t ha^{-1}) was recorded in weed free treatment, which was significantly higher than all the weed control treatments except two hand weeding (5.80 t ha^{-1}), butachlor at 1.5 kg ha^{-1} + one hand weeding (5.45 t ha^{-1}), butachlor at 1.5 kg ha^{-1} (5.40 t ha^{-1}), combination of trisulfuron and pretilachlor at 0.009 + 0.5 kg ha^{-1} (5.28 t ha^{-1}) and pretilachlor at 0.75 kg ha^{-1} (5.27 t ha^{-1}). The lowest grain yield (3.41 t ha^{-1}) was recorded in non-weeded control. The reduction in grain yield due to weeds over weed free and two hand weeding was 43.36 and 41.21 per cent, respectively. The trisulfuron (6 and 13 DAT) and bensulfuron-methyl at both the doses produced grain yield statistically as good as recommended herbicides butachlor at 15 kg ha^{-1} (3 DAT) and pretilachlor at 0.75 kg ha^{-1}.

P-30

Effect of integrated nutrient supply in rice (*Oryza sativa* L.) on succeeding wheat (*Triticum aestivum* L.) and weed dynamics

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The field experiment was conducted to evaluate the efficacy of organic sources, viz. FYM (farmyard manure),WCS (wheat cut straw) and GM (*Sesbania* green manure) in combinations with fertilizers in rice and their residual effects on succeeding wheat in an going long-term experiment on integrated nutrient management in rice-wheat system during 2003-04 and 2004-05 at Kumarganj, Faizabad. Inadequate and imbalanced fertilization in the system fail to sustain productivity and soil health. Both crops of the rice-wheat system were found fertility exhaustive and had resulted in decline of soil organic carbon as well as available P and K. The increasing level of nutrient upto 100% RDF applied either through inorganic fertilizer alone or in combination with organic sources (FYM, WCS and GM) significantly increased the grain and straw yield of rice.

Grain and straw yields of wheat significantly increased with increasing level of nutrient (NPK), applied from 0 to 100% RDF either through fertilizer alone or in combination with organic sources in rice and 100% RDF through chemical fertilizer alone in wheat. Maximum grain yield of wheat (38.11 q ha^{-1}) was recorded with the application of 50% N through FYM + 50% RDF through fertilizer to rice and 100% RDF through chemical fertilizer alone to wheat (T_6). The substitution of N by 25% through organic sources and 75% RDF to rice and 75% RDF to wheat through fertilizers produced significantly lesser grain yield than 100% RDF to both the crops. Application of 25-50% N through FYM in rice caused significant increase in weed population and its dry weight in wheat as compared to GM and WCS. The lowest weed density was noted in unfertilized control and increased with increase in doses of fertilizers.

P-31 Efficacy of herbicide and their mixture in wheat

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A field experiment was conducted during 2003-04 and 2500-06 to study the efficacy of herbicide and their mixture in wheat at Sardar Vallabh Bhai Patel University of Agriculture & Technology, Meerut. The soil of experimental site was sandy loam in texture, low in organic carbon, medium in available phosphorus and potassium with pH 7.8. The experiment was laid out in randomized block design with four replications. ten treatments consisting weedy, weed fre, pendimethalin @ 1.25 kg.ha as PE, isoproturon @ 750 g + 2,4-D @ 250g/ha as POE, isoproturon @ 1.0 kg/ha, metribuzin @ 200 g/ha, metribuzin @ 250 g/ha as POE, sulfosulfuron @ 25 g/ha, clodinafop propargyl 60 g/ha fb. metsulfuron methyl (MSM) 4 g/ha as POE, fenoxaprop @ 120 g/ha fb. MSM 4 g as POE. Phalaris minor, *Chenopodium album*, *Fumaria Parviflora, Solanum nigrum,* and *Anagallis arvensis* were the major weed species in the experiment site. All the weed control measures lead to significant reduction in weed population and weed dry matter as compared to weedy check. There was significant decease in weed population and weed dry matter accumulation in weeds with the application of sulfosulfuron @ 25 g/ha as POE compared to other herbicidal treatments. Ear length, number of spike lets/ear, number of grains/ear, 1000 grain weight and grain yield of wheat was significantly increased over weedy check. The highest grain yield was recorded under weed free condition though it remained at par with sulfosulfuron @ 25 g/ha and clodinafop propargyl 60 kg/ha fb. MSM 4 g/ha. Thus, post emergence application of sulfosulfuron @ 25 g/ha and clodinafop propargyl 60 g/ha Fb. MSM 4 g/ha proved most effective for controlling weeds and grain yield of wheat crop.

P-32 Effectiveness of herbicides for direct-seeded rice under puddle irrigated conditions

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A field experiment were conducted under AICRP on rice, Research farm, college of Agriculture, Rewa for two conductive years 2004 and 2005 with the objective to judge effectiveness and comparative efficiency of various herbicides and economics for controlling weeds in direct-seeded rice under puddle irrigated conditions. Results that the application of butachlor + prpanil @ 1.12 + 1.12 kg a.i./ha recorded higher plant height (85.50 c.m.), number of tillers/m^2 (314.50), lower number of grassy, broad-leaved and total number of weeds/m^2 (9.75), dry weight of weeds/m^2 with the WCE of 74.67%. It also recorded highest panicle length higher number of fertile grains, gram yield of 31.57 q/ha and net profit of Rs. 3457.50/ha.

P-33 Chemical weed management in late-sown wheat (*Triticum aestivum* L.) in the lateritic belt of West Bengal.

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A field experiment was conducted during *rabi* season of 2004-05 and 2005-06 at the Agricultural Farm of the Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal in late sown wheat (*Triticum aestivum* L.). Fourteen treatments were assigned in a randomized block design with three replications. Among the chemical weed management practices, pendimethalin at 0.75 kg/ha as pre-emergence with one hand weeding at 30 DAS recorded the lowest number as well as total weed dry matter, higher weed control efficiency, lower weed index, higher values of growth and yield attributes and yield of wheat followed by pendimethalin alone at 0.75 kg/ha as pre-emergence, isoproturon at 0.75 kg a.i./ha as pre-emergence + one hand weeding at 30 DAS, 2, 4-D at 0.5 kg/ha as post-emergence and metsulfuron-methyl + chlorimuron-ethyl (almix) at 4 g / ha as early post-emergence. Almix at 4 g/ha as post-emergence was found effective in controlling broad-leaved weeds in late sown wheat. The new herbicides viz., prometryn and carfentrazone + isoproturon (Affinity) were effective in lower doses but showed phytotoxicity in wheat plant at higher doses. The grain yield reduction in late sown wheat due to weed infestation was to the tune of 24.54 - 29.62 %. Thus pendimethalin at 0.75 kg/ha as pre-emergence alone or in combination with one hand weeding at 30 DAS appeared to be the best for weed management in late sown wheat in the lateritic belt of West Bengal.

P-34 Effect of nitrogen and weed management on productivity of wheat

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A field experiment was conducted during winter season of 2004-05 to 2006-07 to evaluate the effect of weed management and nitrogen levels on weed growth and productivity of wheat. Increasing levels of nitrogen from 0 to 40, 40 to 80 and 80 to 120 kg/ha increased weed density by 34.0, 29.5 and 40.1 percent and weed dry matter by 33.5, 24.9 and 14.6 percent respectively. The weed control efficiency was higher at lower nitrogen levels as compared to their respective next higher levels. The N- uptake by weed and wheat was significantly higher at 120 kg/ha over 80 kg/ ha. Significantly higher wheat grain yield (3339 kg/ha) was recorded at 120 kg/ha over 80 kg/ha. Among weed control measures, isoproturon + 2,4-D each 0.75 kg/ ha post emergence recorded lower weed density (25.3/m^2) and weed dry weight (17.2/m^2)as compared to isoproturon or 2,4-D @ 1.0kg/ha compared to isoproturon or 2,4-D @ 1.0kg/ha applied individually remaining at par with weeding at 15, 30 & 45 DAS indicating higher weed control efficiency(85.3%) . The N uptake by weed was recorded minimum by isoproturon + 2,4-D @ 0.75 kg/ha each post emergence (11.5kg/ha) and maximum by wheat (68.8kg/ha) being at par with weeding at 15,30 & 45 DAS . Maximum grain yield (2465 kg/ha) was recorded by isoproturon + 2,4-D @ 0.75kg/ha each post emergsnce being at par with weeding at 15,30 and 45 DAS.

P-35

Chemical weed management in irrigated wheat (*Triticum aestivum* L.)

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Wheat (*Triticum aestivum* L.) is one of the most important food crop. The nutritive values of wheat is fairly high as compared to other cereals. It contains 11.8, 1.5, 71.2 and 1.5 per cent protein, fat, carbohydrates and mineral matter, respectively. The productivity of wheat depends on several factors viz., variety, time of sowing, irrigation, fertilizer and weed management. Among these, weed management is serious trouble for wheat cultivation. It reduces wheat yield by 50 per cent. Hence, it is most important to control weeds effectively in time to realize higher yield potential of wheat crop loking to the importance of this a field experiment was carried out during rabi season of 2004-05 on loamy sand soil at Agronomy Instruction Farm, CPCA, Sardar krushinagar to find out suitability of different chemical control measure along or mixture and their effects on growth, yield and quality of wheat. The experiment was laid out in randomize block design with four replications, having ten treatments (weedy check, isoproturon 1000 g ha^{-1}), metasulfuron methyl (4 g ha^{-1}), 2-4-D (400 g ha^{-1}), pendimethalin (1000 g ha^{-1}), metasulfuron methyl + isoproturon (2 g +500 g ha^{-1}), 2,4-D + isoproturon (20g + 50g ha^{-1}), hand weeding at 35 (DAS) days after sowing, interculturing at 30 DAS and weed free were tried. The wheat variety GW-32 was sown at 2.5 cm apart with 150 kg N+60 kg P_2O_5 ha^{-1}. The results showed that significant reduction in weed count and dry weight of weeds were brought by metasulfuron methyl + isoproturon, 2,4-D + isoproturon, hand weeding and interculturing at 60, 90 DAS and at harvest over rest of the treatments. The WCE of 81.76 % was obtained with metasulfuron methyl + isoproturon (2 g +500 g ha^{-1}). The significantly higher grain yield (4420 kg ha^{1}) and straw yield (6800 kg ha^{-1}) were found in weed free treatment but it was at par with metasulfuron methyl + isoproturon, 2-4-D + isoproturon, and hand weeding once at 35 DAS and interculturing at 30 DAS. The net profit was higher (Rs.39360 ha^{-1}) in metasulfuron methyl + isoproturon and lowest in weedy check (Rs 24485 ha^{-1}).

P-36 Effect of organic manures and herbicides on yield and yield attributing characters of wheat

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A field experiment was carried out in winter seasons during 2005-06 and 2006-07 at Bihar Agricultural College, Sabour, Bhagalpur to study the effect of organic manures and herbicides on yield and yield attributing characters of wheat (*Tricticum aestivum* L. emend. Fiori & Paol.). The soil of experimental field was sandy loam in texture, low in organic carbon (0.43%) and available nitrogen (178 kg/ha), medium in available phosphorus (11.70 kg P/ha) and potassium (167.6 kg K/ ha) and neutral in reaction (pH 7.1). The experiment was laid out in split-plot design with 3 replications, keeping four levels of organic manures in addition to recommended dose of nitrogen only (no organic manure, farm yard manure @ 10 t/ha, vermicompost @ 5 and 10 t/ha) in main plots and five weed control treatments (weedy check, weed free, 2,4-D at 0.75 kg/ha, sulfosulfuron at 0.025 kg/ha and isoproturon at 1.0 kg/ha) in sub-plots. The average N, P_2O_5 and K_2O contents in FYM and vermicompost were 0.60, 0.26 and 0.68 and 1.35, 0.56 and 1.12, respectively. Wheat variety 'PBW-343' was sown at 20 cm row spacing using seed rate of 125 kg/ha on 28 November, 2005 and 1st December, 2006. The major weed flora observed in experimental plots included *Chenopodium album* L., *Anagallis arvensis* L., *Oxalis corniculata*, *Melilotus indica* L. and *Spergula arvensis* L. among the broad-leaf weeds and *Phalaris minor*, *Avena fatua*, *Cynodon dactylon* and *Cyperus rotundus* among the narrow leaf weeds through out the crop season.

Application of organic manures increased the number of effective tillers, grain weight / ear, 1000-grain weight, grain and biological yields as well as weed biomass over no organic manures. The highest grain yield was recorded with the addition of vermicompost @ 10 tonnes/ha, which was significantly higher than that recorded under other treatments. Overall increase in grain yield was 22.2, 17.3 and 36.6% owing to FYM at 10 tonnes/ha and vermicompost at 5 and 10 tonnes/ ha, respectively over no organic manure. Sulfosulfuron at 25 g/ha was as effective as weed-free treatment.

Isoproturon at 1.0 kg/ha and 2,4-D at 0.75 kg/ha gave significantly more yields than the weedy check. Vermicompost at 10 t/ha gave better results under weed-free conditions followed by application of sulfosulfuron at 0.025 kg/ha applied 30 days after sowing. Among the organic sources, vermicompost was found to be more effective than FYM.

P-37 Weed density, weed dry weight and nitrogen uptake by weeds in wheat (*Triticum aestivum*) crop as influenced by nitrogen levels and weed control measures

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A field experiment was carried out during *Rabi* season of 1998-99 at Agronomy Research farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. The soil of the experimental field was silt loam in texture having pH 8.4, available N, P and K content was 201, 15 and 261 kg ha^{-1}, respectively. The experiment comprising of 20 treatment combinations was laid out in randomized block design with 3 replications. The treatment consisted of 4 nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) and 5 weed control measures (weedy check, weed free, isoproturon @ 1.0 kg ha^{-1}, 2,4-D @ 0.5 kg ha^{-1}, isoproturon @ 1.0 kg ha^{-1} +2,4-D @ 0.5 kg ha^{-1}. Wheat variety 'HUW-234" was sown on 8th December, 1998 with the spacing of 20 cm apart using 125 kg seeds ha^{-1}. A common dose of phosphorus and potassium of 60 and 40 kg ha^{-1}, respectively was applied as basal and nitrogen was applied as per treatment. Increasing levels of nitrogen up to 180 kg ha^{-1} recorded significantly lower weed density at all the crop growth stages. Application of 180 kg N ha^{-1} recorded significantly higher dry matter and nitrogen uptake of weed. Among the herbicidal treatments, 2, 4-D @ 0.5 kg ha^{-1} recorded significantly lower weed density, dry weight and nitrogen uptake as compared to rest of the weed control treatments.

P-38 Weed density, yield and fertility status as influenced by residue management in wheat

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A field experiment was conducted to study the effect of three residue management practices (removal, burning and incorporation of rice residue), two wed control measures (weedy check and herbicide) and three nitrogen levels (60, 120 and 180 kg/ha applied in three splits of 2:1:1 ratio) to find effect on the weed dynamics, fertility status in a swell-shrink black cotton soil. Among the residue management practices, removal of the residue reduced total weed density. The year and weed dry weight in 2nd and 3rd years as compared to removal. The application of isoproturon at 0.75 kg/ha + 2,4-D at 0.5 kg/ha as post controlled the weed resulting lower dry weight. No significant effect of residue management practices was observed on wheat yield in the first year. However, during subsequent 2nd and 3rd year, the highest wheat yield was recorded in the residue-incorporated plots. Irrespective of straw management practice, no significant increase in wheat yield was recorded beyond the N dose of 120 kg/ha. Compared to burning, the incorporation of rice straw significantly increased the organic C, the bacterial and fungal population in soil. It was concluded that rice straw incorporation was best among the given straw management practices in terms of weed suppression, improved soil health and increased wheat yield.

P-39 Effect of integrated nutrient management on weed density and weed dry weight in rice-wheat cropping system

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A field experiment was conducted at Agronomy Research Farm Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad during *rabi* season of 2006-07. The soil of the experimental field was silt loam having pH of 8.8, available N, P and K of 102, 13.8 and 355 kg ha^{-1}, respectively. The 12 treatment comprised of three organic sources (farm yard manure, wheat cut straw and sesbania green manure) with inorganic fertilizers in rice and through fertilizers in wheat were tested in randomized block design with four replications.

Nitrogen substitution through farm yard manure or green manure by 25 or 50 per cent along with 75 or 50 per cent recommended N P K through fertilizers to rice produced equal rice grain yield to 100 per cent recommended NPK dose through fertilizer . Among organic sources green manuring and farm yard manure being at par and produced 10-15 q ha^{-1} higher rice grain yield over that of wheat cut straw. There was positive residual effect of FYM and sesbenia green manuring on succeeding wheat crop. The highest rice yield equivalent (100.4 q ha^{-1}) was noted with 50 per cent recommended N P K dose through fertilizers + 50 percent N through FYM closely followed by 50 per cent recommended N P K dose through fertilizers + 50 percent N through sesbania aculeate in rice and 100 per cent recommended N P K dose through fertilizer in wheat (97.6 q ha^{-1}). Decrease in weed density and weed dry weight was noted where 25 or 50 per cent nitrogen was substituted through farm yard manure and minimum was noted in unfertilized control.

P-40 Effect of herbicides on growth and yield of wheat (*Triticum aestivium* L.) and associated weeds

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A field experiment was conducted during *rabi* season of 2004 at Agricultural Research Farm (Pili Kothi) of T. D. P. G. College, Jaunpur. The experimental site was sandy loam in texture having medium values of organic carbon (0.45 %), available N (257.15 kg/ ha), available K (188.16 kg/ ha) and low value of available P (7.0 kg/ha) with pH 7.5. The eight treatments viz. weedy, hand weeding, pendimethalin 1.0 and 1.25 kg a.i. /ha (1 DAS), isoproturon 1.0 and 1.25 kg a.i. /ha, 2, 4-D 0.5 kg a.e. /ha and sulfosulfuron 0.025 kg a.i. /ha (30 DAS) replicated thrice were laid down in randomized block design. Wheat (HUW-234) was sowing in rows 22.50 cm apart, on Nov. 30, 2004 and harvested on April 4, 2005. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha. Half of the dose of N (60 kg) and total P_2O_5 and K_2O were applied as basal. Remain half of the N (60 kg) was top dressed at 28 DAS after first irrigation. Other agronomic practices were adopted as per recommendation for wheat crop.

The major weed flora in experimental field were *Parthenium hysterophorous* (61.05%), *Anagallis arvensis* (16.85%), *Phalaris minor* (5.79%), *Cynodon dactylon* (6.34%), *Cyperus rotundus* (4.72%) and other weed species (5.25%). The maximum yield was recorded with weed free (43.23q/ha) which was statistically at par with sulfosulfuron 0.025 kg a.i. /ha (35DAS), pendimethalin 1 and 1.25 kg a.i. /ha (1DAS) and 2, 4-D 0.5 kg a.e. /ha. Among the herbicides, the lowest weed density at 60 DAS was recorded with sulfosulfuron which was at par with pendimethalin 1.25 kg a.i./ha. sulfosulfuron 0.025 kg a.i. /ha controlled *Parthenium hysterophorous*, *Anagallis arvensis* and *Phalaris minor* effectively but had no effect on *Cynodon dactylon*.

P-41 Correlation and regression studies on weed parameters and yield attributes with grain yield of wheat

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The study was carried out during winter seasons of 2003-04 and 2004-05 at the National Research Centre for Weed Science, Jabalpur to predict the correlation of various crop growth and yield attributing characters and weed parameters with grain yield of wheat. The study indicated that grain yield was negatively correlated with weed population (-962), weed dry weight (-0.944), and NPK depletion by weeds (r = -0.945, -0.939, -0.952) but had positive correlation with growth parameters *viz.*, LAI, number of tillers and plant dry weight and yield attributes *viz.*, number of effective tillers, length of earhead, number of grains per earhead, 1000-grain weight as well as NPK uptake by crop except plant height which was negatively correlated (-0.793) with grain yield. The reduction in grain yield of wheat was 6.11 kg ha^{-1} and 12.89 kg ha^{-1} with unit increase in weed plant/m^2 and weed dry weight (g m^{-2}), respectively.

P-42 Studies on the effect of soil moiture and weed management of wheat

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A field experiment was conducted during *rabi* seasons of 2002-03 and 2003-04 at Rajendra Agricultural University, Pusa (Samastipur) on sandy loam soil to study the effect of soil moisture and weed management in wheat (*Triticum aestivum* L.). The results revealed that the weed dry biomass was increased with the increase in irrigation levels but the difference were not significant. All weed control treatments reduced the weed dry biomass significantly over weedy check. Higher reduction was observed in hand weeding which was found to be at par to sulfosulfuron 25 g/ha. Number of effective tillers/m^2, grains/ear and test weight increased significantly with increasing the irrigation levels. Significant increase in grain and straw yields were observed with two irrigation levels over one irrigation level which was at par with three irrigation levels. Among weed management treatments, hand weeding, sulfosulfuron 25 g/ha and isoproturon 0.75 kg/ha were found to be at par among themselves but significantly superior over weedy check. Higher weed control efficiency was recorded in hand weeding (HW) which was closely followed by sulfosulfuron 25 g/ha and isoproturon 0.75 kg/ha treatment.

P-43 Effect of modified planting methods supplemented with herbicides on weed management in wheat

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Field experiments were conducted during 2005-06 and 2006-07 winter (*rabi*) seasons with different planting methods viz., conventional/flat sowing, FIRBS (furrow-irrigated raised bed) and skipping one row after every 4 rows in the main plot and different weed control treatments, e.g. unweeded control (UWC), fenoxaprop-p-ethyl @ 100 g/ha, tank-mix of fenoxaprop-p-ethyl + 2, 4-D (@ 80 g/ha + 0.25 kg/ha), tank-mix of fenoxaprop-p-ethyl + isoproturon (@ 80 g/ha + 0.40 kg/ha) and isoproturon @ 0.75 kg/ha in the sub-plot replicated thrice in a split – plot design. All the herbicides were applied as post – emergence at 30 days after sowing (DAS) of wheat using 350 liters of water per hectare. Weed population and dry weight and wheat dry weight, tiller number and leaf area per 10 cm row length although were non-significant across the modified methods of planting. However, skipping one row after every 4 rows recorded significant high wheat leaf area. This resulted in higher leaf area index and grain yield of wheat than in conventional sowing.

Tank-mixes of fenoxaprop-p-ethyl + 2,4-D (80 g/ha + 0.25 kg/ha) and fenoxaprop-p-ethyl + isoproturon (80 g/ha+ 0.40 kg/ha) as post-emergence were equally effective towards reduction of total weed dry biomass and proved superior to other treatments in controlling broad0spectrum weeds. Wheat leaf area (both flag leaf area and on area-basis) was, however, higher in isoproturon @ 0.75 kg/ha alone, which might be due to possible little phytotoxicity to wheat in the tank-mixes. There was no significant variation with respect to tiller number of wheat across weed control treatments. Wheat grain yield in the tank-mixes of fenoxaprop-p-ethyl + 2,4-D (80 g/ha + 0.25 kg/ha), fenoxaprop-p-ethyl + isoproturon (80 g/ha + 0.40 kg/ha and isoproturon (0.75 kg/ha) was significantly higher than in fenoxaprop-p-ethyl (100 g/ha) alone and weedy control.

P-44

Bio-efficacy of SYN-8424 against grassy weeds in wheat

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Weed control spectrum and efficacy of various doses of SYN-8424 in wheat were evaluated during winter season of 2005-2006. The treatments consisted of five doses of SYN-8424 with built in adjuvant (40, 45, 50, 60, 120 g ha^{-1}), SYN-8424 (45 g ha^{-1}) + hasten (500 g ha^{-1}), clodinofop (60 g ha^{-1}), sulfosulfuron (25 g ha^{-1}), fenoxaprop-p-ethyl (100 g ha^{-1}) both with the adjuvant at recommended dose, isoproturon (1000 g ha^{-1}) applied 33 days after sowing, weed-free and weedy checks. Experiment was laid out in a randomized block design with three replications. All the herbicides were sprayed at 500 g ha^{-1} spray volume. Wheat variety UP- 2382 at a row spacing of 20 cm was sown on December 22, 2005. The major weeds of the experimental field as recorded at 30 days after sowing were *Phalaris minor* (38%), *Medicago denticulata* (15.8%), *Melilotus* spp. (13%), *Coronopus didymus* (7.7%)), *Chenopodium album* (7%), *Polygonum plebijum* (5.3%), *Rumex acetosella* (5.3%), *Cyperus rotundus* (2.6%), *Anagallis arvensis* (2%). Other weeds like *Vicia sativa*, *Fumaria parviflora* and *Avena fatua* constituted 3.3 per cent of the total weed population.

Spray of SYN-8424 with the built in adjuvant was 20 per cent more effective as compared to that of adding adjuvant separately. SYN-8424 at 50 g ha^{-1} recorded light yellowing of crop plants at 7th day of application which recovered subsequently. New leaf curling of wheat was noted with the use of SYN-8424. Contact leaf yellowing of the crop was observed by the application of fenoxapprop-p-ethyl after 3 day of its spray but the new leaves were not affected. Uncontrolled weeds on an average reduced the grain yield of wheat by more than 46 per cent. The grain yield was increased significantly due to different herbicidal treatments over weedy check. All the herbicides except SYN-8424 at 60 g ha^{-1} with built in adjuvant and SYN-8424 at 45 g ha^{-1} with hasten at 500 g ha^{-1} gave wheat grain yield at par with weed free treatment. Increasing dose of SYN-8424 from 40 to 120 g ha^{-1} reduced grain yield of wheat but the difference was non-significant. Clodinofop at 60 g ha^{-1} was also effective against grassy weeds as compared to fenoxaprop-p-ethly, sulfosufuron and isoproturon. These herbicides were not effective against non-grassy weeds and sedges and produced wheat grain yield at par with weed free treatment.

P-45 Effect of rates of Hancer (isoproturon 50%+ 2, 4 d ethyl ester 10%wp) on wheat and associated weeds

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A field experiment was conducted during *rabi* season of 2005-06 and 2006-07 at GBPUA&T, Pantnagar to evaluate the weed control efficacy of Hancer (isoproturon 50%+ 2,4 D ethyl ester 10% WP) at various doses i.e. 1500, 1750, 2000, 2250 and 2500 g ha^{-1} on mixed weed flora and grain yield of wheat". It was compared with clodinafop-propargyl 400 g ha^{-1} and sulfosulfuron at 33.3 g ha^{-1}, weed-free and weedy-check. All these treatments were replicated thrice a in randomized block design. Wheat variety UP2382 at 100 kg seed/ha was sown on December 9,2005 and December 8, 2006 at a row spacing of 20 cm apart. The herbicides were applied as spry at 35 days stage of crop.

The major weeds in the experimental fields were: *Phalaris minor* among grasses and *Chenopodium album, Melilotus* spp., *Medicago denticulata, Rumex acetosella* and *Coronopus didymus* among broad leaved weeds. Hancer at all the doses provided control of *P. minor, C. album, Melilotus spp., M. denticulata, R. acetocella* and *C. didymus*. Buts its efficacy at 2000 2250 and 2500 g ha^{-1} were higher than that at 1500 and 1750 g ha^{-1} against weeds. The weed control spectrum and efficiency of Hancer at 2500 g ha^{-1} was comparable to that of sulfosulfuron 33.3 g ha^{-1} and clodinafop-propargyl at 400 g ha^{-1}. The effect of Hancer and other treatments on total weed dry matter production was similar to that of weed density. Weed competition in weedy plots caused 63.1 and 62.0 per cent reduction in the grain yield of wheat during 2005-06 and 2006-07, respectively. Highest grain yield was recorded under weed free treatment. There was significant increase in the grain yield of wheat of under hancer at various doses and other herbicides over weedy check. Hancer at 2250 and 2500 g ha^{-1} and sulfosulfuron at 33.3 g ha^{-1} produced wheat grain yield at par with weed free conditions and these were significantly higher than clodinafop-propargyl.

P-46 Effect of Pinoxaden 5EC on weeds in wheat crop

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A field trial was conducted during rabi season of 2005-06 and 2006-07 at G.B. Pant University of Agriculture & Technology Pantnagar 263145 Udham Singh Nagar (Uttrakhand) to evaluate the bio-efficacy of various doses of a new herbicides molecule i.e. pinoxadon 5 EC at 35,40,45,50,100 and 200 g a.i./ha against grassy weeds of wheat. Clodinafop propargyl at 60 g and salfosulfuron at 25 g a.i./ha along with weed free and weedy check were kept for comparison. Wheat variety 'PBW-343' was sown on December 02, 2005 and December 08, 2006 with a row spacing of 20 cm. Herbicide application was done at 30 days after sowing (DAS).

Phalaris minor, Chenopodium album, Medicago denticulata, Coronopus didymus, Melilotus indica, and *Rumex acetosella* were the major weed species in the experimental field. All the weed control treatments caused significant reduction in the density and dry weight of total weeds over weedy check at 60 days stage of crop growth. The lowest density and dry weight of weeds were recorded with sulfosulfuron at 25 g a.i./ha + surfactant at 1250 ml/ha which was followed by pinoxaden at 45 or 50 g a.i./ha. application of pinoxaden 45 or 50 g a.i./ha at 30 days after sowing was very effective for the control of *phalaris minor*.

Uncontrolled weeds caused 46.7 and 50.6% reduction in the grain yield of wheat during 2005-06 and 2006-07, respectively, when compared with weed free condition. All the herbicides caused significant increase in grain yield of wheat over weedy check. The highest grain yield was obtained with weed free treatment which was at par with sulfosufuron at 25 g a.i./ha. Irrespective of rates of application of pinoxaden and clodinafop propargyl at 60 g ha^{-1}, the highest grain yield of wheat was noticed with pinoxaden at 50 g a.i. ha^{-1} which was at par with pinoxaden at 45 g a.i./ha.

P-47 Chemical weed control in hybrid maize (*Zea mays* L.)

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The field experiment was conducted at Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during *Kharif,* 2005 and 2006 to devise an effective and economic weed control technique in hybrid maize. The trial was fitted in randomized block design with three replications and 10 treatments. The soil was acidic in reaction and sandy loam in texture with low in available N and medium in available P and K status. The hybrid maize variety 'MRM-3765' was sown on 17th and 22nd June 2005 and 2006, respectively. The treatments consisted of pre-emergence application of pendimethalin @ 1 kg/ha, alachlor @ 1 kg/ha, atrazine @ 0.75 kg/ha, atrazine @ 0.375 kg + pendimethalin @ 0.5 kg/ha, atrazine @ 0.375 kg + alachlor @ 0.5 kg/ha and hand hoeing at 20 DAS alone or with post-emergence spray of paraquat @ 0.5 kg/ha or 2, 4-D amine salt @ 0.5 kg/ha at 40 DAS and hand hoeing and weeding at 20 and 40 DAS were compared with un weeded control.

The major narrow leaved weeds were *Digitaria ciliaris, Echinochloa colona, Paspalum scrobiculatum, Eleusine indica, Sporobolus diander* and *Dactyloctenium aegyptium.* The most prevalent broad leaved weeds were *Commelina benghalensis, Melochia corchorifolia* and *Ageratum conyzoides.* Hand weeding twice remarkably reduced the monocot and dicot weed density and weed biomass and also increased WCE. It was followed by alachlor and atrazine treatments which remained at par with twice hand weeding. The crop growth and yield attributes along with grain (5699q/ha) and stover (73.64 q/ha) yields were significantly enhanced with alachlor @ 1 kg/ha being at par with atrazine @ 0.75 kg/ha. Unchecked growth of weeds depressed the yield to the tune of 73.73% in hybrid maize. The maximum depletion of nutrients (59.25 kg N, 12.40 kg P and 69.25 kg K/ha) was observed in unweeded control. Pre-emergence application of alachlor @ 1 kg/ha resulted in maximum uptake of nutrients (126.7 kg N, 52.58 kg P and 138.85 kg K/ha) by hybrid maize followed by atrazine @ 1 kg/ha. Alachlor registered the highest net profit Rs. 22276.00/ha and net productive value (1.68) followed by atrazine giving the corresponding values of Rs. 222033.60 q/ha and 1.64, respectively.

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Weed control in maize (*Zea mays* L.) based intercropping system under rainfed condition

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An experiment was conducted at Birsa Agricultural University farm, Ranchi during *Kharif* season of 2004 and 2005 to study the effect of cropping system and weed control on weeds and productivity of crops. The soil of the experimental plot was sandy loam in texture having available N (261.6 kg/ha), available P (21.5 kg/ha) and available K (195 kg/ha) with pH (5.9). The experiment was conducted in split-plot design with three replications. The treatments in the main plots were: five cropping system viz. maize sole (75 cm), soybean sole (30 cm), groundnut sole (30 cm), maize + soybean (1:2) and maize + groundnut (1:2). In sub-plots, 5 weed management practices i.e. weed control treatments were: weedy check, hand weeding at 15, 30 and 45 DAS, oxyfluorfen 0.2 kg/ha, pre-emergence, alachlor 2.0 kg a.i., pre-emergence, butachlor 1.5 kg/ha, pre-emergence + quizalofop-ethyl 100 ml/ha, as post-emergence.

The dominant weeds were: bermuda grass (*Cynodon dactylon* (L.) Pers, crow footgrass (*Dactyloctenium aegyptium* (L.) willd), barnyard grass (*Echinochloa crusgalli* (L.) Beuwv), goose grass (*Eleusine indica* (L.) Gaertn), torpedo grass (*Panicum repens* (L.)), pigweed (*Amaranthus viridis* (L.)), floss flower (*Ageratum conyzoides* L.), day flower (*Commelina benghalensis* L.), cock's comb (*Celosia argentea* L.), niruri (*Phyllanthus niruri* L.) and purple nut ledge (*Cyperus rotundus* L.). Intercropping of maize with soybean and groundnut effectively reduced the weed density and dry weight of weeds at 30 and 60 days after sowing compared to their pure cropping. The grain yield of maize under intercropping was on a par with that obtained under its pure cropping during the individual year of the experimentation. However, on the basis of two years pooled data the grain yield of maize was significantly influenced by cropping system. The grain yield of maize obtained under maize + soybean (1:2) intercropping was statistically at par with that obtained under its pure cropping and were significantly superior to the grain yield obtained under maize + groundnut intercropping system but significant reduction (24.6% and 18.7%) in grain yield of soybean and groundnut was noticed in intercropping systems compared with its sole cropping. Maize equivalent yield in maize + groundnut (1:2) and maize + soybean (1:2) intercropping system was statistically alike (6608 kg/ha and 6344 kg/ha, respectively). Hand weeding at 15, 30, and 45 days after sowing was comparable with pre-emergence application of oxyfluorfen 0.2 kg/ha in reducing the population of weeds and weed dry matter production at 30 and 60 days after sowing. oxyfluorfen 0.2 kg/ha proved equally effective and as good as hand weeding in increasing the grain yield of maize, soybean and groundnut. Hand weeding at 15,30 and 45 days after sowing gave the highest maize equivalent yield (5947 kg/ha) which was statistically at par with the equivalent yield obtained with pre-emergence application of oxyfluorfen 0.2 kg/ha (5602 kg/ha).

P-49 Weed dynamics, productivity and net monetary returns as influenced by winter maize (*Zea mays*) based intercropping systems in central Uttar Pradesh

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A field experiment was carried out for two consecutive winter seasons of 2003-04 and 2004-05 on sandy loam soil at Kanpur to study the effect of different *rabi* crops on wed dynamics, productivity and net returns of winter maize-based intercropping systems. The treatments comprised sole cropping of maize and six intercropping systems viz., maize + potao (1+1), maize + Indian mustard (1+1), maize + toria (1+2), maize + pea (1+2), maize + linseed (1+2) and maize + wheat (1+2) sown in between two rows of winter maize. The results revealed that intercropping of pea was most effective in smothering weeds (58.9%) and toria (54.6%) grown as intercrop. All the intercropping systems recorded significantly lesser weed dry-matter accumulation over sole cropping of maize. Lowest weed dry-matter accumulation was recorded with maize+toria, which was at par with maize + pea. Maize + potato registered the highest maize grain yield (60.90 q/ha) followed by maize + pea (53.50 q/ha) over sole maize (49.91 q/ha) and other intercropping systems under study. Toria, Indian mustard and wheat reduced maize yield by 80.77, 47.71 and 59.97%, respectively. Maize + potato intercropping system gave highest mean maize equivalent yield of 137.91 q/ha with net return of Rs. 32369/ha followed by maize + pea (92.63 q/ha and Rs 27679/ha) as against 49.21 q/ha and Rs. 7800/ha with sole cropping of maize.

P-50 Efficient weed control method in intercropping of maize and urdbean

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A field experiment involving treatment combinations of different intercropping viz., 1:1, 2:1 and 2:2 row ratios with four weed control methods viz., weedy check, hand weeding at 25 DAS, alachlor @ 2 kg a.i/ha and alachlor @ 1.5 kg a.i/ha + hand weeding at 40 DAS was conducted during kharif seasons of 2003 to 2005 consecutively under rain fed situation of Agricultural Research Station, Kathalagere. Higher productivity (63.29 q/ha) noticed in alachlor @ 1.5 kg /ha + HW @ 40 DAS and hand weeding @ 25 DAS (62.50q/ha) compared to alachlor @ 2kg /ha (57.19q/ha) indicates beneficial effect of integrated approach in weed control. Increase in integrated approach was noticed to be 64.4% over the weedy check indicates productivity can be easily increased and sustained provided intercropping approach is handled. Higher benefit cost ratio of 1.92, 1.76 and 1.60 recorded for 2:2, 2:1 and 1:1 planting pattern indicated profitability of having the better spacing of 2:2 compared to rest of the row ratios. Paired row of maize with two rows of urdbean exhibited its effective utility of the natural resources compared to other intercrops by recording land equivalent ratio ranged from 1.38 to 1.68 under the weed control methods evaluated.

P-51 Integrated weed management in lowland rice through physical, cultural and chemical methods

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A field experiment was conducted at Tirupati campus of A.N.G.Ranga Agricultural University, S.V Agricultural College during two consecutive *rabi* seasons of 2003 and 2004 in a split plot design to evaluate the efficiency of microherbicides under different puddling and water management practices. Puddling and water management practices had significant effect on weed growth and yield of transplanted rice. Intensive puddling with continuous submergence (IPCS) recorded the lowest weed density and dry weight, highest stature of yield attributes *viz.*, panicles m^{-2}, total and filled grains $panicle^{-1}$, panicle length, 1000 grain weight and yield with higher economic returns. It was comparable with intensive puddling with irrigation at 1 day after disappearance of ponded water (IPDDPW) but the lowest water requirement and the highest WUE were registered with IPDDPW followed by IPCS. The increase in grain yield was 40.10, 31.18, and 13.62 percent in IPCS, IPDDPW and normal puddling with continuous submergence (NPCS) over normal puddling with irrigation at 1 day after disappearance of ponded water (NPDDPW). Among the weed management practices, oxadiargyl at 75 g ha^{-1} + HW at 40 DAT recorded the highest values of all the yield attributes, yield and economic returns with lesser weed density and dry weight. On an average, the increase in grain yield was 39.49 and 34.23 percent with oxadiargyl at 75 g ha^{-1} + HW at 40 DAT and HW twice at 20 and 40 DAT, respectively over unweeded check.

P-52 Correlation studies in maize + urdbean intercropping under different weed management practices

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A field experiment was conducted at ARS Kathalagere during *kharif* season of 2003 to 2005 with treatment combinations of different row ratios of maize + urdbean under different weed management practices. Correlation coefficients for maize grain yield in intercropping with plant height, 100 seed weight and stover yield were evaluated for their relation

Positive significant correlation coefficient noticed for maize grain yield Vs 100 seed weight are in the range of 0.53 to 0.87, 0.60 to 0.82, 0.48 to 0.70 and 0.43 to 0.95 under the treatments sole maize, 1: 1, 2:1 and 2:2 row ratios respectively. Similarly for grain yield Vs stover yield, correlation coefficient are in the range of 0.46 to 0.87, 0.39 to 0.92, 0.72 to 0.96 and 0.89 to 0.97 under same treatments respectively. Higher correlations were noticed for weed control methods of hand weeding with or without weedicide.

Treatment combination paired row of maize + two rows of urdbean with alachlor @ 1.5 kg/ha + HW @ 40 DAS recorded higher correlation coefficient i.e., 0.95and 0.96 for grain yield *Vs* 100 seed weight and *Vs* stover yield respectively. This indicated superiority of the 2: 2 intercropping with integrated weed management. Positive correlation noticed between 100 seed weight and stover yield in the weed control methods are in the range of 0.17 to 0.85, 0.13 to 0.82, 0.52 to 0.64 and 0.71 to 0.96 in sole maize, 1: 1, 2:1 and 2:2 row ratios respectively. Paired row of maize + two rows of urdbean with alachlor @ 1.5 kg/ha + HW @ 40 DAS recorded higher correlation coefficient (0.96). Maize grain yield in intercropping is having good association with characters 100 seed weight and stover yield. This has been reflected in higher productivity for paired row of maize with two rows of urd bean intercropping under weed control methods alachlor @ 1.5 kg/ha + HW @ 40 DAS.

P-53 Efficiency evaluation of manually operated weeders on weed control and productivity of irrigated maize

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Maize (*Zea mays* L.) is the third most important cereal crops, and no cereal crop on the earth that has so much yield potential as that of maize. As the crop is heavily fertilized and sparsely grown, severe weed infestation is experienced, resulting in to a drastic reduction of grain yield. Manual weeding is laborious, back breaking and time consuming and hence efficient mechanical weeders help to obtain expected yield. Recently developed manually operated weeders weeding efficiency has not so for been evaluated. Hence, a field experiment was conducted during *kharif* 2006, to evaluate the efficiency of different manually operated weeders on weed control and productivity of irrigated maize. The treatments consisted of four manually operated weeders *viz.*, crescent hoe , multi tyne, wheel hoe and rotary peg weeders weeding on 25 and 45 DAS and were compared with hand weeding on 25 and 45 DAS, PE atrazine 0.5 kg ha^{-1} on 3 DAS + HW on 45 DAS and unweeded control in randomized block design with three replication.

Results revealed that PE atrazine 0.5 kg ha^{-1} on 3 DAS + HW on 45 DAS reduced the weed density and dry weight and enhanced the WCE and yield. Among the mechanical weeders, wheel hoe weeding twice efficiently suppressed the weed growth and recorded a grain yield of 4814 kg ha^{-1}, comparable to the best treatment. It could be concluded that PE atrazine 0.5 kg ha^{-1} on 3 DAS + HW on 45 DAS can keep the weed density and dry weight below the economic threshold level and increase the yield. Among the mechanical weeders evaluated wheel hoe is a promising weeding tool for maize.

P-54 Weed management in *rabi* maize + potato intercropping system

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A field experiment was conducted at the Rajendra Agricultural University, Bihar, Pusa during winter (*rabi*) seasons of 2004-05 and 2005-06 to study the effect of weed management practices on weed control and yield of maize + potato intercropping system. The highest maize grain equivalence yield (165.7 q/ha) was recorded in hand weeding (twice). Amongst the chemical and cultural treatments, atrazine 0.5 kg/ha + hand weeding at 50 days after sowing (DAS) recorded the highest maize grain equivalent yield (142.9 q/ha) followed by atrazine 0.5 kg/ha + earthing up (141.5 q/ha), isoproturon 0.75 kg/ha + earthing up (140.9), alachlor 1.5 kg/ha + hand weeding at 50 DAS (138.9). the lowest maize grain equivalent yield was recorded in weedy check. All the weed management practices significantly reduced the weed density of grasses, sedges and broad-leaf weeds, resulting in their reduced dry weight. The highest weed control efficiency (76.44%) was recorded with hand weeding (twice) followed by atrazine 0.5 kg/ha + hand weeding at 50 DAS (66.25%). Maximum net return was recorded under hand weeding (twice) which was at par with atrazine 0.5 kg/ha + one hand weeding at 50 DAS.

P-55 Evaluation of potentiality of different age of Sesbania on weed dynamics and yield of transplanted rice (*Oryza sativa* L.)

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The field experiments were conducted at National Research Centre on Weed Science, Jabalpur during *kharif* seasons of 2004 and 2005, to evaluate the potentiality of different age of Sesbania on weeds and grain yield of transplanted rice.The experiments consisted of four age of Sesbsnia (30,45,60and75 days old) was carried out in randomized block design and replicated four times. The data averaged over two seasons revealed that different age of Sesbania had marked influence on density and dry weight of weeds, yield attributing traits and grain yield of transplanted rice. The density and dry weight of weeds (*Echinochloa colona*, *Eclipta alba*, *Alternanthera philoxeroides* and *Cyperus iria*) were higher in plots receiving 30 days old Sesbania but scaled down correspondingly with increase in age of Sesbania being the minimum in plots receiving oldest age of Sesbania (75 days). The yield attributing traits (effective tillers per hill, weight of panicle and test weight) and grain yield of rice were also influenced significantly by age of Sesbania. The lower values of yield attributes including grain yield (33.96 q/ha) were recorded in plots receiving 30 days old Sesbania but the yield attributing traits and grain yield (45.20 q/ha) attained the maximum values when 60 days old Sesbania was incorporated in the plots. The latter age of Sesbania proved more remunerative in terms of NMR (15340) and benefit over per rupee of investment (2.20) than early (30 days) and old aged (75 days) Sesbania.

P-56 Integrated weed management in maize - groundnut cropping system in southern Telangana zone of Andhra Pradesh

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A field experiment was conducted on sandy loam soils of medium fertility status during 2006-2007 at College Farm, College of Agriculture, Acharya N.G.Ranga Agricultural University, Rajendranagar involving maize – groundnut system which is the predominant system in southern, central and northern Telangana zones of Andhra Pradesh. The main objective was to study the effect of different weed management practices on shift in weed flora and integrated control of weeds in maize- groundnut system. The treatments include, atrazine@ 1.0 kg a.i/ha; maize + cowpea; maize + cowpea with pendimethalin 0.5 kg/ha; atrazine 0.75 kg/ha fb mechanical weeding and farmers practice of weeding twice as main plots to *kharif* maize and weed control treatments like hand weeding at 20 & 40 DAS, pendimethalin 1.0 kg/ha and unweeded control for *rabi* groundnut. The experiment was laid out in split plot design with three replications.

The dominant weed flora of the experimental field was *Cyperus rotundus, Cynodon dactylon, Panicum spp, Parthenium hysterophorus, Legasca mollis , Euphorbia geniculata, Commilina benghalensis* and *Trichodesma indica.* The results revealed that atrazine either at 1.0 kg ha^{-1} or 0.75 kg ha^{-1} fb mechanical weeding resulted in good broad leaved weed control and higher yield in maize(6335 and 6629 kg ha^{-1}) ; where as farmers practice of weeding twice on 20 & 40 DAS resulted in lowest weed dry matter(22gm^{-2}) and higher pod yield(1496kg ha^{-1}) of *rabi* groundnut followed by pendimethalin @ 1.0 kg ha^{-1}(714 kg ha^{-1}). Highest weed dry matter recorded with maize + cowpea clearly suggested that the purpose of growing cowpea as intercrop to smother weeds was defeated. Weed control treatments applied to *rabi* groundnut did not influence the *kharif* maize with regard to weed dry matter.

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Enhancement of production of pigeonpea due to adoption of integrated weed management system

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Integrated weed management helps in reducing the weed population without much adverse effect on crop growth characters, drymatter and yield. Therefore, the experiment on integrated weed management in pigeonpea variety BSMR-736 was conducted during 2003 in a randomized block design with three replications and nine treatments combinations comprises of mechanical, herbicidal, mechanical coupled with herbicide and a control treatment.

The results revealed that the values of all growth characters and yield attributes of pigeonpea were significantly more in weed free plot. This was followed by integrated weed management treatment viz. pendimethalin @ 1.0 kg ha^{-1} as pre emergence of hand weeding at 45 days after sowing (DAS). However, the values of growth attributes and yield of pigeonpea in integrated weed management treatment viz. pre emergence application of pendimethalin @ 1.0 kg ha^{-1} one hand weeding at 45 DAS recorded a mean plant height (178.05 cm), mean plant spread (88.93 cm), mean number of branches (14.20), dry matter per plant at 120 DAS (61.13 g) and increased values of these characters ultimately resulted in good seed yield (22.30 q ha^{-1}). The lowest seed yield was recorded in weedy check (15.12 q ha^{-1}).

Weed intensity and weed dry matter at harvest were significantly less in weed free treatment followed by integrated weed management treatment, whereas it was maximum in weedy check (206.57 m^2 and 12.22 q ha^{-1}, respectively) treatment. Maximum net returns Rs. 18605/- and B:C ratio (2.23) were obtained due to pendimethalin @ 1 kg ha^{-1} plus as pre emergence hand weeding at 45 DAS followed by weed free treatment. The benefit cost ratio was maximum (2.23) in same IWM treatment due to higher value of pigenpea and less cost of cultivation.

P-58 Integrated weed management in summer groundnut (*Arachis hypogaea* L.)

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To evaluate different weed management treatments for controlling weeds thereby increasing the yield of summer groundnut. Field experiments were conducted for three consecutive summer seasons of the year 2001, 2002 and 2003 at the integrated Oil Seed Research Scheme, Navsari Agricultural University, Navsari. The experimental soil was clayey in texture, low in nitrogen (0.059%), medium in phosphorus (24.8 kg ha^{-1}) and high in potassium (377 kg ha^{-1}) with pH 7.5. Nine treatments comprised of local method of two hand weeding (H.W.) and interculturing (I.C.) at 25 & 45 days after sowing (DAS), fluchloralin @ 1.20 kg ha^{-1} as pre-emergence, fluchloralin @ 0.9 kg ha^{-1} + one H.W. and 45 DAS, pendimethalin @ 1 kg/ha as pre-emer, pendimethalin @ 0.75 kg/ha + one H.W. at 45 DAS, oxyfluorfen @ 0.2 kg ha^{-1} as pre-emer, oxyfluorfen @ 0.15 kg ha^{-1} as pre-emer. + one H.W. at 45 DAS, weed free and unwedded control were tested in randomized block design replicated thrice. The crop was sown at a spacing of 45 x 10 cm using seed rate of 100 kg ha^{-1} in the first week of February in first two years and in the last week of January in the third year and was harvested in the last week of May. It was fertilized with 25-50-00 NPK kg ha^{-1}. All the herbicides were applied at 3 DAS as pre-emergence.

Pod and fodder yield, dry weight of weeds and net realization were significantly influenced due to various treatments in all the individual years and in pooled while plant stand remained unaffected in all observations. Looking to pooled analysis, pendimethalin @ 0.75 kg ha ha^{-1} + one H.W. at 45 DAS recorded significantly the highest pod yield (3477 kg ha^{-1}), the lowest dry weight of weeds (1421 kg ha^{-1}) and maximum net realization (Rs. 39995/ha) while the highest fodder yield (5885 kg ha^{-1}) was obtained under (weed free). The higher profitable pod yield of summer groundnut could be obtained by keeping the crop weed free by applying pendimethlin @ 0.75 kg ha^{-1} coupled with one hand weeding at 45 days after sowing.

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Weed Management in *Kharif* groundnut

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Weed infestation is a major limiting factor in *Kharif* groundnut production. Depending on weed intensity, the yield reduction in groundnut may be as 76%. Thought traditional method of weeding is effective, due to non-availability of labourers in time and like in labour wages the crop production programme under hand weeding (HW) many a times becomes nonremunerative. Chemical weed control was found to be the best alternative to manual weeding in the initial stages of growth, Keeping this in view, a field experiment was conducted to find out sound, effective and economical weed management technique for *Kharif* groundnut.

The field experiment was conduct at Central Research Station, OUAT, Bhubaneswar consecutively for three wet seasons (2003-2005). The treatments comprising of pre-plant incorporation of trifluralin (1.25 kg/ha), pre-emergence application of pendimethalin, alachlor and butachlor each at (1.25 kg/ha and oxyfluorfen at 0.06 kg/ha, post-emergence application of quinol-fop-p ethyl (0.075 kg/ha), farmer's method of weeding and unweeded check were tried in a randomized block design with three and replications.

The weed flora of the experimental plot was dominated by *Echinochloa colona Digitaria ciliaris, Dactyloctenium aegyptium, Paspalum scrobiculatum, Cynodon dactylon, Celosia argentea, Cleome viscosa, Cyperus rotundus and Fimbristylis miliaeea.* Form the observation taken at various stages, it was observed that most of the grassy weeds were effectively controlled by trifluralin, oxyfluorfen, alachlor, pendimethalin and butachlor. But the population of braodleaf weed was affected little. Pre-emergence application of oxyfluorfen effectively controlled most of the broadleaf weeds specifically *Celosia argentea* and the effect persisted up to harvest of the crop. With the advent of the time there was a shift in weed category from grasses to broad leaf weeds in almost all the treated plots barring oxyfluorfen. The grassy weeds were most effectively controlled by application of quizol-fop-ethyl at 25 DAS. Among the broad leaf weed. The emergence percentage of *Celosia* varies from 9 to 34%. The highest pods/plant. (19) and pod yield (1795 kg/ha) were obtained from oxyflurorfen treated plots due to effective control of *Celosia* from the initial stage of crop growth. Three year data conclusively revealed that all the weed control treatments were effective in *Kharif* groundnut significantly increasing yield over control with varying WCE of 70 to 85% and B:C ratio of 1.71 to 1.76.

P-60

Effect of soil solarization on weed control, growth and yield of groundnut crop in conjuction with cultural and chemical method of weed control

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An experiment was conducted during 2003-2004 on loamy sand at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of soil solarization on weed control, growth and yield of groundnut crop in conjunction with cultural and chemical method of weed control under North Gujarat condition. Treatments consisted of two thickness of TPE (0.025 mm and 0.050mm) with three durations of soil solarization (15, 30 and 45 days) along with cultural (weed free and H.W + earthing up) as well as chemical method. (pendimethalin @ 1.0 ha^{-1}) of weed control with standard weedy check as control were studied in randomized block design with four replications.

The results revealed that soil solarization with TPE 0.025mm for 45 days increased the soil temperature to extent of 10.6 °C and 8.6 °C over non solarized at 5 & 10 cm depth of soil, respectively. The minimum count and dry weight of grasses, broad leaved, sedges and total were recorded in weed free , followed by H. W. + earthing up and TPE 0.025mm for 45 days at 30 and 60 DAS. While, grasses, broad leaved, sedges and total weed population and dry weight of weeds at 90 DAS and harvest were decreased under weed free, followed by TPE 0.025mm for 45 days. These treatments also followed the same trend for dry weed biomass. While, maximum WCE was recorded in weed free, followed by soil solarization with TPE 0.025mm for 45 days. The weed index was lowest under TPE 0.025mm for 45 days. Maximum plant height, number of branches and leaves, leaf area, LAI, dry matter accumulation in leaves, stem, pods and TDM at their respective stages were recorded under soil solarization with TPE 0.025mm for 45 days.

With regards to yield attributing characters, the maximum number of pods (22.24), pod weight (20.23$gplant^{-1}$),test weight (55.00 g), shelling percentage (70.63) and kernel yield (19.63qha^{-1}) and pod yield of groundnut (27.68 qha^{-1}) were registered under soil solarization with TPE 0.025mm for 45 days followed by weed free. Likewise, haulm yield and oil contents observed higher under soil solarization with TPE 0.025 mm for 45 days and was on par with weed free and H.W. + earthing up. It can be concluded that soil solarization with TPE 0.025mm for 45 days was found effective in controlling weed population as well as dry weight of weeds and producing higher yield of groundnut.

P-61 Effect of different weed control methods on weed flora, growth and yield of summer groundnut (*Arachis hypogaea* L.)

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Groundnut is an important leguminous cum oilseed crop in India. Productivity of groundnut in India is around 1042 kg/ha as compared to 6833 kg/ha in Israel and 2842 kg/ha in USA. The first 3 to 4 weeks of crop growth period are critical for weed control in groundnut and uncontrolled weeds reduce yield up to 35-40 per cent. A field experiment was conducted during summer 2000 to 2003 at, Regional Research Station, Sardarkrushinagar (North Gujarat) to find out suitable method of application along with concentration of pendimethalin for checking weed and growth, yield and economic under summer conditions. The experiment was laid out in randomized block design with four replications, having twelve treatment viz. spraying pendimethalin @ 0.75 and1.0 kg ha^{-1} with and without one interculturing, pendimethalin @ 0.75 and 1.0 kg ha^{-1} mixing with soil and broadcasting with and without interculturing, pendimethalin @ 0.75 kg ha^{-1} with first irrigation, two interculturing and two hand weeding at 25 and 35 DAS, weed free and weedy check were tried. The groundnut variety 'GG-2' was sown at 30 cm apart with basal dose of 25kgN and 50kg P_2O_5 was applied. The pooled results revealed that significantly the highest pod yield (2951 kg ha^{-1}) and haulm yield (5871 kg ha^{-1}) were produced in weed free plot and it was at par with pendimethalin +one interculturing treatment The dry weight of weeds was minimum (347 kg ha^{-1}) under weed free treatment with highest WCE (81.43%) and net returns of Rs. 44014 ha^{-1} with BCR (3.31). From the results, it could be concluded that under shortage of labour, pendimethalin 1.0 kgha^{-1} in 500 litre of water as pre-emergence application with one interculturing at 25 DAS. whereas, under sufficient availability of farm labours, keep weed free crop up to 60 days with two Interculturing at 25 & 35 DAS and three hand weeding at 25, 35 and 60 DAS for higher yield and returns.

P-62

Integrated weed management in soybean (*Glycine max* (L.) Merrill)

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A field experiment was carried out on *Vertisols* at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2003 under rainfed condition. The soybean was grown during *kharif* season and environment was more conducive for excessive weed infestation. The experiment comprising of 15 treatments *viz.*, imazethapyar @ 50,75,100 and 125g ha^{-1} with and without hand weeding, chlorimuron @ 9.37g ha^{-1} and pendimethalin @ 750g ha^{-1} with and without hand weeding, farmer's practices (two hand weeding + one intercultivation), weed free and weedy check were replicated thrice and laid out in randomized complete block design.

Imazethapyar @ 75g ha^{-1} and 100g ha^{-1} alone and with hand weeding were found effective in reducing both population and dry weight of weeds and also recorded higher weed control efficiency (72.40, 71.93, 87.58 and 84.15, respectively).There was an improvement in growth and yield components of soybean with the application of imazethapyar @ 75g ha^{-1} alone and with hand weeding recorded significantly higher seed yield (2351 and 2424 $kgha^{-1}$)as compared to imazethapyar @ 50 g ha^{-1} (2015 $kgha^{-1}$). Weedy check recorded significantly lower seed yield (1329 $kgha^{-1}$). Further application of imazethapyar @ 75 and 100g ha^{-1} alone and with hand weeding recorded significantly higher nutrient uptake by crop compare to imazethapyar @ 50g ha^{-1} and vice versa with respect to uptake of nutrients by weeds. The study revealed that integration of imazethepyr @ 75g ha^{-1} applied as a post-emergence and along with hand weeding was effective for efficient weed control, higher yield in soybean.

P-63 Effect of integrated weed management on growth, yield attributes and yield of soybean (*Glycine max* L.)

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A field experiment was conducted at Agricultural Research Station, Ummedganj, Kota during *Kharif* 2005 to study the Effect of integrated weed management on growth, yield attributes and yield of soybean (*Glycine max* L.). The experiment was carried out in randomized block design comprising eight treatments viz T_1: In situ mulching with weeds at 30 DAS, T_2: polythene mulching (pre-emergence), T_3: quizalofop ethyl @ 50 g ai/ha + chlorimuron ethyl @ 9 g/ha as POE,T_4: quizalofop ethyl @ 50 g ai/ha as POE, T_5: clomazone ethyl @ 1 kg/ha as PE,T_6: clomazone ethyl @ 1 kg/ha as PE + one hand weeding at 30 DAS,T_7: Two hand weeding at 20 and 40 DAS and T_8: weedy check with three replications. The soil of the experimental field was clay loam, alkaline in reaction (pH 7.7), low in organic carbon (0.41 %), medium in potassium (291.5 kg/ha) and low in available phosphorus (20.5 kg/ha) and sulphur (15.5 kg/ha). The recommended dose of nitrogen and phosphorus (20 & 60 kg/ha) was given through diammonium phosphate. The variety of soybean (Pratap Soya-1) was used in this experiment. Results revealed that hand weeding twice at 20 & 40 DAS significantly reduced weed population and dry weight at 30 and 60 DAS, respectively. Hand weeding twice also increased significantly number of branches/plant (9.33), pods/plant (175), seeds weight (11.3g), seed yield (2278 kg/ha), straw yield (2975 kg/ha) and net return (Rs. 16627/ ha) over clomazone ethyle, weedy check quizalofop ethyle, respectively. However, in situ mulching of weeds at 30 DAS gave significantly lower total weed population, dry weight of weeds and higher branches/plant, pods/plant, seed weight, seed ,straw and net return/ha as compared to weedy check, clomazone ethyle and quizalofop ethyl, respectively.

P-64 Integrated weed management in pigeonpea

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A field experiment was conducted during *kharif* season of 2002, 2003 & 2004 at Marathwada Agril. University, Parbhani in a randomized block design comprising of comprising of eight weed management treatments i.e., T1- farmers practice (1 HW at 2 WAS & 3 H at 3, 6 &9 WAS), T2- hand weeding at 30 & 60 DAS, T3- PE pendimethalin 1.00 kg/ha + HW and H at 40- 45 DAS, T4- pigeonpea + soybean (2:4) + PE pendimethalin (@ 0.75 kg/ha + HW at 6 WAS), T5 - pigeonpea + soybean (2:4) + PE Alachlor 2.0 kg/ha + HW @ 6 WAS, T6- pigeonpea (weedy check), T7- pigeonpea + soybean (2:4) (weedy check) and T8- weed free sole pigeonpea crop (weeding at 20 days interval).

The weed panorama in the experimental field revealed that pigeonpea was associated with 50% monocot and 50% dicot weeds during crop growth period. The weed free crop of pigeonpea + soybean recorded the minimum dry weed weight followed by pigeonpea + soybean (2:4) + PE pendimethalin @ 0.75 kg/ha + HW at 6 WAS and both were significantly superior over both the controls.

The highest weed control efficiency was obtained in pigeonpea + soybean (2:4) + PE pendimethalin @ 0.75 kg/ha + HW at 6 WAS for broad leaved weeds at it was highest in pigeonpea + soybean weed free plot followed by pigeonpea + soybean (2:4) + PE pendimethalin @ 0.75 kg/ha + HW at 6 WAS for grassy weeds. The grain yield pigeonpea was significantly affected due to different weed control treatments. The highest (pooled) grain yield and net monetary return were observed in pigeonpea + soybean intercropping + PE - alachlor @ 2.0 kg/ha + HW at 6 WAS which was found at par with pigeonpea + soybean (2:4) + PE pendimethalin @ 0.75 kg/ha + HW at 6 WAS and significantly superior over rest of the weed control treatments. The results of the present investigation thus clearly indicate that the economic and effective weed management in pigeonpea can be achieved by intercropping soybean in pigeonpea with pre-emergence application of alachlor @ 2 kg/ha followed by one hand weeding @ 6 WAS or intercropping of soybean with PE pendimethalin @ 0.75 kg/ha followed by 1 HW at 6 WAS.

P-65 Effect of groundnut varieties/genotypes on weed suppression/tolerance

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The field trials were conducted in *Kharif* and *Rabi* seasons during 2004, 2005 and 2006. Six genotypes (Somnath, TAG 24, TG 3, TMV 2, AK 12-24 and Smruti) were studied with reference to their ability to compete with weeds so that weed intensity could be reduced and the women especially working on their own field are relieved to some extent from sharing heavy burden of weeding. The experiment was conducted in a randomized block design with three replications.

Differential weed count study revealed that *Cyperus compressus, Mitracarpus verticillatus, Bulbostylis barbata, Dactyloctenium aegyptium, Panicum walense and Perotis indica* were the major weed species during *Kharif*, while *M. verticillatus, D. aegyptium, D. ciliaris and P. indica* during *Rabi* season.

Variety 'Somnath' recorded highest number (869.3/m^2) of weeds during *Kharif* and TG 3 recorded the lowest (695. 1) weed count. *Bulbostylis barbata* species found in highest number (236.1/m^2) followed by *M. verticillatus* (190.93/m^2) and *Perotis indica* recorded the lowest average count (25.41/m2). While during *Rabi* season, the highest weed count was recorded under variety AK 12-24 (128.6/m^2) followed by TAG 24 (128.0/m^2) and variety Somnath recorded the lowest weed count (107.3/m^2). During this season, *M. verticillatus* was found in highest number (42.56/ m^2) followed by *D. ciliaris* (32.8/m^2). The plant population of *P. indica* (12.6) was also lowest during *Rabi* season. The weed population during *Rabi* season was, however, far lower than *Kharif* season. Data on dry weight of weeds revealed that variety AK 12-24 recorded the lowest weight (94.9 g/m^2) closely followed by Smruti (122.4 g/m^2) and TG 3(139.5 g/m^2) during both the seasons.

Groundnut variety 'TMV 2' recorded the highest mean yield (18.66q/ha) both under weed free and weedy conditions showing highest yield potential and response to weeding input during *Kharif* season. Groundnut variety Somnath recorded the highest mean yield (24.10q/ha) under weed free conditions showing highest yield potential and response to weeding input during *Rabi* season. Under weedy conditions, however, variety 'TMV 2' yielded the highest (14.72 q/ha). Data on yield losses due to weeds revealed that variety Smruti in *Kharif* and AK 12-24 during *Rabi* seasons recorded the minimum loss indicating highest tolerance to weed infestation. Variety Somnath recorded the lowest tolerance during *Kharif* season.

P-66 Effect of row spacing and weed management practices on density and dry matter of weeds and yield of pea

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A field trail was laid out at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad during *rabi* season, 2005-06. The soil of the experimental field was silt loam in texture and medium in fertility with pH of 7.9. The treatment comprised of three row spacing viz; 20, 25 and 30 cm and five weed management practices viz; weedy, weed free, hand weeding at 20 and 40 DAS, pendimethalin @ 1.0 kg ha^{-1} pre-emergence and quizalofop ethyl @ 50 g ha^{-1} at 20 DAS in a randomized block design with three replications. The sowing of pea variety "Rachana" @ 80 kg seed ha^{-1} was done in lines as per treatment on 7th November, 2005. A common dose of 100 kg DAP was applied as basal to the crop.

The results revealed that row spacing did not cause significant variation in weed density. However, significantly lowest weed dry weight was recorded under widest row spacing of 30 cm as compared to closer one. Application of pendimethalin @ 1.0 kg ha^{-1} (pre- emergence) significantly reduced the weed density and weed dry weight per unit area as compared to hand weeding twice (20 & 40) and quizalofop. Pre- emergence application of pendimethalin @ 1.0 kg ha^{-1} along with row spacing of 30 cm significantly reduce the weed density and weed dry weight as compared to rest of the treatment combinations. The significantly higher seed yield was registered under wider spacing (30 cm) as compared to 20 and 25 cm. Weed free treatment provided the highest seed yield which was significantly higher than herbicide, hand weeding and weedy treatments

P-67 Effect of fertilizers and weed management practices on weed control in Chickpea *(Cicer arietinum L)* under middle Gujarat conditions

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A field experiment was conducted at College Agronomy Farm, Anand Agricultural University, Anand during *Rabi* seasons of the years 2003-04 and 2004-05 to study the effect of fertilizers and weed management practices on weed control in chickpea *(Cicer arietinum* L*)* under middle Gujarat conditions. The results revealed that fertilizer treatments did not show significant influence on density and dry weight of weeds, no. of pods plant^{-1} and weight of 100 seeds (g), but recorded significantly higher seed and straw yields under application of 5 t ha^{-1} FYM than others barring 5 t ha^{-1} FYM + 1.5 kg ha^{-1} Mo. Application of oxadiargyl @ 0.075 kg ha^{-1} and IC+HW carried out at 20 and 40 DAS recorded minimum density and dry weight of weeds with the weed control efficiency of 76.5 and 71.5 per cent, respectively. Further, seed and straw yields were significantly recorded higher under IC+HW at 20 and 40 DAS as compared to rest of the treatments except application of oxadiargyl @ 0.075 kg ha^{-1} and pendimethalin @ 0.75 kg ha^{-1}.

P-68 Effect of herbicides on weed control productivity and economics of maize (*Zea may*)

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A field experiment was conducted during the rainy season of 2006 and 2007 at research form college of Agriculture, Gwalior Madhya Pradesh to evaluate the effect of different herbicides and levels on sandy loam soil. The major weed flora recorded in the experimental field comprised *cyperus rotundas Cynodon dactylon, Echinochloa Crus galli, Commelina bengalensis, Digera arvensis and Phyllanthus nururi* in both the seasons. Among herbicides the highest seed yield 3808kg/ha was obtained with application of alchlor at 1.00 kg/ha as pre emergence followed by metolachlor at 1.00 kg/ha, atrazine at 1.00 kg/ha as pre emergence, pendimethalin at 1.00 kg/ha and 24-D at 0.5 kg/ha PoE and they were significantly on a par with weed free (4480 kg/ha). All the herbicides treatments significantly reduced the weed population and their dry weight. Significantly lower dry weight and maximum weed control efficiency were recorded with application of atrazine at 1.00 kg/ha followed by metolachlor at 1.00 kg/ ha PE. However, highest net return and benefit cost ratio was obtained under weed free and application of alachlor at 1.00 kg/ha PE, respectively followed by metolachlor at 1.00 kg/ha and atrazine 1.00 kg/ha PE. Among the doses of herbicides recommended dose preformed better than higher dose in respect to grain yield.

P-69 Response of spring sunflower (*Helianthus annuus* L.) to weed management in tarai region of Uttarakhand

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Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops that can be fitted in to different cropping systems not only to make the system viable and sustainable but also to increase oilseed production in the country because of its photo-insensitivity, short duration (90-100 days), high adaptability to diverse environment, tolerant to water stress. Tarai area of Uttarakhand is highly potential for sunflower production as its acreage has increased many folds during last five years. The crop is grown mostly in the vacant fields after sugarcane ratoons, potato, green pea, late rice, rapeseed and mustard etc. during spring season (February to June).

The frontline demonstrations were conducted on farmers fields during 2001-02, 2002-03, 2004-05, 2005-06 and 2006-07 to demonstrate the benefits of improved weed management practices (improved technology, IT) compared to farmers' practices (FP). Total 13 frontline demonstrations were conducted at various locations during last five years. The crop was grown with all recommended practices in both the plots except the weed management. Under improved technology, the pendimethalin @ 1.5 kg a.i./ha was sprayed as pre emergence herbicide on second day of sowing followed by one hand weeding and inter culture at 25-30 days after sowing. Similarly, the farmers did not care about the weed management properly. Some of the progressive farmers used pendimethalin and others followed only one hand weeding at 20-25 days after sowing. On the other hand, some farmers did not adopt weed management practices at all.

The results indicted that the improved technology of weed management increased seed yield of sunflower by 24.2 % over farmers' practices, while the yield increase was in the range of 12.3 to 40 .0 % during last five years. The gross returns also improved under improved technology and it was on an average 23 % higher than farmers' practices. However, the selling rate varied year to year drastically, that also made significant difference in the gross returns. The benefit : cost (B:C) ratio also varied greatly year to year i.e. 1.57 to 2.44 under IT and 1.50 to 2.44 under FP, while the average value was 2.14 and 1.88 under IT and FP, respectively. The net profit was recorded higher under improved technology and varied from Rs. 6000/- to 18000/- and 3122/- to 14619/-per hectare under IT and FP, respectively. The net profit was on an average Rs. >10,000/- per hectare, that is nearly equal to Rs. >100/- per day. Therefore, growing of sunflower crop during spring season in Tarai region of Uttarakhand may help farmers to earn Rs. 10,000 to 18,000/- per hectare within 100 days and it signifies urgent need of transferring the sunflower technology to the farmers in the state.

P-70 Integrated weed management in lentil (*Lens culinaris* Medik.)

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A field experiment was conducted during *Rabi* season of 2006-07 at Sardar Vallabh Bhai Patel University of Agriculture & Technology, Meerut, to evaluate the different weed control treatments on growth and yield of lentil. The soil of the experimental site was sandy loam in texture having organic carbon (0.47%), available N (210 kg/ha), available P (15 kg/ha) and available K (185 kg/ha) with p^H 8.2. The experiment consisted of ten treatments viz. weedy check, weed free, one hand weeding at 30 DAS, pendimethalin @ 1.0 kg. a.i. ha^{-1} pendimethalin @ 1.0 kg. a.i. ha^{-1} + one hand weeding at 30 DAS, pendimethalin @ 1.0 kg. a.i. ha^{-1} + quizalofop-ethyle @ 50 g. a.i. ha^{-1}, quizalofop-ethyle @ 50 g. a.i. ha^{-1}, quizalofop-ethyle @ 50 g. a.i. ha^{-1} + one hand weeding at 45 DAS, 25 per cent higher seed rate and 25 per cent higher seed rate + one hand weeding at 30 DAS were laid out in randomized block design with three replications. *Chenopodium album* and *Convolvulus arvensis* were the dominant weeds in the experimental field. Weed control treatments reduced the density and dry weight of weeds over weedy check at all stages of crop growth. Test weight remained unaffected due to different treatments. Quizalofop-ethyle @ 50 g. a.i. ha^{-1} + one hand weeding at 45 DAS and 25 per cent higher seed rate + one hand weeding at 30 DAS produced grain yield at par with that of weed free condition.

P-71 Comparative efficacy of dinitroaniline herbicides in cumin

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Field experiments were conducted at AICRP on Weed Control Farm, Anand to assess effectiveness of dinietroaniline herbicides for weed management in cumin-pearlmillet cropping system. The soil of the experimental field was sandy load having pH 8.20 with 0.019% nitrogen, 56 kg P_2O_5/ha and 345 kg K_2O/ha. The experiment was laid out in randomized block design with four replications. The treatments consisted pre-plant application of pendimethalin (1.0 lg/ha), fluchloralin (1.0 kg/ha) and trifluralin (0.5 & 1.0 kg/ha) along with weed free hand weeding twice at 30 & 45 DAS and weedy check. Both the crops were raised by adopting recommended package of practices of the region. Results revealed that pre-plant application of pendimethalin or fluchloralin or trifluralin @ 1.0 kg/ha was effective in controlling weeds in *Rabi* cumin whereas in cumin-pearlmillet cropping system only trifluralin @ 0.75-1.00 kg/ha was effective for weed management without reducing the yield of succeeding pearlmillet. Plant growth of pearlmillet in terms of germination, plant height and grain yield was significantly lower where pendimethalin or fluchloralin was applied @ 1.0 kg/ha in preceding *Rabi* cumin crop.

P-72 Effect of integrated weed management on weed dynamics and grain yield of lentil (*Lens culinaris*)

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A field experiment was conducted at research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur during *rabi* season of 2002. The soil of the experimental plot was sandy loam, low in organic carbon (0.43%), available N (189.8 kg/ha), P_2O_5 (19.7 kg/ha) and K_2O (129.1 kg/ha) with pH 8.1. The treatment comprised ten weed control treatments, i.e. weedy check, weed free, hand weeding 30 DAS, 25% higher seed rate, hand weeding 30 DAS + 25% higher seed rate, pendimethalin @ 1.0 kg/ha (pre-emergence), isoproturon @ 1.0 kg/ha (pre-emergence), isoproturon @ 0.75 kg/ha + hand weeding 40 DAS, pendimethalin @ 0.75 kg/ha + hand weeding 40 DAS, isoproturon 0.75 kg/ha (pre-emergence) + hand weeding 40 DAS. The experiment was laid out in randomized block design with three replications. Weed control treatments significantly reduced weed density, weed dry-biomass and recorded higher weed control efficiency and grain yield of lentil than weedy check. Among the weed control treatments pre-emergence application of isoproturon @ 1.0 kg/ha recorded lowest weed population, weed dry bio-mass and highest weed control efficiency but was found at par with weed free treatment, hand weeding 30 DAS and pre-emergence application of pendimethalin followed by hand weeding 40 DAS and significantly higher than other weed control treatments. Application of pendimethalin proved significantly inferior to isoproturon. Pre-emergence application of isoproturon also recorded maximum grain yield which was found at par with weed free situation and significantly higher than other weed control treatments.

P-73 Integrated weed management in direct seeded rice of irrigated ecosystem in Indo Gangenetic plain of Bihar

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The field experiments were conducted on dry loamy soil at Irrigation Research Station Bikramganj (Rohtas) under Rajendra Agricultural University Bihar for three consecutive *kharif* seasons of 2003, 2004 and 2005 with four rice crop establishment and five weed management methods. The four rice crop establishment methods are Transplanting, dry drilling by zero till drill after tilling, dry drilling by zero till drill without tilling, wet drilling by rice drumm seeder. The five weed management methods are control, herbicide + 1 hand weeding, pendimethalin. 1.0 kg/ha + 2 hand weeding, 2 hand weeding, pendimethalin. 1 kg/ha PE *fb* 2,4-D 0.5 kg POE. Results revealed that all the weed management methods were statistically at par (5338 kg/ha) with all the methods by rice crop establishment except transplanting in which grain yield was not influenced significantly by weed control method.

P-74 Bio-efficacy of new herbicides for weed control in irrigated linseed

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A field experiment was conducted during *Rabi* season of 2006-2007 under All India Coordinated Research Project on linseed at Mauranipur centre of this University to evaluate the most effective and remunerable herbicides for weed control in irrigated linseed in Bundelkhand tract of Uttar Pradesh. Twelve treatments consisting isoproturon (1.0 kg/ha) alone and in combination with 2,4-D (0.5 kg/ha), sulfosulfuron @ 10, 20 and 30 g/ha, clodinafop @ 60, 80 and 100 g/ha, clodinafop 60 g and 80 g/ha blended with 2,4-D (0.5 kg/ha) along with hand weeding twice (20 and 40 days after sowing) and weedy plots were assigned in randomized block design replicated thrice. All treatments resulted in significant reduction in the total density and dry matter of weeds. Sulfosulfuron at 20 g/ha proved most effective in arresting population (36.2/m^2) and dry matter accumulation of weeds (20.29 g/m^2) which was comparable with sulfosulfuron at 30 g/ha and clodinafop at 100 g/ha. There was tremendous reduction in the grain yield of linseed due to uncontrolled weeds. Grain yield under weedy condition was significantly les than all other treatments. Non-significant variations in grain yield could be observed at doses ranging from 10 to 30 g/ha and 60 to 100 g/ha of sulfosulfuron and clodinafop, respectively. Thank mixture of isoproturon at 1.0 kg/ha and clodinafop at 60 g and 80 g/ha with 2, 4-D at 0.5 kg/ha also resulted comparable grain yield of linseed. Thus, tank mix application of isoproturon at 1.0 kg/ha or clodinafop at 60 g/ha with 2,4-D (0.5 kg/ha) may be used for weed control in linseed crop for higher grain yield and net return.

P-75 Effect of integrated weed management in kharif sorghum

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A study was carried out during the *kharif* season of 2001-2002 to 2004-2005 to determine the most suitable integrated weed management treatment in *kharif* sorghum. Highest grain yield and maximum weed control efficiency were recorded which was at par with treatment (PE-atrazine 0.50 kg/ha supplemented with hand weeding and hoeing at 6 WAS), and found significantly superior over rest of the treatments. The highest net monetary returns was achieved with (PE-atrazine 0.50 kg/ha + POE 2,4-D 0.80 kg/ha at 6 WAS), which was at par with (Rs. 8157/ha) i.e. (PE-atrazine 0.50 kg/ha supplemented with hand weeding and hoeing at 6 WAS).

P-76 Response and residual effect of various herbicides in late *Kharif* brinjal – summer cowpea crop sequence

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A field study was undertaken to study the response of brinjal to various herbicides and the residual effect of these herbicides on succeeding summer cow pea at the Instructional Farm, Navsari Agricultural University, Navsari during late *Kharif* and summer seasons of 2001-02 to 2005-06. Eight treatments comprising of fluchloralin at 0.90, kg fluchloralin @ 0.9 kg ha^{-1} as pre-emergence + hand weeding HW at 30 days after sowing DAS (W_1) + fluchloralin at 1.35 kg ha^{-1} pre-emergence (W_2). Alachlor at 1.0 kg ha^{-1} as pre-emergence + H.W. and hoeing at 30 DAS (W_3), alachlor at 1.5 kg ha^{-1} as pre-emergence (W_4), paddy straw mulch at 5 t ha^{-1} (W_5). Black polyethylene mulch (50 micron) (W_6), local practice i.e. 2 H.W. + 2 hoeing at 20 and 40 DAS (W_7) and un weeding control (W_8), were tested in randomized block design with three replications. The experimental soil was clayey in texture. The brinjal variety "Surati Ravaiya" and cow pea variety Pusa Falguni were sown at a spacing of 90 x 60 cm and 45 x 20 cm using seed rate of 0.5 and 25 kg ha^{-1}, and fertilized with 100-50-50 and 20-40-0 NPK kg ha^{-1}. respectively. Both the crops were integrated as and when required.

Significantly the lowest number of weeds and dry weight of weeds were recorded under treatments W_6 (black polyethylene) in individual year as well as in pooled data. Yield of brinjal also affected significantly due to various treatments. On the basis of pooled data treatment W_6 recorded the highest yield but found at par with treatment W_3 (alachor at 1.0 kg ha^{-1} as pre-emergence + H.W. and hoeing at 30 DAS) un weeded control (W_8) treatment recorded significantly, the lowest yield and highest number of weeds m^2 and dry weight of weeds throughout the investigation period. Similarly, treatment W_6 being at par with W_3 recorded the highest yield of summer cowpea. This W_6 treatment also recorded significantly the lowest number of weeds and dry weight of weeds indicating residual effect in cowpea crops. Maximum net income was realized under treatment W_3.

Late *Kharif* brinjal crop may be fertilized with 100-50-50 NPK kg ha^{-1} and kept weed free by applying alachlor at 1.0 kg ha^{-1} at 3 days after sowing coupled with one hand weeding and hoeing at 30 days after sowing to obtain higher profitable yield. Then after succeeding cow pea crop may be grown without any harmful residual effect of this herbicide.

P-77 Effect of soil solarization on weed control, growth and yield of aftermath potato crop

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An experiment was conducted during 2003-2004 and 2004-05 on loamy sand soil of C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of soil solarization on weed control, growth and yield of groundnut and its aftermath effect on potato crop was studied under north Gujarat condition. Treatments consisted of two thickness of TPE (0.025 mm and 0.050 mm) with three durations of soil solarization (15, 30 and 45 days) along with cultural (weed free and hand weeding twice plus earthing up) as well as chemical method (metribuzin @ 1.0 kg ha^{-1}) of weed control with weedy check as control were studied in randomized block design with four replications. Weed free recorded maximum reduction in grasses, broad leaves, sedges and total weeds population as well as dry weight of weeds and dry weed biomass, which remains at par with TPE 0.025 mm for 45 days. Maximum plant height, number of leaves and leaf area of potato were recorded in order of TPE 0.025mm for 45 days >weed free>hand weeding twice plus earthing up treatments.Yield attributing characters such as number of tuber, tuber weight, large size tuber and medium size tuber in potato were registered higher under soil solarization with TPE 0.025mm for 45 days followed by hand weeding twice plus earthing up and weed free. Whereas, small size tuber yield was recorded higher under weed free followed by hand weeding twice plus earthing up and TPE 0.025mm for 45 days .The maximum total tuber yield of potato was registered under soil solarization with TPE 0.0252mm for 45 days (30.44 t ha-1), which followed by hand weeding twice plus earthing up (29.50 t ha-1) and weed free (28.56 t ha-1) treatments .

It is concluded that soil solarization with TPE 0.025mm for 45 days was found effective in controlling weed population as well as dry weight of weeds and producing higher tuber yield of potato

P-78 Integrated management of *Cuscuta* in *Amaranthes* spp.

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Cuscuta species have become a serious problem especially in crops like onion, chillies, pulses and green vegetables. It is an obligate parasite that attacks stems and leaves of host plants and germinates independently without any stimulate. In Tamil Nadu, green vegetable (*Amaranthes* spp.), the cash crop, is found to be infested sporadically with *Cuscuta* especially in Coimbatore and Erode districts. An attempt was made to manage this parasitic weed with the pre-emergence and post-emergence application of pendimethalin (0.75 kg/ha), fluchloralin (0.75 kg/ha), paraquat (0.80 kg/ha) and glyphosate (0.40 kg/ha). The effect of these treatments compared with hand removal of *Cuscuta* and control. Weed flora of the experimental site: *Cuscuta chinensis, Trianthema portulacastrum, Digera arvensis, Cleome viscosa, Cynodon dactylan* and *Cyperus rotundus* are the predominant weeds in the experimental sites. In this treatment hand removal of *Cuscuta sp.* and other weeds reduced the weed coverage (3.2 to 4.6 %) at 25 DAS. Post-emergence directed application of either paraquat 0.80 kg/ha (or) glufosinate 0.40 kg/ha on 20 DAS, reduced the *Cuscuta* weed coverage and dry weight of both *Cuscuta* sp. and other weeds at 2 DAS. Pre-emergence application of either fluchloralin or pendimethalin a 0.75 kg/ha on 3 DAS failed to reduce weed coverage and dry weight as compared to hand removal. Higher greens yield and better economic returns could be obtained with hand removal of *Cuscuta chinensis* and for other weeds in greens effectively controlled by post-emergence application of paraquat at 0.80 kg/ha on 20 DAS.

P-79 Weed control in ratoon sugarcane

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A field experiment was conducted at Zonal Agricultural Research Station, V.C.Farm, Mandya, during the year 2005 with an objective of controlling weeds in Ratoon Sugarcane crop. The experiment was laid out in RCBD with three replications. Three pre-emergent herbicides were evaluated with the combination of post-emergent herbicide and with cultural practice and trash mulching in all the rows and in the alternate rows as a non-chemical mode of weed control is also taken up for study to compare the effectiveness in comparison to weedy check and recommended practice of weed control i.e., 3 hoeings. The research results revealed that application of metribuzine @ 1.0 kg a.i/ha as a pre-emergent spray followed by post-emergent application of 2, 4 – D 1.0 kg a.i/ha at 45 days. After ratoon initiation during the year 2005-2006 recorded significantly higher yield followed by application of metribuzine @ 1.0 kg a.i/ha as pre-emergent spray with one hoeing at 45 DARI (94 t/ha). Higher total weed density and dry weight of weeds were observed in weedy check (204.66 no./m^2 and 1833 gm/m^2) and the treatment that receives 3 hoeings (168.67 no./m^2 and 100.30 gm/m^2) and recorded significantly lowest yield (74.00 and 74.0 t/ha), respectively.

P-80 Productivity of french bean as influenced by integrated nutrient and weed management

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Twelve combinations of four integrated nutrient management systems {50% NPK through fertilizers + 50% N through FYM (F1), 50% NPK though fertilizers + 50% N through vermicompost (F2), 50% N each through FYM and vermicompost (F3) and 100% NPK through fertilizers (F4)} and three weed management systems (hand weeding twice, pendimethalin 1.20 kg/ha and pendimethalin 0.9 kg/ha + hand weeding) were evaluated for weed control, yield and returns in French bean for the summer seasons of 2004 and 2005 at Palampur. Results of the study revealed that pendimethalin and pendimethalin + hand weeding reduced weed count and dry weight effectively and increased plant height, leaves/plant, crop dry weight, pods/plant, pod yield and net returns. However, pendimethalin was superior to pendimethalin + hand weeding in influencing mean weed count and net returns. 50% NPK through fertilizers + 50% N through FYM gave lowest mean weed dry weight accumulation and highest mean plant height, leaves/plant in 2005, mean crop dry matter and mean net returns. Green pod yield was highest in the treatment combination 50% NPK through fertilizers + 50% N through FYM + pendimethalin + hand weeding in 2005. However, 50% NPK through fertilizers + 50% N through vermicompost + pendimethalin and 50% N each through FYM & vermicompost + pendimethalin or pendimethalin + hand weeding were as good as the above treatment combination in influencing mean green pod yield. 50% NPK though fertilizers + 50% N through vermicompost + pendimethalin (Rs 29375/ha) and 50% NPK though fertilizers + 50% N through FYM + pendimethalin + hand weeding gave higher mean net returns.

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Integrated weed management in brinjal

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A field experiment was conducted to study the effect of different weed control treatments on yield of brinjal and associated weeds during *Kharif* 2006 at the Vegetable Research Center of G.B.Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand. Sixteen weed control treatments were tested in a randomized block design with 3 replications. Pendimethalin, isoproturon and oxyfluorfen at their respective doses were sprayed within 3 days of transplanting as pre-emergence application. Fluchloralin at all the doses was incroprated in to the soil before planting the crop. All the herbicides at their lower dose were supplemented with one hand weeding at 45 days after transplanting. One hand weeding at 30 days and two manual weedings each at 30 and 45 days along with weed-free and weedy checks were also maintained to compare with the herbicide alone and manual weeding.

Thirty five days old seedlings of 'Pant Rituraj" variety of brinjal were transplanted in the second week of July, 2006 at a spacing of 50 cm apart in rows. The crop was fertilized uniformly with 120 kg N, 80 kg P_2O_5 and 60 kg K_2O per hectare through urea, diammonium phosphate and muriate of potash, respectively. Recommended package of practices other than weed control was adopted to raise the experimental crop.

The major weed flora consisted of *Echinocloa colona, sanguinalis, Eleusine indica, Eclipta alba, Corchorus acuitangulas, Caesulia axillaries* and *Cyperus rotundus*.

Fluchloralin at 1.0 kg, pendimethalin at both the doses and oxyfluorfen at higher dose of application reduced weed density significantly as compared to weedy check. All the herbicidal treatments reduced dry matter accumulation by weeds significantly as compared to weedy check. Maximum reduction in dry matter of weeds was recorded under oxyfluorfen at 0.25 kg ha^{-1}, however this treatment proved toxic to the crop and gave the minimum fruit yield. Uncontrolled weed growth on an average recorded 66.2 per cent reduction in brinjal fruit yield Pendimethalin 1 kg ha^{-1} being on par with weed-free treatment produced significantly higher fruit yield as compared to rest of the treatments under study. Fluchloralin at 1.0 kg ha^{-1} and lower dose of oxyfluorfen supplemented with on hand weeding at 45 days after transplanting also proved effective than other treatments. Oxyfluorfen at 0.25 kg ha^{-1} proved toxic to the crop.

P-82 Bio–efficacy of herbicides for control of weeds in direct seeded onion (*Allium cepa.* L.)

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An experiment was conducted to study the efficacy of different herbicides applied alone, integrated approach involving application of lower dose of herbicides in combination with one hand weeding in comparison to manual weeding at different growth stages on the bulb yield of onion. Application of oxyflurofen @ 0.14 kg ai ha^{-1} resulted in significantly maximum bulb yield (139.05 q ha^{-1}) followed by pendimethalin @ 1.25 kg ai ha^{-1} (136.83 q ha^{-1}) and metolachlor @ 1.25 kg ai ha^{-1} (132.13 q ha^{-1}) which were on par with each other. Integrated weed management treatments involving pre-emergence application of herbicides *viz.*, oxyfluorfen @ 0.09 kg ai ha^{-1}, pendimethalin @ 0.75 kg ai ha^{-1} and metolachlor @ 0.75 kg ai ha^{-1} in combination with one hand weeding at 45 days after sowing resulted in higher bulb yield of onion (148.91, 147.25 and 146.50 q ha^{-1}, respectively) due to maintenance of weed free condition during initial stages with per emergence application of herbicides and control of late emerged weeds as a result of one hand weeding at 45 days after sowing. At 30, 45 DAS and at harvest, weed control efficiency (WCE) was more than 90 percent with all the herbicidal treatments except butachlor @ 1.75 kg ai ha^{-1} (63.2%, 63.94% and 74.15%). All the integration treatments have achieved highest WCE of more than 82.00 per cent except butachlor @ 0.75 kg ai ha^{-1} + one HW at 45 DAS (72.35 and 68.69%), at 30 and 45 DAS, respectively. The weed index values ranged from 8 to 9.49 per cent in integrated treatments as compared to 86 per cent with weedy check indicating least crop weed competition.

P-83 Weed management in direct sown onion

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Field crops were conducted in 2004 and 2005 at NRC Onion and Garlic Pune to find out a suitable and cost effective methods of weed control for direct sown onion crop. Different herbicides i.e. pendimethalin oxydiargyl and oxyfluorfan (Goal) were applied to onion crop in different concentrations just after sowing to study their effect on seed germination and weed growth. It was found that the pendimethalin (Stomp)@ 2ml/l, oxydiargyl (Raft) and oxyfluorfan (Goal) @ 1ml/l effectively control both dicotyledonous and monocotyledon weeds up to one month. The numbers of weeds were lowest (1.5/ml) in oxyfluorfan treatments after one month while it was highest (57.67/ml) in control treatment. The application of oxydiargyl and oxyfluorfan adversely affected the germination and the number of seedling. Highest yield was obtained in pendimethalin (22.75t/ha) which was at par with hand weeding (21.25 t/ha).The yield in oxydiargyl and oxyfluorfan treatments required between 3.83 to 13.08 t/ha. There was no effect of these treatments on the bulb size and total soluble solids content in onion. The B:C ratio was also highest in pendimethalin application (2ml /per l).

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Integrated weed management in onion (*Allium cepa* L.)

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A field experiment was conducted with single application, sequential application of herbicides and their integration with hand weeding for weed control in onion during winter season of 2005-06 at New Delhi. The soil was sandy loam (Typic Ustochrepts : Order Inceptisols) with pH 7.7 low in organic C (0.35 %) and medium in available P (15.0 kg/ha) and K (170 kg/ha). The plot size was 3X5 m^2. Forty five days aged seedlings of recommended variety Pusa-Red were transplanted in the flat beds at a spacing of 20 cm X 7.5 cm during first week of January. Twelve treatment combinations consisting pre-emergence application pendimethalin (1.0 kg/ha), oxyflurofen (0.25 kg/ha) and pre-planting incorporation of fluchloralin (1.0 kg/ha)alone and each followed by one hand weeding, sequential application of pendimethalin (0.75 kg/ha as pre-emergence) followed by pendimethalin (0.75 kg/ha as broad cast), oxyflurofen (0.25 kg/ha as pre-emergence) followed by oxyflurofen (0.25 kg/ha as broadcast) and fluchloralin (1.0 kg/ha as pre-planting incorporation) followed by fluchloralin (1.0 kg/ha as broadcast) hrough mixing uniformily in sand at 30 DATP, two hand weedings, three hand weeding and weedy check were laid out in the randomized block design with four replication. Total density and dry weight of weeds in each plot was recorded at harvest by random sampling technique by using a quadrate of 0.25m^{-2}. (as per the random list count quadrat method). Bulb yield was recorded at harvest.

The dominant weed species observed in the experimental field were: *Dactyloctenium aegyptium, Eleusine indica, Cynodon dactylon, Cyperus rotundus,* and *Parthenium hysterophorus.* Sequential application of pendimethalin @ 0.75 kg/ha as pre-emergence followed by pendimethalin @ 0.75 kg/ha as broadcast (sand mix) at 30 days after transplanting, fluchloralin @1.0 kg/ha pre plant incorporation fb fluchloralin @ 1.0 kg/ha (as broadcast), pendimethalin @ 1.0 kg/ha + 1 hand weeding and fluchloralin @ 1.0 kg/ha + 1 hand weeding were on a par with 3 hand weedings. The lowest bulb yield (3.91 t/ha) was recorded in unweeded plot due to severe weed competition. Pre-emergence application of oxyflurofen at 0.25 kg/ha did not prove effective in controlling weeds in onion. The highest weed control efficiency (85.80 %) was achieved due to three hand-weeding followed by sequential application of pendimethalin @ 0.75 kg/ha as pre-emergence followed by (fb) pendimethalin @ 0.75 kg/ha as broadcast (sand mix) at 30 days after transplanting. But the highest net return (Rs. 74690/ha) was recorded under sequential application of pendimethalin @ 0.75 kg/ha as pre-emergence followed by (fb) pendimethalin @ 0.75 kg/ha as broadcast (sand mix) closely followed by three hand weeding and fluchloralin @1.0 kg/ha pre plant incorporation fb fluchloralin @ 1.0 kg/ha (as broadcast).

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Integrated weed management in cabbage based cropping system

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A field experiment was conducted at Students Instructional Farm of C.S.A.U&T Kanpur during two consecutive years (2005-06 and 2006-07) to develop effective weed management practices for the cabbage based intercropping and to select out a suitable crop combination involving cabbage and other vegetables/spices. Five cropping system i.e. cabbage pure, cabbage + aniseed, cabbage + table pea, cabbage + coriander, cabbage + fenugreek were tried with three weed control measures i.e. unweeded, manual weeding twice, pendimethalin 1 kg/ha + 1 HW in randomized block design with three replications. Cabbage cv. Pride of India, aniseed cv. Azad-1 , Table pea cv. Azad pea-1 , coriander cv.Azad Dhania-1 and fenugreek cv. Azad-1 were used. Cabbage seedlings were transplanted at row spacing of 45 cm, and in between 2 rows of cabbage, 4 rows of each aniseed, table pea, coriander and fenugreek were adjusted as per treatments. The results revealed that *Phalaris minor was* dominent weed flora during both the years. Intercropping of aniseed, table pea, coriander and fenugreek in between rows of cabbage led to weed suppression to the extent of 19.13 %, 27.67%, 31.67% and 42.72% respectively. Application of pendimethalin (1 kg/ha) followed by one hand weeding were registered significant reduction in weed dry weight resulting in 90.72%, 87.7%, 78.93%, 85.18% and 72.67% weed control efficiency in cabbage sole, cabbage + aniseed, cabbage + table pea, cabbage + coriander and cabbage + fenugreek, respectively. Manual weeding thrice prevented weed competition in the entire cropping system resulting increased cabbage equivalent yield. Among the intercropping, cabbage +table pea intercropping system appeared to be more remunerative in terms of cabbage equivalent yield (464.15 kg/ha). Manual weeding thrice proved its superiority over pendimethalin (1 kg/ha) supplemented with one hand weeding with respect to cabbage equivalent yield in all the cropping system.

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Effect of soil solarization on weed dynamics, weed seedbank, chemical and biological status of soil and productivity of crops in niger-tomato cropping system

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In recent years, there has been increasing concern regarding the hazards of chemicals to the environment, the farmers and the consumers. Therefore, interest in non-chemical approaches which aim to reduce pesticide usage is growing. Considering this harvesting of solar energy through soil solarization for controlling soil-borne pests including weeds, pathogens and nematodes will be the key preposition to reduce the dependency on chemicals. Therefore a field experiment was conducted with objective to assess the effectiveness of soil solarization for a period of 45 days on weed dynamics in niger-tomato cropping system. Treatments consisted of non-solarization and soil solarization with and without FYM and crop residue as main treatments along with 3 weed-control measures, *viz,* recommended dose of herbicide, half of recommended dose of herbicide as per crop and weedy check. Treatments were replicated 3 times in a randomized block design in factorial arrangement. Soil solarization (SS) for a period of 45 days alone reduced the emergence of *Phyllanthus niruri*, *Echinochloa colona*, *Mollugo* sp., *Dinebra* sp., *Commelina communis, Cyperus iria*, and and *Euphorbia geniculata* by over 85 per cent in niger and by more than 75 per cent of *Avena sterilis* and *Cichorium intybus* in tomato. Soil solarization failed to check the emergence of *Medicago hispida* and *Vicia sativa* where soil solarization checked the emergence by 16 and 26 per cent only. Among weed control treatments, application of recommended dose (0.5 kg/ha) of metribuzin or its half (0.25 kg/ha) reduced emergence of *E. colona* in niger and *A. sterilis, C. intybus* and *M. hispida* in tomato. Higher seed yield of niger (900 kg/ha) and fruit yield of tomato (35 t/ha) were recorded with soil solarization, which were at par with SS+FYM 5t/ha. Recommended dose of metribuzin under non-solarized (NS) condition helped to attain the maximum seed yield of niger and fruit yield of tomato. Soil solarization with reduced dose of metribuzin (0.25 kg/ha) was as effective as metribuzin 0.50 kg/ha in non-solarized treatment in increasing the yield of niger and tomato. Soil solarization significantly killed the weed seeds lying up to 10 cm soil depth only. Soil solarization for 6 weeks alone and with farmyard manure at 5 t/ha killed the seeds of *Echinochloa colona, Euphorbia geniculata and Commelina communis*. However, it had no effect on the seed reserves of *Medicago hispida* even at germinating zone. Soil solarization significantly increased the electrical conductivity (EC) and content of soil organic carbon (SOC) and available nutrients. The effect was more pronounced in combination with FYM and wheat residue. The addition of wheat residue, however, increased SOC content only under solarization treatment. Significant increase in the available P, S, K, Fe, Mn and Zn content in soil was recorded due to solarization treatment. However, no significant effect of solarization was noticed on soil pH and available copper content.

Soil solarization had variable effect on the population of major micro flora of soil. The population of total fungi and *Trichoderma* spp. was decreased significantly in 0-10 cm soil depth of solarized plots. However, populations of total bacteria and actinomycetes were increased. Soil population of *Pseudomonas fluorescens* was not affected significantly due to solarization. In general application of herbicides had caused adverse effect on all above groups of soil microbes.

P-87 Effect of weed control methods on economics and quality of transplanted onion

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An experiment was conducted to study the efficacy of different herbicides applied alone, integrated approach involving application of herbicides in combination with one hand weeding in comparison to manual weeding at different growth stages on the bulb yield, economics and quality of onion bulbs. The experiment consisted of 16 treatments of which 4 were herbicide treatments, 6 were hand weeding treatments, 4 were integrated weed control treatments, one weedy check and weed free check treatment. The experiment was laid out in randomized block design.

Integrated weed management treatments involving pre-emergence application of herbicides *viz.*, oxyfluorfen @ 0.09 kg ai ha^{-1}, pendimethalin @ 0.75 kg ai ha^{-1} and metolachlor @ 0.75 kg ai ha^{-1} in combination with one hand weeding at 45 days after transplanting (DAT) resulted in significantly higher bulb yield of onion (159.73, 155.13 and 152.66 q ha^{-1}, respectively) due to maintenance of weed free condition during initial stages with pre emergence application of herbicides and control of late emerged weeds as a result of one hand weeding at 45 DAT.

The weed control efficiency was more than 93 per cent. The weed index values ranged from 6.20 to 23.22 per cent in integrated treatments as compared to 76.04 per cent with weedy check indicating least crop weed competition. Integrated weed control treatments were on par with each other and recorded maximum bulb diameter of 5.21 to 5.38 cm and large sized bulb yield ranged from 23.50 to 44.50 per cent. Maximum net returns was obtained with the application of oxyfluorfen @ 0.09 kg ai ha^{-1} + one hand weeding at 45 DAT (Rs. 40867 ha^{-1}) followed by pendimethalin (Rs. 38427 ha^{-1}) and metolachlor (Rs. 37969 ha^{-1}) each @ 0.09 kg ai ha^{-1} + one hand weeding at 45 DAT.

P-88 Post-emergence herbicidal management of *Cyperus rotundus* in banana

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Cyperus rotundus is a perennial from rhizomes and tubers that may reach 60-75 cm in height. *Cyperus rotundus* is reproduced by tubers and rhizomes, very little reproduction by seeds. It thrives in moist soils and is spread by flood water and cultivation and is a common weed in agronomic and horticultural crops, nurseries. It is a common weed in garden land crops like banana, grapes, tapioca, cotton and chillies and other vegetable crops and is not controlled by most commonly used herbicides. Hence, an on-farm trial was carried out in farmer's holding with an objective to evaluate the efficacy of herbicidal management of *Cyperus rotundus* in banana. Experiment was conducted in randomized block design and replicated thrice. Treatments were glyphosate 41% SL (Roundup) 15 ml / l, glyphosate 71% G (Mera) 6 g /l, glyphosate 71% G (Mera) 9 g /l, metribuzin 70% WP (Sencor) 3 g/l and unsprayed control. Results revealed that the *Cyperus rotundus* was effectively controlled by glyphosate 41% SL (Roundup) 15 ml / lit of water by reducing the weed density and weed dry weight considerably. The effect was more pronounced beyond 15 DAHS. The effect of granular formulation of glyphosate in containing *Cyperus rotundus* was better than metribuzin but less than liquid formulation of glyphosate. Yield of banana was higher in glyphosate 41% SL (Roundup) 15 ml / lit of water and it was followed by glyphosate 71% G (Mera) 9 g / lit of water. Metribuzin 70% WP (Sencor) 3 g / lit of water was effective in controlling *Cyperus rotundus* to certain extent, the yield of banana was fairly less due to moderate phytotoxicity of herbicide on banana. Gross return, net return and benefit: cost ratio was higher with glyphosate 41% SL (Roundup) 15 ml / lit of water, even though the cost of cultivation was higher.

P-89 Effect of some new herbicides on weed parameters and cane yield of sugarcane (*Saccharum officinarum* L.)

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A field experiment was conducted during the cropping seasons of 2002-03, 2003-04 and 2004-05 at Sugarcane Research Institute Farm, Pusa (Samastipur) to study the effect of herbicides for controlling weeds in sugarcane (*Saccharum officinarum* L.). Weed population, weed dry weight, tillers (120 DAP), millable canes, cane and sugar yield were significantly influenced by herbicides. Uncontrolled growth of weeds reduced the yield of sugarcane by 29% in comparison to manual hoeing at 30, 60 and 90 DAP. Amongest herbicides, application of metribuzin (1 kg ai/ha) Pre-emergence + 2, 4-D (1kg ae/ha) as 60 DAP + hoeing at 90 DAP recorded the maximum cane yield (70.25 t/ha) followed by application of hexazinone + diuron WP. mixture (1.20 kg ai/ha) as pre-emergence + hoeing at 90 DAP (65.46 t/ha). There was no marked variation in sucrose percentage in juice by weed management practices.

P-90 Integrated weed management in fruit crops

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The diverse soil types and climatic conditions in our country encourage the growth of broad spectrum weeds. Nurseries have also faced a serious weed problems particularly with annuals (mono and di-cots both) and it must be taken care of for producing healthy planting materials. In case of fruit trees, the critical period of competition is generally for 3-5 years. The percentage losses caused due to unchecked weeds (34-72 per cent) to fruit crops are dependent upon the crop, varieties, the agro-climatic conditions and plant protection measures adopted in the cultivation of that crop. In order to achieve the highest productivity from fruit crops, weeds must be managed intelligently. Identification and distribution of problem weeds are the first priority in determining the weed control programme. During the years of establishment of trees, Cultivation is also practiced. Sod strips, cover crops and mulches between the rows and beneath the trees can be utilizes for the purpose. The season long efficacy of numerous, economical soil applied herbicides and post emergence herbicides makes herbicides as the most widely utilized weed management tools in citrus. Current weed management technology in orchard heavily depends on herbicides and causes some environmental problems. To develop an eco-friendly and sustainable one, we have to refine the herbicide technology with objective to reduce the herbicide environmental impacts without losing weed control effectiveness. A total weed control system in fruit crops may include the exploitation of potential of all available control methods.

P-91 Efficacy of herbicides on weed density and dry root yield of Aashwagandha

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On the basis of two years (2001-02 and 2001-02) mean data, significantly higher root yield of 8.58 q/ha was recorded under trifluralin 4 L/ha alongwith one interculture at 50 DAS as compared to other herbicidal treatments and weedy check (4.756q/ha.), however it was at par with weed free check. The weed density was highest in weedy check followed by trifluralin @ 2 L and pendimethalin @ 2L and 3 L/ha. The lowest weed density was recorded under weed free check. Similar effects were also observed at using trifluralin 41/ha. (70 plants) and pendamethalin 21/ha. (59 plants) at various concentrations compared to weedy check to attain better plant height (35 cm) and root length (29 cm) as compared to control (14.3 and 16.3cm, respecetively)

P-92 Integrated weed management in summer bottle guard (*Lagenaira leucantha* R.)

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Field experiments were conducted during three consecutive summer seasons of the year 2003 to 2005 at the Instructional Farm, Navsari Agricultural University, Navsari. The experimental soil was clayey having low in organic carbon (0.45%), medium in phosphorus (23.2 kg ha^{-1}) and high in potassium (369 kg ha^{-1}) with pH 7.6. Twelve treatments comprising of local practices i.e. two hand weeding (H.W.) and hoeing at 30 and 60 days after sowing (DAS), paddy straw mulch @ 10 t ha^{-1}, black plastic mulch, protected spray of glyphosate @ 1.2 kg ha^{-1} as post emergence at 30 DAS, protected spray of glyphosate @ 0.8 kg ha^{-1} as post emergence at 30 DAS + 1 H.W. 60 DAS + hoeing 60 DAS, pendimethalin @ 1.0 kg ha^{-1} (pre-eme), pendimethalin @ 0.75 kg ha^{-1} (pre-eme) + 1 H.W. and hoeing at 60 DAS, fluchloralin @ 1.0 kg ha^{-1} (pre-eme), fluchloralin @ 0.75 kg ha^{-1} (Pre-eme) + 1 H.W. and hoeing at 60 DAS, trifluralin @ 0.5 kg ha^{-1} (pre-eme) + 1 H.W. 30 DAS, Trifluralin @ 1.0 kg ha^{-1} (pre-eme) + 1 .W. 30 DAS and un weeded control were studied in randomized block design replicated thrice. The crop was fertilized with 100-50-0 NPK kg ha^{-1} in the third weed of February and irrigated as and when required.

The weed flora comprised of *Echinochloa crusgalli, Desmostachya bipinnata, Cynodon dactylon, Sorghum halepense, Eragrostis major* among monocots, *Euphorbia hirta, Phyllanthus maderaspantensis, Melilotus alba, Digera arvensis, Physalis minima, Abutilon indicum and Chrozophora rottleri among dicots and Cyperus rotundus* among sedges were observed. Looking to pooled data treatment W_3 (plastic mulch) recorded significantly the lowest dry weight of weeds being at par with (straw mulch), (pendimethalin @ 1.0 kg ha^{-1} pre-eme) and W_7 (Pendimethalin @ 0.75 kg ha^{-1} pre-eme + 1 H.W. and hoeing at 60 DAS). The highest fruit yield (10080 kg ha^{-1}) was recorded under W_1 (2 H.W. + 2 hoeing at 30 & 60 DAS) being at par with treatments W_3 (black plastic mulch). All weed control treatments had recorded significantly higher fruit yield over control. Maximum net return was obtained under W_4 (protected spray of glyphosate @ 1.2 kg ha^{-1} as post emergence at 30 DAS) which was closer to W_6 (pendimethalin @ 1.0 kg ha^{-1} pre-eme) and W_8 (fluchloralin @ 1.0 kg ha^{-1} pre-eme).

The higher profitable fruit yield of summer bottle guard could be obtained by keeping the crop weed free either by spraying of glyphosate @ 1.2 kg ha^{-1} as post emergence at 30 DAS or pendimethalin @ 1.0 kg ha^{-1} (pre-eme) or fluchloralin @ 1.0 kg ha^{-1} as pre-emergence.

P-93

Weed control studies in fenugreek (*Trigonella foenum-graecum* L.)

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Field experiment was conducted at Agronomy Instructional farm, C.P. College of Agriculture Sardar Krushinagar, Dantiwada Agricultural University, Sardar Krushinagar to evaluate weed control treatments in fenugreek (*Trigonella foenum-graecum* L.) during rabi season of 2003-2004 .

Twelve treatments of weed control viz T_1 (pendimethalin 0.50 kg/ha PE), T_2 (pendimethalin 0.75 kg/ha PE), T_3 (pendimethalin 1.00 kg/ha PE), T_4 (fluchloralin 0.75 kg/ha PE), T_5 (fluchloralin 1.0 kg/ha PE), T_6 (oxyfluorfen 0.12 kg/ha PE), T_7 (oxyfluorfen 0.24 kg/ha PE), T_8 (pendimethalin 0.75 kg/ha PE+ 1 HW + IC at 25 DAS), T_9 (fluchloralin 0.75 kg/ha PE + 1 HW +IC at 25 DAS), T_{10} (oxyfluorfen 0.12 kg/ha + 1 HW +IC at 25 DAS), T_{11} (weed free) and T_{12} (unweed control) were tested in randomized block design with four replications. The soil of experimental plot was loamy sand in texture, low in organic carbon and available nitrogen and medium in available phosphorous and potash. The results of experiment indicated that maximum value of plant height (56.35 cm) and yield attributing characters *viz.* number of pods per plant (28.40), number of seeds per pod (21.40) and test weight (11.00g) were recorded under weed free treatment. Pendimethalin @ 0.75 kg/ha PE + 1HW + IC at 25 DAS and fluchloralin @ 0.75 kg/ha PE + 1 HW + IC at 25 DAS were found equally effective in respect of recording higher values of plant height and yield attributing characters as recorded in weed free treatment.

The highest seed (16.49 q/ha) and straw (27.90 q/ha) yields were recorded under weed free treatment. However, pendimethalin @ 0.75 kg a.i./ha PE + 1 HW + IC at 25 DAS were found statistically equal with that of weed free treatment in respect of the seed (15.11 and 14.35q ha^{-1}) and straw (27.86 and 27.08 q ha^{-1}) yield.

Besides weed free treatment, pendimethalin @ 0.75 kg a.i./ha PE + 1 HW + IC at 25 DAS and fluchloralin @ 0.75 kg a.i./ha PE + 1 HW + IC at 25 DAS were found more effective in reducing weed population over rest of the treatments. Significantly lower dry weight of weeds, weed index and higher weed control efficiency were recorded under weed free, followed by pendimethalin @ 0.75 kg/ha PE + 1 HW + IC at 25 DAS and fluchloralin @ 0.75 kg/ha PE + 1 HW + IC at 25 DAS treatments. Among all the treatments tried in this experiments, weed free was found to be best for recording maximum net realization of Rs. 18663/ha followed by pendimethalin @ 0.75 kg a.i./ha PE+1 HW +IC at 25 DAS and fluchloralin @ 0.75 kg a.i./h PE+ 1 HW +IC at 25 DAS treatments under which the net realization was obtained Rs. 16634 and 15337 respectively. Under north Gujarat condition effective, efficient and economic weed control in *Rabi* fenugreek can be achieved by maintaining weed free condition during crop growth period. Alternatively, pendimethalin @ 0.75 kg a.i./ha PE + 1 HW + IC at 25 DAS and fluchloralin @ 0.75 kg a.i./h PE+ 1 HW +IC at 25 DAS could be employed, where farm labours are scarce and labour charges are also high.

P-94 Efficacy of combi (ready mix of 2, 4-D + glyphosate) against weeds in non-cropped land

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A field experiment was conducted in non-cropped area at College of Agriculture, JNKVV, Jabalpur (M.P.) during post *Kharif* season of 2006 to evaluate the efficacy of combi against weed. Seven treatments consisting of post-emergence application of glyphosate (41% SL) and combi (35% 2, 4-D + 35% glyphosate) at 2.0, 2.5, 3.0, 3.5 kg/ha including weedy check, were laid out in a randomized block design and replicated four times.

The data revealed that the activity of combi against monocot perennial weeds (*Desmostachea bipinnata, Cynodon dactylon* and *Cyperus rotundus*) were improved and paralysed the population and dry weight of these weeds at 30 DAYS after application when applied at 2.0 kg/ha and proved superior over glyphosate applied at same rate. However, there were cent percent control of perennial with in 21 and 15 days after application when combi was applied at 2.5 and 3.0 kg/ha and higher rates 3.5 kg/ha, respectively and proved better even to glyphosate applied at higher rate (4.0 kg/ha).

The activity of combi against dicot annual weeds (*Alternanthera sessilis* and *Anacyclis spp.*) was improved with time as it paralysed the population and dry weight of dicot weeds cent percent at 15 days after experiment when applied at 2.0 kg/ha and proved significantly superior over glyphosate applied at same rate, as it has significantly more density of dicots. However, there were total control of dicots within 7 days after application when combi was applied at other doses (2.5, 3.0, 3.5 kg/ha), and proved better even to glyphosate applied at higher rate (4.0 kg/a). there was no resurgence in perennial monocots and dicot annuals at 610 days after application under all the herbicidal treatments except in glyphosate when applied at lowest rate 2.0 kg/ha as post emergence.

The microbiological analysis of soil indicated that the reduction in population of bacteria, fungi and actinomycetes at 90 days after application was more (21, 24 and 35%) when combi was applied at 2.0 kg/ha compared to check herbicide (glyphosate at 2.0 kg/ha), as it caused only 15, 11 and 32 percent reduction in population of above microbes respectively.

P-95

Effect of herbicide and cultural methods on weed control in grain amaranth (*Amaranthus hypochondriacus* L.)

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Grain amaranth (*Amaranthus hypochondriacus* L.) is an important pseudocereal crop of North Gujarat in rabi season. Weed infestation is the major constraint limiting the production of grain amaranth under the condition of shortage of labour for weeding during initial stages of crop growth. A field experiment was conducted at Regional Research Station, S.D.A.U., Sardarkrushinagar(North Gujarat) during *rabi* season to find out efficient and cost effective weed management for grain amaranth. The experiment was laid out in a randomized block design with four replications, having twelve treatments comprising cultural as well as chemical weed control methods alongwith unweeded check viz., fluchloralin 0.45 kg/ha pre-sowing (PS) + one HW at 25 DAS, fluchloralin 0.45 kg/ha (PE) + one HW at 25 DAS, fluchloralin 0.90 kg/ha (PS), Fluchloralin 0.90 kg/ha (PE), isoproturon 0.25 kg/ha (PE) + one HW at 25 DAS, isoproturon 0.50 kg/ha (PE) + one HW at 25DAS, isoproturon 0.75 kg/ha (PE) , isoproturon 1.00 kg/ha (PE), one hand weeding at 25 DAS, two HW at 25 & 50 DAS, weed free up to 70 days and unweeded check were tried. Variety GA-1 was sown at 45 cm row distance with uniform fertilizer dose of 60 kg N and 40 kg P2O5.

The results revealed that lowest dry weight was found in weed free treatment (114 kg ha^{-1}) with highest WCE (89.51%). The grain yield was significantly increased in all cultural treatments as compared to chemical treatments due to phytotoxic effects of herbicides on seed germination. Weed free treatment gave higher grain yield (1178 kg ha^{-1}). The net return of Rs 8184 ha^{-1} was obtained in two HW at 25 and 50 DAS with higher BCR(2.16).

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Bio-efficacy and phytotoxicity of new herbicide molecule XL COMBI-SG in tea weed management

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Tea is the one of the most important cash crops in North West Bengal but the losses in production and degradation of the quality of the tea due to interference of weeds now posing threats to the tea growers of this region. Some weed flora like *Conyza bonariensis* has already showed resistance against glyphosate in the many American countries.

To search for the alternatives, a field experiment was conducted at Kamalpur Tea Estate locating at Bagdogra area of Siliguri, district Darjeeling in West Bengal during March – May (summer) and June - August (*Kharif*) 2007 to find out the effect of new herbicide molecule XL COMBI-SG (glyphosate ammonium Salt 35 % + 2, 4 – D ammonium salt 35 %) on the bio efficacy on tea weed flora and phytotoxicity on tea plants. The experiment was carried out in a randomized block design with seven treatments replicated thrice. The treatments comprised of two doses of the standard market available glyphosate 41 % SL viz. Glycel (5 and 10 ml l^{-1} water), four doses of the testing herbicide XL-COMBI-SG (3, 5, 7 and 10 g l^{-1} water) and weedy check. The herbicides were applied on third week of March (summer) and June (*Kharif*), 2007 in both the seasons with a knapsack sprayer fitted with flatjet deflector nozzle with a spray volume of 500 l ha^{-1}.

The major weed flora were *Axonopus compressus, Paspalum conjugatum, Paspalum distichum, Oplismenus compositus, Eleusine indica,* and *Paspalidium flavidum* among grasses, *Cyperus compressus, Cyperus mucronatus, Cyperus iria,* and *Cyperus aromaticus* among sedges whereas *Pteridium aquilinum, Oxalis corymbosa, Peparomia pellucida, Capsella bursa pastoris, Muehlenbeckia platyclada, Crassocephalum crepidioides, Acalypha indica, Scoparia dulcis, Mikania micrantha, Sida carpinifolia, Coccinea grandis, Ipomoea digitata, Ageratum conyzoides* and *Leucas linifolia* were common among broadleaf weeds. The maximum control of grasses, sedges and broadleaf weeds was obtained from the testing XL-COMBI-SG 10 g l^{-1} water followed by XL-COMBI-SG 7 g l^{-1} water and the standard glyphosate 41 % SL 10 ml l^{-1}. The gradual decrease in weed control efficiency after 45 DAA was recorded mainly due to the resurgence of the perennial weeds having stolon or sucker (grasses), nut (sedges) and corm, tuber, rhizome (broadleaf). No phytotoxicity was recorded in tea plants either due to the standard Glyphosate or the testing new molecule XL-COMBI-SG. Therefore, from this experiment it could be concluded that XL-COMBI-SG 7 or 10 g l^{-1} water for controlling the tea weeds may be a replacing of the standard glyphosate 41 % SL applied @10 ml l^{-1} water.

P-97 Management of parasitic weed *Orobanche* in transplanted tobacco in western zone of Tamil Nadu

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Orobanche is a total root parasite on tobacco in India and debilitates the plant to the maximum, resulting in stunted crop growth and very poor yield. Hand removal is quicker method of *Orobanche* control. But it is very laborious and expensive. Growing trap crop in rotation with tobacco will be most effective method in *Orobanche* control. But it is not possible to take pre tobacco trap crop in Western Zone of Tamil Nadu. Keeping this in mind. The field experiment was conducted in the hot spot area's with the following objectives to evaluate the weed control efficiency of chemical weed management and to workout economics of the different weed control treatments. Neem cake 100 and 200 kg/ha, $CuSo_4$ 5%, glyphosate 0.1 and 0.2%, glyfosinate 0.1 and 0.2%, paraquat 0.1 and 0.2% on 4 - 5 weeks and 8 - 10 weeks after planting were compared with unweeded control in a RBD with five replication in tobacco during *rabi* 2005 - 06. The herbicides evaluated (glyphosate, paraquat, glufosinate) did not affect the *Orobanche* germination and shoot emergence appreciably. In contrast glyphosate caused crop phytotoxicity interms of discoloration of leaves. Substantial reduction in *Orobanche shoots* (61.7%) was recorded with the plant hole application of neem cake either at followed by 100 kg / ha (51.6%) with $CuSO_4$ 5% solution also reduced the Orobanche infestation by 37.1%. Among the total herbicides applied, glyphosate (either at 0.1 or 0.2%) reduce the *Orobanche* better than with other two herbicides *viz.*, paraquat or glufosinate. Due to initial phytotoxic effects on the plants paraquat as well as glufosinate failed to increase the yield of tobacco.

P-98 Studies on integrated weed management in ratoon sugarcane

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A field experiment on integrated weed management in ratoon sugarcane was conducted at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad for three years during 2005, 2006 and 2007. The results of the experiment depicts that the treatment with Atrazin @ 2.0 kg/ha as a pre-emergent on 3 DAH + 2, 4-D @1.25 kg/ha as a post-emergent on 90 DAH + direct spray of glyphosate @ 1.0 kg/ha on 150 DAH recorded significantly superior yield, yield attributing characters and B:C ratio as compared to other 9 treatments. The mentioned treatment recorded Sugarcane yield of 130, 125 and 120 t/ha with millable canes of 1.20, 1.17 and 1.05 lakh/ha. The highest weed control efficiency (87, 98 and 98 per cent) and C:B ratio (1:13.1, 1:12.6 and 1:7.7) were recorded during the year 2005, 2006 and 2007, respectively. While weedy check recorded weed control efficiency (38.51, 33.9 and 41.9 per cent, respectively), yield (41.20, 60.0 and 55.07 t/ha, respectively) and C:B ratio (1:5.8, 1:5.5 and 1:2.7, respectively).

P-99 Management of *Cuscuta chinensis* and other weed flora in lucerne (*Medicago sativa*)

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A field experiment was conducted on sandy loam soil of medium fertility status during rabi 2005-06 and 2006-07 at College of Agriculture, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad. The experiment with 10 treatments *viz.* pendimethalin 0.5 kg ha^{-1}pre-emergence as sand mix, imazethapyr 150g ha^{-1} as post emergence spray at 15 DAS, stale seedbed with paraquat 0.5 kg ha^{-1},stale seedbed followed by pendimethalin 0.5 kg ha^{-1} as pre-emergence , soaking lucerne seed of local market in water,pure seed of lucerne with weeding at 30 DAS, farmers practice of weeding at 30 DAS in lucerne of local market seed, lucerne raised out of pure seed (weedy check) and lucerne raised with seed of local market(weedy check) was laidout in randomized block design replicated thrice. Major weed flora observed was *Cuscuta chinensis, Cyperus rotundus*, *Panicum* spp., *Parthenium hysterophorus, Legasca mollis, Digera arvensis, Euphorbia geniculata, Trichodesma indica, Cichorimum intybus* and *Amaranthus viridi.* Among these weeds. Per cent infestation of *Cuscuta* was the highest (95%) in lucerne raised with seed of local market (weedy check). The crop raised out of pure seed was not infested with *Cuscuta* indicating the importance of source of seed in raising lucerne for fodder. The herbicidal treatment i.e. imazethapyr 150g ha^{-1} as post emergence spray was effective against *Cuscuta* and other weed flora which resulted in low weed dry matter and high green fodder yield and statistically similar to cultivation of pure seed of lucerne coupled with hand weeding at 30 DAS and significantly superior over the other treatments.

P-100 Screening of new herbicides for efficient weed control in sugarcane

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A field experiment was conducted to screen new herbicides for effective weed control in sugarcane at Zonal Agricultural Research Station, V.C. Farm, Mandya. The experiment was conducted at 2004, design adopted was RCBD with three replications. New herbicides were screened for herbicide efficiency as pre-emergent sprays or combination of herbicides or post-emergent sprays followed by either hoeing or post-emergent application of 2,4-D in comparison with recommended chemical atrazine @ 2.0 kg a.i/ha and recommended cultural practice i.e., 3 hoeing. Among the herbicides tested application of metribuzine as pre-emergent spray @ 1.0 kg a.i/ha followed by one hoeing after 60 days after planting control the weeds to the maximum extent (67.00 gms/m^2) followed by metribuzine as pre-emergent spray @ 1.0 kg a.i/ha followed by 2,4-D application as post-emergent spray at 60 days after planting and hoeing at 90 days after planting (68.5 gms/m^2) and resulted in higher cane yield (128 t/ha and 123 t/ha) respectively which were on par with each other.

P-101 Planting pattern and weed management studies under urdbean + ragi intercropping cropping system

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A field experiment was conducted during *kharif* season of 2006 at Crop Research Centre, G. B. P. U. A. & T., Pantnagar, to find out an appropriate planting pattern and weed management practice in urdbean + ragi intercrops grown on sandy loam in texture having medium organic carbon (0.57%), available P (15.5 kg/ha) and high available potassium (256 kg/ha) with pH 7.6. Sixteen treatments comprised of four planting pattern {sole urdbean, sole ragi, urdbean+ragi (1:1) and urdbean+ragi (2:1)} in main plots and four weed practices (weedy, hand weeding 25 DAS, pendimethalin 1.0 kg a.i. /ha and pendimethalin 0.75 kg a.i. /ha+ 40 DAS hand weeding) in sub plot were laid out in split plot design with three replications. Planting was done on August 1, 2006 and harvested on November 11, 2006.

Sole cropping of urdbean and ragi produced significantly higher grain yield (1187 and 3927 kg/ha) than that of intercropping. Between intercropping patterns, 2:1 out yielded 1:1 with respect to urdbean yield and the reverse was true for ragi. Both the intercropping patterns which were on par gave significantly higher urdbean equivalent yields than that of sole cropping of either urdbean or ragi

All weed management practices registered their significant superiority over control (weedy) with respect to yields of urdbean and ragi as well as urdbean equivalent yield. Application of 0.75 kg/ha Pendimethalin as pre-emergence + one hand weeding at 40 DAS recorded significantly higher yield of urdbean as well as urdbean equivalent yield than remaining treatments, while the yield of ragi under this treatment was on par with HW 30 DAS.

P-102 Efficacy of herbicides on weeds and seed yield of fenugreek (*Trigonella foenum- graecum* L.)

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A field experiment was conducted in a randomized block design with three replications during rabi season of 2005-2006 at Vegetable Research Centre- of G.B.Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand. Pendimethalin, isoproturon and metribuzin were sprayed at pre-emergence just after sowing the crop. Fluchloralin was incorporated in to the soil before planting. Metribuzin at 0.15 kg ha^{-1} was subjected to one hand weeding at 40 days after sowing (DAS). Metribuzin at 0.35 kg ha^{-1} as pre-emergence spray was also compared with its post-emergence application. All the herbicides were applied as spray using 500 l of water per hectare.

Fenugreek variety "Pusa early bunching" was sown on November 16, 2005 with a seed rate of 20 kg ha^{-1}, 30 cm apart in rows. The crop was fertilized uniformly with 40 kg N, 60 kg P_2O_5 and 40 kg k_2 O ha^{-1} through urea, diammonium phosphate and muriate of potosh, respectively. The crop was harvested on April 22, 2006.

Phalaris minor, Chenopodium album, Anagallis arvensis, Fumaria parviflora, Vicia sativa, Cyperus rotundus, Medicago denticulata were the major weeds observed in the crop.

Some other notable weeds were *Physalis minima*, *Coronopus* spp. and *Melilotus* spp. All the herbicides reduced weed density significantly as compared to weedy check at 30 days stage. Dry matter accumulation by the weeds at lower doses of isoproturon (0.50 kg ha^{-1}) and metribuzin (0.15 kg ha^{-1}) was at par to that of weedy check plots.

On an average, uncontrolled growth of weeds resulted in to 86.3 per cent reduction in the seed yield of fenugreek when compared with weed-free treatment. All the herbicides except that of lower dose of isoproturon and post-emergence spray of metribuzin gave the similer yield to that of weedy plots. Post-emergence application of metribuzin proved toxic to the crop. Weed-free treatment followed by hand weeding twice (20 & 40 DAS), metribuzin at 0.15 kg ha^{-1} + one hand weeding and pendimethalin at 1 kg ha^{-1} proved promising for fenugreek and increased seed yield significantly over control.

P-103 Studies on spray application techniques for herbicides in actual field conditions

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Usually for herbicide applications, high volume spraying technique has been recommended at the rate 500 to 650 l/ha which in turn requires large quantities of water. Different spray application techniques have been evolved based on different principles and methods of spray droplet generation like high volume spraying (HV), medium high volume spraying (MHV), low volume spraying (LV), very low volume (VLV) and ultra low volume spraying (ULV) based on the spray volume to be applied per unit of field or crop area. Therefore studies were made to evaluate the different spray application techniques in soybean (*Kharif*) and wheat (*Rabi*) crops. Field experiment was conducted to evaluate the different spray application techniques in randomized laid out field plots of (10×4.5) m size with six treatments and four replications.

The weed control efficiencies attained in different spray treatment indicated that the herbicide Fenoxaprop controlled Kharif weed population varying between 63 to 66 per cent as compared to 54 to 66 per cent by quiziloprop. Both the herbicide worked well in the different spray treatments as indicated by weed dry matter reduction of the order of 84 to 92% in case of fenoxaprop and 86 to 88 per cent by quiziloprop herbicide. The grain yield of soybean was found varying closely between 6.93 to 8.0 q/ha in different spray treated experimental plots. Therefore, in case of both herbicides, weed control achieved was similar and comparable in high volume, medium high volume, low volume and very low volume sprayings.

The weed control efficiencies attained in wheat crop by different spray treatments indicated that the herbicides metribuzine controlled the *Rabi* weed population varying between 54-79 per cent as compared to 69-82 per cent by 2, 4-D. The dry matter reduction was found of the order 76-90% in case of metribuzine and 83-94% by 2, 4-D herbicide. The grain yield of wheat found was varying closely between 31.5-38.2 q/ha in different spray treatments of metribuzine treated plots and 31-41 q/ha in 2, 4-D treated experimental plots. Therefore in wheat, both herbicides metribuzine and 2, 4-D worked well and similar comparable results was achieved in the HV, MHV, LV and VLV spray applications.

P-104 Integrated weed management studies in spring planted sugarcane

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A field trial was conducted during 2003-04 and 2004-05 at G.B. Pant University of Agriculture &Technology, Pantanagar to study the effect of integrated weed management practices in spring planted sugarcane. Experiment with twelve treatment consisting of ametryn at 2.0 kg ha^{-1} as pre-emergence alone, ametryn at 2.0 kg ha^{-1} followed by (fb) hoeing at 60 days after planting (DAP) or hoeings at 60 and 90 DAP, ametryn at 2.0 kg ha^{-1} fb 2,4-D 1.0 kg ha^{-1} or metsulfuron methyle (MSM) 4.0 g ha^{-1} at 70 DAP, metribuzin at 800 g ha^{-1} fb hoeing at 60 DAP or hoeing at 60 and 90 DAP, glyphosate at 1.5 kg ha^{-1} before sugarcane emergence and after weed emergence fb hoeing at 60 DAP, atrazine at 2.0 kg ha^{-1} or metribuzin 1.0 kg ha^{-1} applied after first irrigation fb hoeing, three hoeing at 30, 60 and 90 DAP and weedy check were replicated thrice in a randomized block design. Three budded set of sugsrcane variety Co-pant 90223 were planted on march 20, 2003 and Feb. 27, 2004 at a row spacing of 75 cm. Herbicides as per treatment were applied as spray using 600 litres of water per hectare.

Cyperus rotundus, Echinochloa spp, Celosia argentia, Ipomoea spp and Commelina spp were the dominating weeds associated with the crop and constituted 46.08, 21.16, 12.97, 5.46 and 4.78 of total weed population, respectively. Lowest density as well as dry weight of total weeds were recorded under the treatments of three hoeing at 30, 60 and 90 DAP and it was at par with pre emergence application of metribuzin at 800 gha^{-1} or ametryn 2.0 $kgha^{-1}$ supplemented with two hoeing at 60 and 90 DAP, except total weed dry weight in pre-emergence application of ametryn at 2.0 $kgha^{-1}$ supplemented with two hoeing.

Uncontrolled weeds on an average caused 69.2 per cent reduction in cane field when compared with three hoeing given at 30,60 and 90 DAP stages. The highest cane yield was recorded with three hoeing at 30,60 and 90 DAP treatments which was closely followed by pre-emergence applications of metrinuzin at 800 gha^{-1} or ametryn at 2.0 $kgha^{-1}$ supplemented with hoeing at 60 and 90 DAP. The higher cane yield under these treatments was because of higher values of cane length and millable cane ha^{-1}.

P-105 Integrated weed management in pointed gourd *(Trichosanthus dioca)*

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A field experiment was conducted during 1999-2000 and 2000-01 under state land possessing gangetic river terrace deposited with recent young alluviul soil best suited to the cultivation of cucurbits with the objective to study the efficacy of herbicides with and without hand weeding (spading) in pointed gourd (*Trichosanthus dioca*). The results indicated that higher fruit yield of 126.37 q/ha was obtained under weed free check which was at par with two spading at 30 and 60 days after planting. These two treatments were significantly superior to all herbicidal treatments under test. It was further noted that herbicides were not as effective as weeding or spading, but were significantly superior to weedy check. Application of isoproturon 1.5 kg/ha yielding 84.7 q/ha was statistically superior to fluchloralin 1.5 kg/ha (74.4 q/ha) but statistically at par with alachlor 1.5 kg/ha and pendimethalin 1.0 kg/ha when these herbicides were supplemented with one spading at 60 DAP. There was a significant increase in yield level than those obtained with herbicides alone. The highest per cent increase in yield over weedy check was observed to be 103.3 in weed free check.

P-106 Effect of time of application on the efficacy of glyphosate and combi against weeds in non-cropped land

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A study was conducted during 2007 to evaluate the effect of day time on the efficacy of glyphosate and combi against weeds in non-cropped land under edaphic and climatic conditions of Jabalpur (M.P.). Microbial counts in soil was also recorded at 60 days after start of experiment. The data recorded on weeds reveals that the activity of *combi* at 2.0 kg/ha was little bit better compared to glyphosate applied at the same rate (2.0 kg/ha) against *Desmostachea bipinnata* and *Cynodon dactylon*, The density and dry weight of *Desmostachea bipinnata* and *Cynodon dactylon* were minimum when herbicides were applied at and morning applications. The application of herbicides (glyphosate and combi) at different day times caused marked variation on the population of fungi and actinomycetes except bacterial population at 60 days after start of experiment. The more reduction in the population of fungi and actinomycetes was observed when herbicides were applied during noon time as compared to their application during evening time being comparable to morning time.

P-107 Weed management in spring planted sugarcane (*Saccharum officinarum* L.)

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An experiment was carried out at new area farm of Rajendra Agricultural University, Pusa, Samastipur during spring season of 2000-2001 to study the effect of weed management practices on weeds and productivity of sugarcane. The soil of the experimental plot was sandy loam in texture, calcareous in nature and low in fertility status having available nitrogen (143.60 kg/ha), available phosphorus (20.50 kg/ha) and available potash (119.50 kg/ha) with pH (8.3). The experiment was laid out in randomized block design with three replications. The treatments consisted of nine different weed management practices viz. weedy check; three hoeings at monthly interval i.e. 35, 65& 95 DAP; manual weeding twice at 35& 55 DAP; atrazine @ 2.0 kg a.i./ha (pre-em)+ 2,4-D @ 1.0 kg a.e./ha (post-em at 60 DAP); metribuzin @ 1.5 kg a.i./ha (pre-em); pendimethalin @ 2.0 kg a.i./ha (Pre-em); ametryn @ 2.0 kg a.i./ha (pre-em); metribuzin @ 1.5 kg a.i./ha (pre-em) + 2,4-D @ 1.0 kg a.e./ha (post-em at 60 DAP) and glyphosate @ 1.0 kg a.i./ha as direct spray at 30 DAP.

The dominant weed flora among broad leaves weeds were; *Chenopodium album* L., *Convolvulus arvensis* L., *Melilotus indica* L., *Cannabis sativa* L., *Anagallis arvensis* L. *and Parthenium hysterophorus* L. Among the grassy and sedges weeds, *Cynodon dactylon. pers and Cyperus rotundus* L. severely infested the crop field. The growth, yield and yield attributing characters were significantly influenced by different weed management practices. Among the weed control treatments, hand weeding twice at 35 and 55 DAP was found to be the most effective in controlling the weeds and increasing the growth and yield attributing characters viz. height of canes, tillers count, millable canes, single cane weight and cane diameter mainly due to lesser weed count, dry weight of weeds and better weed control efficiency. The highest cane yield of 68.43 t/ha was recorded under hand weeding performed twice at 35 and 55 DAP and in turn was statistically at par with cane yield obtained under atrazine @ 2.0 kg a.i./ha as Pre-em+ 2,4-D @ 1.0 kg a.e./ha as post-em(64.79 t/ha) and the treatment metribuzin @ 1.5 kg a.i./ha as Pre-em + 2,4-D @ 1 kg a.e./ha as post-em (66.93 t/ha).The maximum net return of Rs. 33971/ha was recorded under the treatment hand weeding twice at 35 and 55 DAP followed by the net return obtained under chemical weeding with atrazine as pre-em +2,4-D as post-em (Rs. 33924/ha) and metribuzin as pre-em+ 2,4-D as post-em (Rs. 32764/ha).

Though hand weeding performed better in controlling weeds, chemical weed control methods seems to be the most economical.

P-108 Nutrient uptake and moisture use of cumin as influenced by crop weed competition

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Cumin (*Cuminum cyminum* Linn.) is the important major seed spice crop of Rajasthan, occupying about 60 % of total cultivated area and production of the country. But the average yield (310 kg ha^{-1}) is very low in the state. Besides, several factors responsible for low yield of cumin, competition offered by weeds is most important. Weeds deplete soil moisture and nutrients considerably resulting in severe loss of yield. Effective weed management play vital role to tackle weed infestation. However, to get economic and effective weed control, identification of critical period of crop weed competition is of prime importance. Hence, a study was conducted to find out critical period of weed removal and its effect on the moisture and nutrient uptake in cumin.

The experiment was conducted at the research farm of Central Arid Zone Research Institute, Jodhpur during winter season of 2004-05 and 2005-06. The experiment was laid out in randomized block design with 3 replications. There were 10 treatments including weed free check up to 15, 30, 45, 60 DAS and up to harvesting and weedy check up to 15, 30, 45, 60 DAS and up to harvesting of the crop. Cumin RZ-19 was sown at 30 cm apart with 12 kg seed ha^{-1} on 11 and 9th November during 2005 and 2006, respectively.

The predominant weed flora comprised of *Chenopodium murale* (44.7%), *Asphodelus tenuifolius* (24.7%) and *Chenopodium album* (10.5%). The highest seed yield (418 kg ha^{-1}) was recorded with weed free check through out the cropping season, while weedy check up to harvest gave only 151 kg ha^{-1} seed yield. Crop kept weed free up to 30 DAS resulted in seed yield at par of that maintained weed free up to harvesting, but further extension in the weedy check period i.e. up to 30, 45 and 60 DAS caused significant reduction in the seed yield. The maximum net return of Rs. 12308 ha^{-1} was recorded with weed free check kept up to 30 DAS.

The water use efficiency was markedly improved with increasing weed free period. The maximum water use efficiency (1.61 kg ha^{-1} mm^{-1}) was recorded with weed free check up to harvesting. Crop kept weed free up to 15, 30, 45 and 60 DAS provided 0.81, 1.44, 1.49, and 1.52 kg ha^{-1} mm^{-1} water use efficiency. On the other hand, weed infestation up to 15 DAS resulted in 1.47 kg ha^{-1} mm^{-1} water use efficiency as compared to 0.66 with weedy check through out the cropping season.

The uptake of nutrients (N & P) by cumin seed was highest with weed free check up to harvesting followed by weed free up to 60, 45 and 30 DAS. Weedy check up to 15 DAS also showed significant increase in the uptake of N and P. Keeping weedy check beyond 30 DAS to harvesting, significantly decreased nutrient uptake as compared to weed free check. Considering the seed yield, monetary benefit, nutrient uptake and moisture use efficiency the critical period of crop weed competition was observed between 25 to 35 DAS.

P-109 Effect of integrated weed management and balanced fertilization on crop weeds competition in coriander (*Coriandrum sativum* L.)

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A field experiment was conducted at Instructional Farm RCA, Udaipur during *Rabi* seasons of 2002-03 and 2003-04 on clay loam soil to evaluate the impact of weed management practices and balanced fertilization on weeds and yield of coriander. The experiment consisted of 11 weed management practices in main plots weedy check one hand weeding (HW) at 30 DAS, two HW at 30 and 45 DAS, pendimethalin 1.0 kg/ha. oxyfluorfen 0.25 kg/ha, metribuzin 0.25 kg/ha + HW at 45 DAS. Metribuzin 0.30 kg/ha + HW at 45 DAS, oxyfluorfen 0.25 kg/ha + HW at 45 DAS, metribuzin 0.30 kg/ha + HW at 45 and oxadiargyl 75 g/ha + HW at 45 DAS and 3 balanced fertilization treatments in sub plots ($N_{60} + P_{30}$, $N_{60} + P_{30} + K_{30}$ and $N_{60} + P_{30} + K_{30} + S_{30}$ kg/ha) were laid out in a split plot design with 3 replications. All herbicides were sprayed three days after sowing using a foot sprayer fitted with a flat nozzle delivering 800 liters of water/ha.

The dominant weed flora of the experimental site were goose foot (*Chenopodium murale* L.). corn spurry (*Spergula arvensis* L.). Indian sweet clover (*Mglilotus indica* L.), searlet pimpernel (*Anagallis arvensis* L.) and purple nutsedge (*Cyperus rotundus* L.), among them goose foot (*Chenopodium murale* L.) was found most dominant weed.

Two hand weeding at 30 & 45 DAS being at par with pandimethalin + hand weeding was found more effective than others in reducing the weed density and dry matter throughout the crop season. Balance fertilization had no influence on weed density. While N+ P + K and N+ P + K + S application increased weed dry matter significantly at all the stages of crop growth as compared to N+ P + K fertilization. Maximum reduction in coriander seed yield was observed in the weedy check. All the weed management practices increased the seed yield of coriander significantly as compared to weedy check. The maximum seed yield (15.84 q/ha) recorded under two hand weeding was 20 per cent higher than weed check. Amongst herbicides, 1 hand weeding treatments, pendimethalin + hand weeding remained at par with two hand weeding representing an increase of 199 per cent in seed yield over weedy check. Balanced fertilization with N+ P + K + S significantly increased the seed yield to the tune of 18.0 and 8.90 per cent over N+P and N+ P + K fertilization respectively.

Pendimethalin + hand weeding at 45 DAS with N+ P + K + S fertilization observed to be best treatment combination for realization of highest net returns from coriander followed by two hand weeding 30 & 45 DAS with N+ P + K + S combination.

P-110 Seasonal stability and competitive ability of weeds in sunflower as affected by crop canopy and weed management practices

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Investigations were carried out for two consecutive *Rabi* seasons (2003 and 2004) on weed flora of the sunflower as affected by different planting patterns and weed management practices. The experiment comprised of two planting patterns (45x30 and 60x22.5 cm) and six weed management practices (unweeded check, hand weeding twice, pre-plant incorporation of fluchloralin, pre-emergence application of pendimethalin, combination of reduced doses of each of the herbicide alone and in combination with one hand weeding) in factorial randomized block design. The planting pattern of 45x30cm resulted in early canopy development with effective light interception. The effect of shading was not significant on grasses and sedges, whereas it was significant on BLWs, where the unit weight of individual BLW was significantly reduced by shading effect, there by reducing the competitive ability of BLWs. Among weed management practices, hand weeding twice resulted in higher light interception by crop with effective shading on weeds, which in turn resulted in reduced weed dynamics, which was at par with pre-emergence application of pendimethalin @ 1 kg ha^{-1}. The late emerging weeds in herbicide sprayed treatments had lower competitive ability due to reduced unit weight. The investigation revealed that the weed flora of sunflower was seasonally stabilized but competitive ability of the weeds depends on type of the weed and weed management practice.

P-111 Effect of genotypes and weed management on weed dynamics of chickpea (*Cicer aritinum*)

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Experiment was conducted in *Rabi* 2006-07 comprising sixteen chickpea genotypes with four combination of weed management in factorial randomized block design with three replications at Rajendra Agricultural University, Pusa, Samastipur. Significant difference was observed among the genotypes for weed suppression and grain yield. Chickpea genotype ICP 92-3, recorded lowest weed count, weed density and weed dry biomass, which was found to be at par with IPC-2000-37, IPC 2003-51 and BG-112 and significantly lower than the rest of the genotypes. Highest weed control efficiency was also recorded under chickpea genotypes ICP-92-3. Weed control treatments recorded significantly lower weed population, weed dry bio-mass and weed density than weedy check. Among the weed control treatments pre-emergence application of pendimethalin at 1.0 kg/ha followed by one hand weeding 40 DAS proved most effective treatment and recorded lowest weed population, weed dry bio-mass as well as highest weed control efficiency and grain yield.

P-112 Studies on weed seed bank under rice – mustard cropping system of Bindhya alluvial and Gangetic alluvial zones of West Bengal

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Investigation on weed seed bank was carried out during *Rabi* 2005-06 to have an idea of the extent of weed seed deposition in the soil of Bindhya alluvial and Gangetic alluvial zones of West Bengal. Twenty soil samples were collected from each depth (0–5, 5–10, 10–15 cm) after harvest of *Kharif* rice (2005) in rice – mustard cropping system in each zone. Two kg dry soil from composite sample was kept in each shallow tray (25 cm x 20 cm) for each depth of soil, replicated thrice, watered as and when required. Emergence of seedlings was recorded in four flushes. Gibberlic acid at 100 ppm was applied to facilitate the germination of remaining weed seeds after third flush. Average bulk density of the soil was calculated to be 1.3 g/cc and 1.4 g/cc in Bindhya alluvial and Gangetic alluvial zone, respectively. Emergence of seedlings of 6 and 7 species in Bindhya alluvial and Gangetic alluvial zone, respectively was recorded of which broad-leaved weeds (*Gnaphalium purpureum* and *Polygonum plebeium*) were dominant and the number was higher in upper surface. Average number of emergence per 100 g. soils was 16 and 12 and the computed number of emergence was 31005 and 25620/m^2 in Bindhya alluvial and Gangetic alluvial zones of West Bengal, respectively.

P-113 Physiological studies on weed control efficiency in coriander

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A field experiment was carried out during *Kharif* season at Main Agricultural Research Stations, University of Agricultural Sciences, Dharwad to know the efficacy of different herbicides in controlling weeds in coriander and to know the influence on physiological and biophysical parameters. The soil of the experimental plot was medium black with 221 kg /ha available nitrogen, 32.4 kg/ha available phosphors and 318.7 kg/ha available potassium. The experiment was laid out in a randomized block design (RBD) with 12 treatments and three replications. The treatments comprised of five pre-emergence herbicides each at two concentrations and were compared with weed free check and unweeded control. Among the herbicides studied pre-emergence application of oxadaizon at 0.5 kg ai/ha oxyfluorfen at 0.15 and 0.20 kg ai/ha and metolachlor at 1.0 kg ai/ha were found more effective in reducing weed biomass. Oxadiazon at 0.6 kg ai/ha and oxyfluorfen at 0.15 kg ai/ha and 0.20 kg ai/ha was found phytotxic to coriander. Metolachlor had recorded higher weed control efficiency coriander yield was highest in metolachlor application (610 and 602 kg/ ha at both the concentrations followed by weed free check (590 kg/ha). Application of metolochlor at both concentrations has increased the chlorophyll content and photosynthetic rate. Regarding the economics of weed management practices, application metolachlor at 1.0 kg ai/ha recorded higher B:C ratio (5.02) with maximum net returns of Rs.18,310 /ha.

P-114 Ecobiology and management of *Eichhornia crassipes* for efficient water productivity

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Water hyacinth (*Eichhornia crassipes*) is a perennial, herbaceous monocotyledon aquatic plant in water bodies. Invasive aquatic weeds has spread throughout the world's waterways as a result of anthropogenic activities. Nowadays water hyacinth becomes a notorious problem in western parts of Tamil Nadu. Considering these situations the pot and tank culture experiments were conducted with the following objectives to quantify the biological characteristics of water hyacinth and to evaluate herbicidal management of water hyacinth. *Eichhornia grassipies* plants were collected uniformly at four leaf stages and inoculated in the cement tanks at the rate of ten plants per tank, for biological studies. Well grown *Eichhornia grassipies* plants were collected at uniform sizes and inoculated in each tank at the rate of 70 plants per tank for management study. Treatments consisted of paraquat 6 and 8 ml, glyphosate10 and 15 ml, 2,4-D Na salt 6 and 8 g/litre of water with ammonium sulphate 2% + 1% surfactant, *Coleous* plant extract 300 ml/l and unsprayed control were evaluated.

Mother plants grow very fast from first to sixth week after inoculation and after that seed maturation and senescence and ramet production started. Ramets emerged from third week onwards and involved in fast growth up to six weeks, which resulted in fast multiplication of water hyacinth. Results on herbicidal management of *Eichhornia crassiees* revealed that glyphosate either at 10 or 15 ml/l of water recorded lower dry weight (2 g/pl) at 21 days after herbicide spraying followed by 2,4-D (6 and 8 g/l) showed epinastic symptoms in the early stage and caused death of plants at later stages. It could be concluded that spraying of glyphosate 10 ml/lit + ammonium sulphate 2% + 1% surfactant may be recommended for the control of water hyacinth in large water bodies.

P-115 Estimation of yield loss due to weeds in maize growing area of the western zone of Tamil Nadu

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Yield loss prediction will enable the economic analysis of weed control which will in turn provide a basis for strategic use of different weed management practices. The broad objective of the study is to assess the yield loss caused by weeds and yield gains associated with certain weed management practices followed in maize growing area of the western zone of Tamil Nadu. Samples of 50 maize farmers are randomly selected in two villages of Coimbatore district to conduct the survey. Survey report revealed that 74% of the sample farms are highly irrigated and weed menace is highly seen. About 62% of the maize farmers expressed that weed infestation reduces the grain yield and estimated yield loss is about 32% due to weeds. Manual weed control is difficult and costlier (Rs.1574.98/ac) among all other weed control methods. About 92.73 % of the farmers apply herbicide spraying, atrazine as pre-emergence herbicide at 1.12kg /ac, (higher rate than the recommended level). Herbicide application control 80% of weed population and remaining uncontrolled weeds are removed manually by hand weeding, by engaging 7 – 8 labours/acre. Hence, tillage, crop rotation, chemical method and hand weeding methods are widely adopted by maize growers and 82% of them are highly satisfied with the existing weed management practices. Private hybrid seed firms play a dominant role (mean score 77.27) in providing technical information to the farmers by employing technical personals. Availability and cost of labour is the primary constraint, followed by cost and availability of inputs (seeds & herbicides). Existence of non awareness and non adoption of labour saving weed implements is prevailed in the study area. Thus, extensional activities should be strengthened to create awareness about different cost effective weed implements among maize growers to mitigate scarcity of labour problem.

P-116 *Tithonia rotundifolia* an invasive noxious weed in black clay soils of western zone of Tamil Nadu

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Tithonia rotundifolia is a noxious weed belongs to the family Asteraceae, native of northern America commonly named as Mexican-sunflower. *T. rotundifolia* is an annual monocarpic plant and seeds exhibit a period of dormancy before germinating. Entire or lobed dark green leaves (3-6" long) with hairy undersides are generally ovate to triangular in shape with serrate to crenate margins. *T. rotundifolia* produces small-sized and many seeds and high reproductive ability of *T. rotundifolia* ensures its early vigorous start in seedling growth, quick establishment, longer survival and to grow more aggressive. *Tithonia rotundifolia*, is an agricultural weed, casual alien, cultivation escape, and noxious weed.

The invaded weed into the black soils of Sulur areas of Coimbatore district has been identified as *Tithonia rotundifolia* (Mill.) Blake. Leaves are spindled shape with shallowly incised at the base. They are thinly hairy in nature with parallel venation. Leave arrangements are alternate and opposite. Stem is succulent and angular. Flowers are with yellow colour petals and ray florets. Flowers are solitary and terminal heads. Roots are adventitious and runners. This species has been reported from Sri Lanka under cultivation as ornamental, but not reported from Tamil Nadu so far. Possibly this species must have been introduced either from other parts of India or from Sri Lanka through flights or horticultural plants as it being invaded in and around the vicinity of Coimbatore Civil Aerodrome. It is further reported that when this plant, if it is grazed by the livestock, it is found to be fatal. Hence, an attempt has been made to managel this obnoxious weed by herbicides like glyphosate, metribuzin and 2, 4-D under non-crop situation. The results revealed that post-emergence application of glyphosate 10 ml+ 2, 4-D 6g+soap solution 2 ml / litre of water could reduce the *Tithonia* density as well as biomass considerably.

P-117 *Parthenium hysterophorus* species diversity across India

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Parthenium is an annual herb belonging to Asteraceae family. Parthenium is a weed of national significance. It is considered to be one of the ten worst weeds in the world. In India, it is estimated to lower the yield of field crops by 40% & forage crops by 90% in severely infested areas. In order to effective control of this weed, an eco-friendly and a novel idea have been implemented. Which is possible through bio-agents / competitive plants such as *Cassia* species, *Hyptis* species etc., which suppresses the Parthenium.

Species diversity influences its response to varying environmental conditions, biotic & abiotic stress. Thus, genetic diversity of this plant may respond differently for the botanical agents. In this context Molecular Marker such as RAPD acts as an important tool for diversity analysis. In present study we have used 57 RAPD primers to screen 30 ecotypes of parthenium from different parts/location of India. Diversity analysis revealed by dendrogram constructed using gene-Linkage and the distance analysis showed diversity and revealed three major groups of parthenium. Grown at different agro-climatic zone, the morphological and diversity analysis were also compared. Suppression response of parthenium, belonging to different clusters to botanical agent was discussed was discussed.

P-118 Influence of different tillage systems and herbicides on soil microflora of rice rhizosphere

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A field study was conducted in an Inceptisol with rainy season rice to evaluate the effect of different tillage systems vis-à-vis different weed control measures on the survival and growth of total bacteria, actinomycetes, fungi, *Rhizobium* and *Azotobacter* in rhizosphere soil. Four types of tillage system were evaluated viz. (i) conventional – conventional (ii) conventional-zero (iii) zero-conventional and (iv) zero-zero tillage systems. Among weed control measures comparative effect of hand weeding and recommended herbicidal application (butachlor as pre emergence and fenoxaprop ethyl + ethoxysulfuron as post-emergence) were tested along with a weedy check. The results of the investigation revealed that maximum growth of different microorganisms was observed in conventional-conventional tillage systems whereas minimum was in zero-zero tillage system. The use of recommended herbicidal application inhibited the microbial growth in rhizosphere soil of rice upto 10 DAS and again in between 20 to 50 DAS of the crop.

P-119 Effect of SRI and conventional rice cultivation on weed dynamics in transplanted rice

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Rice is grown in about 3.5 m. ha in Bihar with a productivity of about 1.4 t/ha. Rice, being the staple food crop, holds the key for food security of the state. Keeping in view the increasing population, enhanced production of rice has to be met in the back drop of declining resources such as land, water, labour and costly inputs. There is need to develop alternative rice production system that require less external inputs. The System of Rice Intensification (SRI) offers opportunities for improving rice production. It is being used increasingly in a variety of agro-ecosystems, with good results on almost all soil types. SRI has the potential to meet the challenge by virture of its capacity to enhance the productivity with less inputs. Rice plant under SRI have large root system, profuse and strong tillers with big panicles and well filled spickelets with higher grain weight. The secret behind this is that rice plants transplanted carefully at wider spacing as their roots can grow longer on soil that is kept well aerated with aboundant and diverse soil microorganisms. Weeds are the major biotic stress in rice cultivation. In general, the yield loss due to uncontrolled weed growth range between 18-20% in transplanted rice.

Keeping all these factors in view, a field experiment was laid out during wet season of 2006 at Rajendra Agricultural Research Farm, Pusa (Bihar) to evaluate the performance of SRI and conventional rice cultivation with reference to weed dynamic in transplanted rice. Experimental result revealed that significantly higher values of growth and yield attributes were recorded under SRI plots. Growth characters affect the yield contributory characters and finally grain yield. Yield contributory characters of rice viz., panicals/m^2, panical length, panical weight, total and fertile spikelets per panicle, 1000-grain weight and finally yield were significantly higher under SRI as compared to conventional rice cultivation. Significant differences in weed population and weed dry weight was recorded under SRI and Non-SRI plots. Again among SRI plots, variation in frequency of cono-weeding, cause significant variation in weed population and biomass.

P-120 Root characteristics and nutrient uptake of chickpea (*Cicer aeritinum* L.) as influenced by phosphorus and weed control measures

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A field experiment was carried out during *Rabi* season, of 2005-06 at Agronomy Research farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. The soil of the experimental field was silt loam in texture with pH 8.1, available N, P and K content was 165, 18 and 244 kg ha^{-1}, respectively. The experiment comprising 16 treatment combinations was laid out in a randomized block design with 3 replications. The treatment consisted of 4 phosphorus levels (0, 20, 40 and 60 kg ha^{-1}) and 4 weed control measures (weedy check, hand weeding at 30 DAS, pendimethalin @1 kg ha^{-1} and rice straw mulch). Chickpea variety 'Udai" was sown on 11th October, 2005 with the spacing of 30 cm apart using 80 kg seeds ha^{-1}. A common dose of nitrogen at 20 kg ha^{-1} was applied through urea as basal and phosphorus applied as per treatment.

Increasing level of phosphorus up to 60 kg ha^{-1} significantly increased root length, number of root nodules $plant^{-1}$ and nodules dry weight and nitrogenase activity, nitrogen and phosphorus uptake by crop. However, weed density and weed dry weight were decreased significantly with increasing level of phosphorus up to 60 kg ha^{-1}. Among weed control measures hand weeding at 30 DAS proved its superiority over rest treatments in respect of grain yield, root characteristics and nutrient uptake, followed by pendimethalin @ 1.0 kg ha^{-1} in chickpea.

P-121 Mistletoes on the tree crops of Kerala

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A survey was undertaken to identify the different species of semi parasitic plants infecting the tree crops of Kerala. From the survey conducted at Palakkad and Trissur districts 10 species of mistletoes of loranthaceae and Viscaceae family were identified. These are shrubby, usually aerial parasitic plants with fruits possessing viscoid layer. They are widely distributed geographically and as a group have a wide host range. Among the parasitic plants *Helicanthus elastica* the common species in the plains was not seen in elevations above 600m. While species such as *Scurrula parasitica*, *Viscum articulatum*, *V. capitellatum*, *V.ramosissimum* and *V. monoicum* were observed in areas where the MSL was above 600m while *Taxillus tomentosus* was seen at a MSL of 850m and above. *V. orientale*, *Macrosolen parasiticus* and *D. falcata* were seen both in the plains and the hilly region. Majority of the host plants are economically important crops such as Mango, Cocoa, Citrus, Rubber, Cashew etc. In Ayurveda the weed is reported to be used for the treatment of diabetics and infertility. However the phyto-chemical properties of the species depends on the host.

P-122 Weed management and rice establishment methods, their impact on weed flora and wheat establishment methods in sequence

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Rice and wheat are two crops on which a major chunk of the world's population depends. In India too intensively cultivated irrigated rice-wheat systems in the Indo-Gangetic Plains (IGP) are of great significant for food security, fuel fodder and feed. The rice-wheat rotation is the principal agricultural production system in south Asian countries, which occupies 13.5 m ha in IGP of Bangladesh, India, Nepal and Pakishtan. Puddling has adverse effects on subsequent cops on heavy textured soil. Wheat growth and yield is less after transplanted rice compared to DSR. Changing rice establishment form transplanting to direct seeding offers the potential to reduce costs through labour by avoiding the costs of transplanting (direct seeding may reduce labour requirements by 50%) and water savings in addition to comparable yield. Continuous direct seeding resulted in succession in weed flora. Weed species shift were evident after six years of cropping seasons with *Ischaemum rugosum* being dominant in wet-seeded plots. *Echinocloa colona* dominating in dry seeded plots and *Cyerus iria* and *E. colona* being most abundant under transplanting. The abundance of *Cyperus rotundus* was promoted under DSR and elevated by zero tillage of wheat. In wheat either higher or equal grain yield were recorded in zero tillage as compared to conventional tillage in all the establishment methods of rice except in rice transplanting. Highest net return was recorded in DSR followed by WSR and lowest in TPR rice establishment method.

P-123 Physiological studies on the effect of herbicides on growth and nodulation in *Vigna radiata* L.

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A field experiment was conducted at the Research farm of Rajendra Agricultural University, Bihar, Pusa during summer seasons of 2003 & 2004 to study the effect of herbicides on growth and nodulation in *Vigna radiata* L. It was observed that the weed population and weed dry weight was checked by the standard doses of oxyfluorfen and metalochlor in *Vigna radiata*. Root permeability was maximum in the treatment with oxyfluorfen along with clomazone and minimum with the oxyfluorfen. Total dehydrogenase activity at root apices was higher in plots treated with oxyfluorfen and minimum in oxyfluorfen along with clomazone treated plot. The leaf area and specific leaf weight (SLW) was found significantly altered by herbicidal treatment. There was no significant difference was observed regarding nodules, pod formation and test weight. Maximum seed yield 3.02 g per plant was recorded in the oxyfluorfen which was on par with the treatment metolachlor applied alone.

P-124

Weed flora of transplanted autumn rice of Barak valley, Assam

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Transplanted autumn rice culture is popular in some specific areas in Assam. The area, production and productivity of autumn rice ("*AUS*") in the Barak valley zone were 22674 ha, 18005 t and 794 kg/ha, respectively, in 2004-05, against 436244 ha, 286326 t and 666 kg/ha, respectively, for the state of Assam. Weed is always been considered as one of the most severe constraints in autumn rice, both for direct seeded and transplanted paddy. Due to high rate of emergence of summer weeds under the influence of hot temperature and increasing rain. Hence, the study has been under taken with an aim to explore the most problematic weed species in the transplanted autumn rice in the Barak valley zone of Assam to facilitate better management.

Sampling was done by random plotting of 1m x 1m square quadrats. The enlisted weed flora of transplanted autumn rice was short listed depending upon the frequency of occurrence in the sampling units as well as confining the study to the critical period of crop weed competition (CWC), which has been determined as 30 to 60 days after transplanting., and the survey was repeated at an interval of 5 to 8 years in each district. The study revealed that sedges were dominant in the entire Barak valley zone with cumulative summed dominance ratio as 44.78, 39.62 and 65.34 in Cachar, Hailakandi and Karimganj districts in 2007. Sedges were found to be dominant in autumn rice since 1992 in this zone; *Fimbristylis littoralis* Gaud. was the most troublesome species at that time in Cachar and Hailakandi districts. However, *Eleocharis acutangula* (Roxb.) Schult had appeared as the most dominant species over all other weeds in 2007 in all the districts of this zone; other dominant weeds were the broad-leaved species *Monochoria vaginalis* (L.) Solms and *F. littoralis* in the critical period of CWC. Amongst the grasses, *Isachne globosa* (Thunb.) Kuntz. and *I. miliacea* Roth has expanded quite dominantly in the fields before ploughing and covered comparatively higher amount of basal area during cropping than other grasses including *Leersia hexandra* Swartz, which was recorded as dominant grass in Cachar districts about one decade ago. Unlike the weed flora of winter rice, the autumn rice fields were dominated by therophytes, which propagate only through seeds. The most interesting feature of the Barak valley zone is the appearance of certain hemicryptophytes like, *Cynodon dactylon, Isachne globosa.*, etc. in the medium lowland autumn rice fields, and that has separated the weed vegetation of this ecosystem from that of the Brahmaputra valley.

P-125 Nutrient removal by weeds at different growth stages of boro rice (summer rice) under different weed management practices

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Boro rice in Assam is cultivated during November/December to May/June and covers approximately 10 per cent of the total rice growing area of the state. The growing season is relatively risk free with higher yield potential responding to an input-intensive rice production technology. Due to low temperature, the weed growth during early vegetative phase of the crop is slow. But, with gradual increase in temperature, weeds offer a stiff competition to the crop and at least two weedings (one at tillering and another at 3 weeks after first weeding) are required for effective control of the weeds. Farmers usually remove weeds manually, mechanically by running a rotary paddy weeder, or use pre-emergence herbicide followed by mechanical weeding. A study was undertaken during 2003-04 in research farm of Assam agricultural University, Jorhat to study the nutrient removal by weeds at different growth stages of boro rice under different weed management practices.

Twelve treatments involving mechanical and chemical weeding methods were tried with three replications in a randomized block design with individual plot size of 3 m X 5 m area in a silty clay loam soil. Weed samples were collected using 1m x 1m square quadrate at 30 days after transplanting (DAT) and after harvest of the crop from respective treatments and were analysed for N, P and K contents following standard procedures.

The highest uptake of nutrients by weeds was observed in weedy plot at 30 DAT, which was 2441 g N, 1095 g P and 4196 g K per hectare. Working with paddy weeder at 20 and 40 DAT resulted in removal of 1050 g N 446 g P and 1925 g K by weeds, which was the lowest among treatments except for P uptake. Among the pre-emergence herbicides, butachlor 1.0 kg ha^{-1} showed relatively lower uptake of nutrients by the weeds. In case of post-emergence herbicides, application of almix 4 g ha^{-1} was at par with weedy plot in terms of removal of N and K by weeds. Nutrient removal by weeds at harvest of the crop was significantly higher in case of the weedy plot, which was 3875 g N, 2570 g P and 9195 g K, compared to all other weed management treatments adopted. Among the pre-emergence herbicides, lowest was observed for oxadiargyl 70 g ha^{-1} + paddy weeder at 30 DAT in case of N, oxadiargyl 70 g ha^{-1} in case of P and pyrozosulfuron ethyl 25 g ha^{-1}+ PW at 30 DAT in case of K uptake by weeds. The nutrient uptake by weeds in post-emergence herbicide applied plots was relatively higher compared to the pre-emergence herbicides or mechanical weeding treated plot.

P-126 Effect of fertilizer levels and intercropping systems on weed dynamics

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An experiment was conducted at Birsa Agricultural University Farm, Kanke, Ranchi during *Kharif* season of 1998 and 1999.The soil of the experimental field was sandy loam in texture, low in organic carbon (0.43 %), available nitrogen (242.0 kg/ha), available phosphorus (9.82 kg/ha), medium in available potassium (170.2 kg/ha) and acidic in reaction (pH 6.2).The treatments comprised of three intercropping systems i.e.,pigeon pea + ground-nut (1:3), pigeon-pea + rice (1:3) and pigeon-pea + maize (1:1) in combination with three fertilizer levels i.e., 100 % recommended dose of fertilizers to both crops , 100 % recommended dose of fertilizers to pigeon-pea + 50 % recommended dose of fertilizers to companion crops and 100 % recommended dose of fertilizers to pigeon-pea + no fertilizers to companion crops along with all the four crops as sole crop for comparison. The crops were sown on 24.6.1998 in the first and on 18.06.1999 in the second year of experimentation. Intercropping of pigeon-pea with ground-nut, rice and maize significantly reduced the weed count, weed density, weed fresh biomass, weed dry biomass and increased weed control efficiency, weed suppression effect and pigeon-pea equivalent yield than sole croppings. Among the intercropping systems, pigeon-pea + ground-nut proved most effective and recorded lowest weed count, weed density, weed fresh biomass, weed dry biomass and highest weed control efficiency, weed suppression effect and pigeon-pea equivalent yield. Although application of 100 % recommended dose of fertilizers to pigeon-pea + no fertilizers to companion crops recorded the lowest weed count, weed density, weed fresh biomass, weed dry biomass and increased weed control efficiency and weed suppression effect but differences were not found significant. The same treatment recorded significantly low pigeon-pea equivalent yield.

P-127 Effect of time of weed removal on growth and yield of kodo millet

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A field experiment was conducted at Dindori (M.P.) to find out the effect of time of weed removal on growth and yield of kodo millet. The result revealed that significantly higher grain yield was obtained when the crop was kept weed free upto 20 days after sowing over weedy check and this was at par with the weed free condition upto 40 days after sowing. However, significantly higher yield was recorded under weed free condition throughout the year over all the treatments including weedy check. It was found that critical period of weed removal in kodo millet is 20-25 days after sowing.

P-128 Competitive ability of wheat and two grassy weeds (*Phalaris minor* and *Avena ludoviciana*) as affected by nitrogen supply

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Nitrogen, compared with other crop nutrients, is required in relatively high quantities by wheat for optimum vegetative and reproductive growth. *Phalaris minor* and *Avena ludoviciana* are the two dominant grassy weeds severely reducing the productivity of wheat crop in the country. Increasing the nitrogen supply may improve the ability of cereals to suppress weeds. Field experiments were conducted in microplots at the farm of National Research Centre for Weed Science, Jabalpur during 2004-05 and 2005-06 to study the effect of N supply on competition between wheat and two prominent grassy weeds viz., *Phalaris minor* and *Avena ludoviciana*. Six treatments comprising three species combinations (wheat monoculture, weed monoculture, wheat and weed mixture in equal proportions) and and two levels of N (20 and 120 kg N ha^{-1}) were studied in a randomized block design, with four replications.

The effects of N supply on competitive ability were examined by calculating plant relative yields (RY), relative yield total (RYT) and relative crowding coefficient (RCC). In both experiments, RY of wheat was <1, indicating that for this species the effects of interspecific competition were greater than the effects of intraspecific competition. In the study with *Phalaris minor,* for both species and N treatments, relative yields (RY) were <1 for both dry weight and N uptake. The effect of low N was to decrease the relative yield of wheat (for dry weight and N uptake) and increase the relative yield of weeds (for dry weight). The RYT was <1 for dry weight and N uptake, indicating that mutual antagonism was occurring. The values of RCC indicate that wheat was more competitive than *Phalaris minor* at high N, but less competitive at low N. In the study with *A ludoviciana,* relative yield of weed was greater than that of wheat for both dry weight and N uptake. This shows that, for this species, the effects of intraspecific competition were greater than those of interspecific competition. RYT was close to unity at both N levels, indicating both species competing for limiting resources. RCC was <1 indicating weed was more competitive than crop at both N levels.

P-129 Response and residual effect of various herbicides in okra (Kharif) – cabbage (Rabi) crop sequence

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A field study was carried out to evaluate direct and residual effect of various herbicides on yield of *kharif,* okra and *rabi* cabbage, respectively for three consecutive years (2001-02, 2002-03 and 2003-04) at the Instructional Farm, Navsari Agricultural University, Navsari. The experimental soil was clayer in texture, low in nitrogen (0.053%) medium in phosphorus (23.9 kg/ha) and high in potassium (372 kg/ha) with pH 7.6. Twelve treatments consisting of FYM at 10 t ha^{-1} + fluchloralin at 0.9 kg/ha as pre-emergence + hand weeding (H.W.) and hoeing at 30 days after sowing DAS (W_1), FYM @ 15 t ha^{-1} + fluchloralin at 0.9 kg/ha as pre-emergence + H.W. and hoeing at 30 DAS (W_2), FYM at 10 t ha^{-1} + fluchloralin at 1.35 kg/ha (W_3), FYM at 15 t ha^{-1} + fluchloralin at 0.9 kg/ ha (W_4), FYM at 10 t ha^{-1} + pendimenthalin @ 0.9 kg/ha as pre-emer + H.W. and hoeing at 30 DAS (W_5), FYM at 15 t ha^{-1} + pendimenthalin at 0.9 kg/ha as pre-emer + H.W. and hoeing at 30 DAS (W_6), FYM at 10 t ha^{-1} + pendimenthalin at 1.35 kg ha^{-1} as pre-emer (W_7), FYM at 15 t ha^{-1} + pendimenthalin at 1.35 kg ha^{-1} as pre-emer (W_8) FYM at 10 t ha^{-1} + local practice i.e. 2 H.W. at 20 and 40 DAS (W_9), FYM at 15 t ha^{-1} (W_{10}), + local practice i.e. (W_{10}), FYM at 10 t ha^{-1} and un-weeded (control), (W_{11}) and FYM at 15 t ha^{-1} and un-weeded (control) W_{12} were tested in randomized block design with three replications. Okra and cabbage were sown at a spacing of 60 x 30 cm and 60 x 45 and fertilized with 100-50-0 and 200-50-0 NPK kg ha^{-1} with seed rate of 10 and 0.5 kg /ha respectively. Okra and cabbage were almost sown in the last weed of June and November, respectively. All the herbicides were applied at 3 DAS.

Significantly, the highest plant height, number of fingers ha^{-1}, finger yield ha^{-1} (8225 kg ha^{-1}) and net realization of Rs 51548 ha^{-1} were recorded under treatment T_8 (FYM at 15 t ha^{-1} + pendimenthalin at 1.35 kgha^{-1}). Almost all weed control treatments found more or less equally effective in controlling weeds. Number of balls ha^{-1} as well as yield of cabbage remained unaffected due to various treatments indicating no residual effect of any herbicide applied to *kharif,* okra crop on succeeding *rabi* cabbage crop.

The higher profitable green finger yield of *kharif,* okra could be obtained by fertilizing the crop with fully composed FYM at 15 t ha^{-1} with 100-50-0 NPK kg ha^{-1} coupled with pendimethelin at 1.35 kg ha^{-1} as pre-emergence to keep the crop weed free and to take succeeding *rabi* cabbage crop without any harmful residual effect.

P-130 Efficacy of herbicides mixtures for weed control in soybean (*Glycine max*) in conjunction with nutrient management and their residual effect on succeeding wheat (*Triticum aestivum*)

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A field experiment was conducted at Agricultural Research Station, Kota during 2002-03 and 2003-04. The experiment consisted of twelve weed control treatments (weedy check, one hand weeding at 30 DAS, two hand weedings at 30 and 45 DAS, alachlor 2.0 kg ha^{-1} PE, alachlor 2.0 kg ha^{-1} PE + one hand weeding at 30 DAS, chlorimuron-ethyl 9 g ha^{-1}, fenoxaprop-p-ethyl 70 g ha^{-1}, quizalofop-ethyl 50 g ha^{-1}, chlorimuron-ethyl + fenoxaprop-p-ethyl (9+70 and 6+50 g ha^{-1}) and chlorimuron-ethyl + quizalofop-ethyl (9+50 and 6+37.5 g ha^{-1}) and three fertility levels (75 per cent RDF, 100 per cent RDF and 125 per cent RDF). The experiment was conducted in a split plot design with weed control treatments in main plot and fertility levels in sub plots replicated thrice. Two hand weedings, alachlor + 1HW and tank mixture of chlorimuron-ethyl + fenoxaprop-p-ethyl were significantly superior in reducing weed density, dry matter and nutrient depletion by both categories of weeds at 50, 70 DAS and at harvest stage over rest of the treatments. Post-emergence application of chlorimuron-ethyl was more effective on broad leaf weeds while fenoxaprop-p-ethyl and quizalofop-ethyl were more effective on grassy weeds. Two hand weedings, alachlor + 1 HW and tank mixture of chlorimuron-ethyl + fenoxaprop-p-ethyl gave the highest values of growth characters as well as yield attributes which were being statistically superior over alone herbicides and weedy check. On mean basis, two hand weedings at 30 & 45 DAS, alachlor (2 kg ha^{-1}) +1 HW at 30 DAS, chlorimuron-ethyl + fenoxaprop-p-ethyl (9+70 and 6+50 g ha^{-1}) registered 23.13, 22.07, 22.52 and 22.21 q ha^{-1} seed yield, respectively. The enhancement in seed yield due to chlorimuron-ethyl + fenoxaprop-p-ethyl (9+70 and 6+50 g ha^{-1}) treatments were 41.0, 59.9, 51.1, 56.6, 163.7 and 39.0, 57.7, 49.0, 54.4, 160.0 per cent compared to chlorimuron-ethyl, fenoxaprop-p-ethyl, quizalofop-ethyl, alachlor and weedy check, respectively. The yield of succeeding wheat crop remained unaffected by weed control treatments applied to preceding soybean crop. Among the fertility levels, recommended dose of fertilizer and 125 per cent of RDF were significantly superior over 75 per cent RDF with respect to growth, yield attributes and yield. RDF and 125 per cent RDF also improved the nutrient uptake and quality of soybean crop in comparison to 75 per cent RDF. Various fertility levels did not influenced the growth, yield attributes and yields of succeeding wheat crop. Among the weed control practices, maximum net returns (Rs. 22885 ha^{-1}) and return per rupee invested (2.71) were recorded under the combined application of chlorimuron-ethyl + fenoxaprop-p-ethyl at 6+50 g ha^{-1} followed by chlorimuron-ethyl + fenoxaprop-p-ethyl at 9+70 g ha^{-1}, alachlor + one hand weeding and two hand weedings. Among fertility levels, highest net returns were obtained with the application at 125 per cent recommended dose of fertilizer which was at par with 100 per cent RDF having higher return per rupee invested (1.85).

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Soil amendment: a technique of soil remediation of metribuzin

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Pesticide residues are usually extracted exhaustively using solvents from environmental before quantitatively determined by analytical techniques such as gas liquid chromatography (GLC) or high pressure liquid chromatography (HPLC). This kind of technique predicts low values of half-life periods for the pesticides in the environment. This is because it has been found that a larger portion of the pesticide remains in environmental samples, which is not accessed by exhaustive solvent extraction. This portion referred to as non-extractable (bound) residue builds up in the environment with time, while the extractable residue, which is accessed by exhaustive solvent extraction decreases. Depending on a particular pesticide compound the extractable residue exhibits diverse behavior in the environment. Most initial studies showed that the extractable residue would build up in the environment and reach a maximum and remain permanently in the environment. Later studies showed that the non-extractable residue became bio-available meaning that it could be accessed and freely became mobile in the environment.

The paper investigates the bioremedation of metribuzin under sterile conditions, unamende and organic compost amendement in acidic and basic soil from rice growing regions of North India. Laboratory studies were carried out using sterile, un-amended, and amended soils in mineralization experiments.The percentage of the total metribuzin showed faster mineralization in basic soil than acidic soil, and organic amendment considerably enhanced mineralization in acidic soil, whereas sterile soils showed negligible mineralization rates. Mineralization of metribuzin in basic soil increased from 0.88±0.21, 22.58±0.35, 24.12±0.15, 26.09±0.3707 to 27.32±0.70 percent in 145 days, whereas values for acidic soil increased from 0.79±0.10, 1.89±0.34, 2.98±0.64, 7.89±0.52 to 12.52±0.57 in 120 days for sterile, un-amended and soils amended with 1000, 2500, and 5000 µg/g organic compost, (farm yard manure) respectively. The differences in extent of mineralization were attributed to the presence of pesticide degrading micro-organims, soil type, moisture, pH, bulk density and differences in mineral constituents. In order to enhance the biodegradation of pesticides in the environment so as to reduce their persistence, various organic materials such as farm yard manure and paddy straw, corn field residues, urban wastes etc can also be used. From the results obtained so far compost could be a potential soil amendment capable of catalyzing the biodegradation of pesticides in soil thus enhancing the bioremediation of degraded environment.

P-132 Evaluation of leaching of butachlor in sandy loam and clay loam soils of Tamil Nadu

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Butachlor, a pre-emergence, translocated and selective herbicide is effective against many annual grasses, sedges and broad leaved weeds. Increased use of this herbicide in rice is widely reported and it is essential to know the down ward movement (leaching) of soil applied butachlor. The present study was taken to study the mobility of butachlor in two different soil types, sandy loam and clay loam soil. Polyvinyl chloride (PVC) columns (10 cm interval diameter and 60 cm long) were cut vertically into two and joined together using adhesive tape. Muslin cloth was tied to one end to hold the soil. Columns were filled with soil from bottom by gently tapping the columns (6.0 kg). Water was added from the top to pre condition the soil. Butachlor was applied at recommended dose (1 kg ha^{-1}) and double the recommended dose (2 kg ha^{-1}). The quantity of herbicide required was calculated based on the open surface area (surface are of a circle = πr^2). Sufficient quantity of water was added (120 ml) everyday to govern the movement of herbicides. A set of columns was used without herbicide for comparison. After 15 days the columns were cut, open and the herbicide content in soil was determined by chemical assay using gas chromatographic technique by following the standard procedure. Movement of butachlor was seen up to 20 cm in sandy loam soil and up to 15 cm in clay loam soil. At the same level of butachlor applied at the same depth the quantity of butachlor detected was more in clay loam soil indicating that clay content is an important factor that has influence on the downward movement (leaching) of butachlor.

P-133 Bioassay study on persistence of pendimethalin in soil

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A pot experiment was conducted at College of Agriculture, Gwalior (M.P.), in 2004-05 to study the persistence of pendimethalin in soil. The soil was sandy clay loam with 55.2% sand, 19.4% silt, 25.4 % clay and 0.54% organic carbon and 7.5 pH. Pendimethalin was applied in pots at the rate of 0.5 to 2.5 kg/ha. Herbicide residue was studied using maize bioassay. Pendimethalin reduced the plant height and fresh weight of maize significantly up to 75 days after application (DAA), while dry weight was reduced up to 50 days only. From 0 to 50 days plant height, fresh weight and dry weight of maize reduced by all the concentrations of pendimethalin significantly except fresh weight at 0.5 kg/ha. At 75 DAA pendimethalin at 1.5 – 2.5 kg/ha affected plant height significantly while fresh weight reduced significantly due to 2.0 – 2.5 kg / ha. Probit transformed response on plant height indicated that growth inhibiting effect of pendimethalin decreased with lapse of time as obvious from GR_{50} values. It required only 1.41 kg/ha of pendimethalin for 50% growth reduction of maize at 0 days after application as compared to 2.41, 2.43, 5.17 and 7.45 kg/ha after 25, 50, 75 and 100 days of application.

P-134 Fate of atrazine in maize ecosystem

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Large amounts of pesticides are used in modern production agriculture. Atrazine (6-chloro-N^2-ethyl-N^4-isopropyl-1,3,5-triazine-2,4-diamine) is one of the most extensively used herbicides for weed control in maize (*Zea mays* L.). With increasing awareness and concern for environmental quality, it is important that we consider not only the effectiveness of a pesticide, but also its persistence and mobility in soil. Understanding degradation of pesticides in is essential in predicting their fate and transport in the environment. With this background a study was taken up in the sandy clay loam soil of Tamil Nadu Agricultural University during Kharif, 2007. The objective of the study was to determine degradation of atrazine in a sandy clay loam soil cropped with maize (CO 1) when applied at recommended (0.5 kg/ha) and double the recommended dose (1.0 kg/ha). The experimental soil was low, medium and high with respect to available nitrogen ($KMnO_4$-N), phosphorus (Olsen – P) and potassium (NN ammonium acetate – K) status. The soil was slightly alkaline in reaction (pH -7.8). Soil samples collected periodically from surface (0-15cm) at regular intervals (0, 10, 20, 30, 45, 60, 90 days and at harvest) were analysed for atrazine residue by following the standard procedure. Atrazine applied at recommended level (0.5 kg/ha) got degraded to the extent of 90 % on 90 days after herbicide application. At increased dose (1.0 kg/ha) atrazine residue was recorded up to harvest.

P-135 Weed control through herbicides in potato and their residual effect on succeeding green gram crop

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On farm trial was carried out at Dariya Niwada village near Shivrajpur (Kanpur Dehat) to evaluate the efficacy of metribuzine and atrazine in potato and their residual effect on succeeding green-gram crop. The crop was grown under recommended package of practices. Metribuzine (0.175 kg/ha) and atrazine (0.25 kg/ha) were compared with weedy and manual weeding in potato crop. After digging of potato, the green gram crop was raised. Pendimethalin (1.0 kg/ha) applied in green gram compared with weedy and manual weeding. Herbicides were applied as pre-emergence treatment. Weed population/m^2 at 60 DAS and yield data were recorded. Results showed that metribuzine (0.175 kg/ha) and atrazine (0.25 kg/ha) demonstrated desired level of weed control resulting in 13.9 % and 10.13% greater yield then untreated. Both the herbicides had no residual effect on succeeding green gram crop. Pendimethalin (1 kg/ha) appeared to be necessary for weed control in green gram.

P-136 Studies on persistence of atrazine in soil of maize crop field

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Field experiment was conducted at Students Instructional Farm of C.S.A.U&T, Kanpur during two consecutive years (2005 and 2006) to estimate the persistence of atrazine in maize crop field. Four doses of atrazine i.e. 0.25, 0.50, 0.75 and 1.00 kg/ha were compared with untreated in randomized block design (replicated four times). Cucumber seed were used as indicator plants. Ten cucumber seeds were sown at 0, 20, 40, 60 days after herbicides application in each plot. Germination was recorded at 10th day after cucumber sowing. Three germinated plants of cucumber were selected and uprooted after 20th day after sowing and then root length and shoot length were recorded. This process was repeated up to at harvest. Results revealed that persistence effect of atrazine was found upto 50 day after application of herbicides in maize crop field during rainy season.

P-137 Studies on herbicides applied with and without FYM on physico- chemical properties of soil and its residues in potato

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A field experiment was conducted at AICRP on Weed Control Farm, Anand to know persistence of fluchloralin and metribuzin applied with and without farm yard manure in sandy loam soil under potato crop. The soil of the experimental field was sandy loam having pH 8.18 with 0.020 % nitrogen, 68 kg P_2O_5/ha and 360 kg K_2O/ha. Fluchloralin (1.00 kg/ha) and metribuzin (0.35 kg/ha) were applied as pre-plant in potato field. Fluchloralin residues were lower at all the intervals under the fluchloralin applied with 10 t FYM/ha as compared to fluchloralin applied alone. Total population of bacteria and fungi were higher in fluchloralin applied at 1.00 kg/ha enriched with 10 t FYM/ha as compared to fluchloralin applied alone. Bacterial population was significantly suppressed by application of herbicides at one and seven days after spraying, while fungal population was significantly suppressed upto fifteen days after application. Soil pH, electrical conductivity, available phosphorus and available potassium were not significantly influenced by application of fluchloralin or metribuzin applied alone or with 10 t FYM/ha. The nitrogen content was recorded significantly highest with application of fluchloralin enriched with 10 t FYM/ ha. The tuber yield of potato was not significantly influenced by various weed management practices.

P-138 Leaching pattern of 2,4-D in wet land soils

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Sodium salt of 2,4-D is the most common herbicide in paddy fields. The chemical is highly soluble in water (4.5 g per 100 ml at 25°C). Earliar reports showed that 2,4-D can leach down as deeply as 90 cm. If so, there is a potential danger of surface and ground water contamination with this herbicide. In order to understand the leaching behaviour of 2,4-D in the wet land soils of Kerala, column-leaching study was conducted by taking intact soil columns from paddy fields of three soil types viz., Kole lands of Thrissur district (acidic soil rich in organic matter), Palakkad (neutral soil poor in organic matter) and Kuttanad in Alappuzha district (highly acidic soil extremely rich in organic matter). 2,4-D was applied on the top of the soil columns of 20 cm length and water was added to pass through the soil. Leachate (50ml) was collected in a beaker kept below the soil column. Columns were cut at 10 cm and 20 cm length, and 2,4-D residue in the 0-10 cm and 10-20 cm layers and in the leachate was estimated by chromotropic acid colorimetrc. Major portion of 2,4-D remained in the first 10 cm soil layer. Soils from Palakkad region recorded the maximum quantity of 2,4-D in the upper soil layer (66.4%) which was followed by Kuttanad (64.5%) and Kole (58.3%). Less than 30 percent of the applied chemical was found in the 10 to 20 cm soil column and only 5 to 15 % was found in the leachate. Leachate collected from the soil columns of the Kole region showed higher quantity of 2,4-D and this is attributed to the higher percolation rate of water through the soil column. At the present recommended rate of 1.00 kg ha,$^{-1}$ the risk of ground water contamination with 2,4-D residues is negligible. Maximum residue limit of 2,4-D for drinking water is 0.1 µg l^{-1} and hence 2,4-D application at rates higher than 1.00 kg/ha (particularly in areas where movement of water through the soil column is greater than 0.01ml min^{-1}) should be restricted.

P-139 Detection of sulfosulfuron residues in surface and subsurface soil

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Presence of herbicide residues in the soil not only damage the succeeding sensitive crops but also adversely affect human and animal health due to bioaccumulation of residues in crop produce. Thus an experiment was conducted to evaluate the persistence of sulfosulfuron residues applied in wheat crop as post- emergence at 25, 50 and 100 g ai ha^{-1} application rates to control weeds. Residues were evaluated in surface and subsurface soil by HPLC using diode array detector (DAD). Sulfosulfuron residues were dissipated at faster rate at initial period and by 150 residues were not found at the detection limit of 0.001 µg/g in the 25 and 50 g/ha rates. However, at 100 g/ha rate residues were not detected after 200 days in surface and subsurface soil. Half-life of sulfosulfuron at various doses was found 17-25 days.

P-140 Residue studies of sulfosulfuron in soil applied in wheat under rice-wheat cropping system

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Field trails were laid out at Agronomy research farm as well as in weed science laboratory of Department of Agronomy, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad during *Rabi* season 2004 and 2005 in a randomized block design with four replications. Application of sulfosulfuron at 20, 25, 30 and 35 g ha^{-1} post-emergence in wheat did not cause significant, plant height and dry matter production of cucumber grown in soil taken after the harvest of wheat. Therefore, sulfosulfuron at 20, 25, 30 and 35 g ha^{-1} as post-emergence applied in wheat to control the weeds did not leave any harmful toxic level of residue in soil under rice-wheat cropping system.

P-141 Anilofos residue studies in soil applied in transplanted rice under rice-wheat cropping system

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Field trails were conducted at Agronomy research farm as well as weed science laboratory of Department of Agronomy, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad during *Kharif* season 2004 and 2005 in a randomized block design with four replications. Application of anilofos at 0.4, 0.6 and 0.8 kg ha^{-1} at pre-emergence in transplanted rice did not cause significant differences in germination, plant height and dry matter production of cucumber grown in soil taken after the harvest of rice. Thus it can be concluded that anilofos at 0.4, 0.6 and 0.6 kg ha^{-1} pre-emergence applied in transplanted rice to control the weeds did not leave any harmful toxic residues in soil under rice-wheat cropping system.

P-142 Determination of oxyfluorfen leaching in clay soil

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Field experiment was conducted during July-September 2007 to determine leaching behaviour and movement of oxyfluorfen in clay soil. Leaching behavior of oxyfluorfen was evaluated in PVC columns (90 cm long and 10 cm diameter) with rainfall of 830.5 mm. Oxyfluorfen was applied in the soil column at 200 and 400 g/ha. After every rain leachates were collected and analyzed for oxyfluorfen residues. Oxyfluorfen movement was also evaluated in the soil at various depth viz. 0-10, 10-20, 20-30, 30-40, 50-60, 60-70 and 70-80 cm. Oxyfluorfen was found distributed in all the soil depths. Residues of oxyfluorfen were also analyzed in the leachates coming after each rainfall. Concentration of oxyfluorfen after first and second rainfall was found 0.066 and 0.064 ppm, however 0.059 ppm oxyfluorfen was detected after last rainfall. The proportion of oxyfluorfen in the top 0-10 cm soil zone was found 13.30 % whereas, it was found 12.25, 12.89, 12.54, 12.15, 11.96, 12.86 and 12.08 %, in 0-20, 20-30, 30-40, 50-60, 60-70, 70-80 cm soil depths respectively.

P-143 Persistence of flumioxazin residues in soybean crop and soil

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Herbicide residues in crop produce and soil is of great concern as very small quantity of persisting residues can cause harmful effect to the environment. Thus an experiment was conducted to evaluate the persistence of flumioxazin in soil and crop produce at harvest at various application rates and time. Flumioxazin is a pre-emergence herbicide and highly active to control annual and perennial broad-leaf weeds and sedges. Flumioxazin was applied at 30, 45, 60 and 90 g a.i/ha rates, as pre-plant incorporation (PPI) and two days after sowing of soybean as pre-emergence herbicide (PE). Soil and crop samples treated with flumioxazin were collected at harvest after herbicide application and analyzed for residues. The residues of flumioxazin in soil and soybean were determined by HPLC using RF detector. Flumioxazin residues were found below the detection limit in the soil and grains applied as PPI. Residues in the grains and soil were below the detection limit of 0.001 mg g^{-1} in treatment applied as PPI at the of doses 30 to 90 g ai./ha. However, 0.0012, 0.0022 and 0.0031 µg/g residues were detected in grains in treatments where flumioxazin was applied as PE at the doses 45, 60 and 90 g a.i./ha. Residues were below the detection limit in the straw at 30 and 45 g a.i./ha^{-1} in PPI, however 0.0015 and 0.0024 µg/g were detected at 60 and 90 g a.i./ha doses respectively.

P-144 Dissipation behaviour of atrazine in acid alfisol and its residues in maize

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Atrazine (2- Chloro 4- (ethylamino)- 6 isopropyl amine s- triazine) belongs to triazine group is recommended as pre as well as post emergence herbicide to control the broad leaved weeds in maize. Persistence and dissipation behaviour of atrazine in soil and its residues in maize was studied during *Kharif* 2005 in midhill conditions of Himachal Pradesh in India. Atrazine was applied as pre and post emergence treatment to maize crop at 1.5 kg ha^{-1} (Pre), 1.5 kg ha^{-1} (early post) and 3.0 kg ha^{-1} (pre) doses. Soil, plant and grain samples were collected at 0,1,3,5,7,10,15,30,45,60,75, 90 days ; at the monthly interval after the herbicide application and at maturity of the crop respectively. The collected samples were analyzed for atrazine residues by GC equipped with ECD. Atrazine residues in soil persisted upto 60,60 and 90 days at three rates of application respectively. Dissipation of atrazine in soil followed first order kinetics with the half life in range of 10.9 - 21.4 days. In plants more than 85% of atrazine metabolized in 42 days after the herbicide application whereas in grain samples, the residues of atrazine were found to be below the detectable limit.

P-145 Persistence of imazethapyr residues in soybean grains, straw and soil

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Imazethapyr belongs to imidazolines group having a toxicity class of III and used as a selective herbicide. It is applied as pre-plant incorporated, pre-emergence, and post-emergence to control grasses and broadleaf weeds. Imazethapyr acts by reducing the levels of three branched-chain aliphatic amino acids. Herbicides when applied post-emergence may leave residues in crop produce and soil, depending on the chemical structure, doses and their interaction with the soil properties. Since herbicides are necessary to manage weeds, their residues in crop produce at harvest are of great concern. Thus at harvest terminal residues of imazethapyr were determined in soybean grains, straw and soil where imazethapyr was applied at 100 g a.i ha^{-1}, 25 days after sowing of soybean. Soil and crop samples from the imazethapyr treated and untreated field were collected at harvest, processed and analyzed by HPLC. The residue level of imazethapyr in soil, soybean grains and straw was found 0.008, 0.102 and 0.301 $\mu g\ g^{-1}$, respectively.

P-146 Weed management through dual cropping of green manure in semi-dry rice

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Semi dry rice cultivation holds special significance in the present day production systems with regard to saving in water consumption, time, labour, energy required for nursery and planting. So there is a need to raise the level of productivity. The present investigation was undertaken to study the influence of green manure intercropping on weeds in direct seeded semidry rice.

Field experiment was conducted at Agricultural Research Station, Bhavanisagar during 2004 to study the effect of dual cropping of green manure for weed control in semidry rice. The experiment was laid out in randomized complete block Design with six treatments with four replication. The treatments consisted of paired row sowing of rice, paired row sowing of rice + daincha and paired row sowing of rice under weeded (hand weeding at 30, 45 and 60 DAS) and unweeded condition, which were compared with recommended practice of normal sowing of rice with herbicide application (pendimethalin @ 1.0 kg ha^{-1}) + hand weeding and normal sowing of rice + two hand weedings.

Paired row sowing of rice with daincha recorded lesser density of weed at all the stages of observation, since daincha intercropping suppressed the weed infestation due to faster canopy cover. Paired row sowing of rice + daincha under weed free condition registered lower weed dry matter as a result of reduction in weed density by smothering effect of green manure. Weed control efficiency was higher in paired row sowing of rice + daincha under weed free condition, which was comparable with paired row sowing of rice under weed free condition and normal sowing of rice with herbicide application + hand weeding. Paired row sowing of rice + daincha under weed free condition improved the growth and yield of rice when compared to the presently recommended methods of either manual weeding twice or pre-emergence application of herbicide followed by hand weeding.

P-147 Eco-friendly approaches for the weed management in betelvine crop

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The various type of weeds are posing serious threat to betelvine (*Piper betle* L.) in Bihar resulting in considerable reduction in yield and quality of the produce (leaves). They compete for space, moisture, light and ultimately nutrients with the crop and also harbour various pathogens and pests which further damage the crop. As such, in an attempt to find out eco-friendly alternative to combat the weed crop competition, the present investigation was carried out during the year 2005-06 and 2006-07 using various weed control method *viz.*, weedy check, 4 hand weeding/year, 8 hand weeding/year, 12 hand weeding/year, alachlor 1.5 kg/ha, polythene mulch and organic mulch in a randomised block design and replicated thrice. A popular betelvine cultivar 'Bangla' was grown keeping 1.50 lac plants/ha. A recommended dose of N:P_2O_5: K_2O (200:100:100 kg/ha) was applied in 4 equal splits/year through organic source under proper moisture condition. The result revealed that the weeds were effectively managed by various treatments *viz.* 12 hand weeding/year (weed free), polythene mulch and organic mulch treatments and recorded significantly higher yield attributes, leaf yield, NPK uptake with minimum disease-pest incidence and showed non significant difference among themselves but found superior over all others. However, hand weeding whether done 4 or 8 times/ year was not so effective but found more effective compared to weedy check and chemical weed control method. Being an evergreen crop, betelvine crop is badly damaged by alachlor application which also results in re-surgence of weeds after 3-4 months. Thus, the weed free (12 weeding/year), polythene or organic mulch provided appropriate and eco-friendly alternative for effective weed management in betelvine crop.

P-148 Weed management in organic farming in okra

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A field experiment was conducted during *Kharif* season of 2006- 2007 at Marathwada Agril. University, Parbhani. The experiment was conducted with an objective to evolve weed management technique/practice for organic farming. The experiment was laid out in a randomized block design comprising of comprising of six weed management treatments i.e., T1- stale seed bed + 1 HW at 30 DAS, T2- green manuring i.e. sowing of live mulch i.e. Dhaincha in between two rows of okra and cutting and spreading at 5 WAS, T3- straw mulch @ 5 t/ha in between rows at the time of sowing, T4- manual weeding (2 HW and 1 H at 30 & 60 DAS), T5- weed free crop (HW at 20, 40, 60 DAS) and T6- weedy check. The results showed that the maximum green okra fruit was observed in weed free plot which was closely followed and was found at par with Stale seed bed + 1 HW at 30 DAS, and manual weeding (2 HW and 1 H at 30 & 60 DAS). Lowest dry weed weight was observed in weed free plots and it was found at par Stale seed bed + 1 HW at 30 DAS. The maximum weed control efficiency was also observed in weed free plots which was closely followed by Stale seed bed + 1 HW at 30 DAS. The results showed that the weed free treatment produced significantly highest green okra fruits than rest of the treatments. But it was found at par with Stale seed bed + 1 HW at 30 DAS and manual weeding (2 HW and 1 H at 30 & 60 DAS).

P-149 Weed dynamics and productivity of various cropping systems under organic farming

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Field experiments were conducted at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 2006-07 to study the weed dynamics and productivity of various cropping systems under organic farming. The experiment concerted of 12 treatments (3 nutrient management 4 cropping system) with strip plot design (unreplicated). Three nutrient management practices applied equal for all 4 cropping systems. The data on weed dynamics of both the years change the weed flora in different cropping systems. Maximum weed population (12.92/m^2) was found in green manures (sunhamp)- rice (Pusa basmati) – berseem (J.B. – 1, both fodder and seed), 9.6/m^2 in rice (Pusa basmati) – potato (K. sunduri) – okra (Parbhani Kranti), 8.86/m^2 in rice (Pusa basmati) – vegetable pea (Arkel) – sorghum (M.P. Chari). The productivity in terms of rice equivalent yield (REY), Rice (Pusa basmati) – potato (K. sunduri) – okra (Parbhani Kranti) was found higher REY (181-9 q/ha) followed by 119.43 q/ha in rice (Pusa basmati) – berseem (J.B.-1, both fodder and seed), 117.07 q/ha in rice (Pusa basmati) – vegetable pea (Arkel) – sorghum (M.P. Chari) and 78.71 q/ha in green manures (Sunhamp) – rice (Pusa basmati) – durum wheat (HD - 4672).

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Influence of drum seeding and non- chemical weed management at different planting dates in boro rice production

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An experiment was conducted at BCKV during 2004 – 2006 in boro rice (cv.IET 4786) using split – split plot design, keeping 4 different dates of sowing(D1- 1st December , D2-15th December D3-30th December and D4-14th January) in main plots , 2 methods of growing (M1 – drum seeding and M2 - transplanting) in sub-plots and 3 non-chemical weed management treatments (W1 – unweeded control , W2 - hand weeding and W3 - weeding by Janapese Paddy Weeder) in sub – sub plots.

Experimental results revealed that among four different dates of sowing , D1(1st December sowing) and D2(15th December sowing) performed better, in all respects , than other two dates of sowing and drum seeding method of rice cultivation gave the higher grain and straw yield as compared to transplanting . On the other hand, hand weeding (W2) performed better for controlling different categories of weeds. But, in most of other cases, it was at par with weeding by Japanese Paddy Weeder (W3). Among 24 different treatment combinations, drums seeded boro rice sown on 1st December combined with Japanese Paddy Weeder weeding (D1 M1 W3), drum seeded boro rice sown on 1st December combined with hand weeding, (D1 M1 W2), drum seeded boro rice sown on 15th December combined with Japanse Paddy Weeder weeding (D2 M1 W3) and drum seeded boro rice sown on 15th December combined with hand weeding (D2 M1 W2), showed better performance in most of the cases.

Hence , the experimental results indicated that drum seeding method of boro rice cultivation (a new technology a developed by the scientists of IRRI)during the first fortnight of December , may be widely acceptable among the farmers and they can replace ages old , traditional transplanting method without reduction in yield and with considerable savings in time , money and man power . Use of Japanese Paddy Weeder (W3) will help to reduce weed management cost as compared to hand weeding (W2).

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Mulching as a non-chemical weed control measure for aonla

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A field trial was conducted at the Agricultural College Farm, Dapoli during late south-west monsoon season of 2007 to study utility of green biomass of different plant species viz. *Smithia sensitiva*, *Glyricidia maculata*, *Pongamia glabra*, *Terminalia spp*, *Holarrhena antidysenterica* as a mulch for weed suppression in canopy area of young aonla plants (75 cm radius) at 3 and 4 kg plant^{-1}. Untreated control and black polyethylene were additional treatments which were replicated thrice.

Weeds namely viz. *Leptochloa chinensis*, *Echionchloa colonum*, *Eleusine indica* from monocots and *Blumea lacera*, *Cyathocline purpnrea*, *Ludwigia octovalvis*, *Mollugo* spp, Euphorbia *hirta* and *Crotalaria spp* grew during post monsoon period. Of these species *L. chinensis* and *B. lacera* were major weeds. At 40 days after mulching, (DAM) while *G. maculata* mulch showed full decomposition, mulches of *P. glabra* and *S. sensitiva* showed partial decomposition. However, mulches of *Terminalia spp* and *H. antidysenterica* did not decompose. At 118 DAM almost all mulches had undergone partial decomposition. All mulching treatments including black polymulch significantly reduced total weed density, growth of BLWs and total weed growth and thus exhibited remarkable increase in weed control efficiency compared to untreated control. Black ploymulch was the best treatment with 100% WCE.

Green leaf mulching in the canopy area of 50 cm radius around young *aonla* plants (3-4 years) with green biomass of all plant species at 4 kg plant^{-1} and that of *P glabra* and *Terminadia spp* at 3 kg plant^{-1} can equally and satisfactorily suppress emergence and growth of new weeds during late monsoon season after application of fertilizers and thus reduce their competition for nutrients and moisture. Moreover, decomposed biomass can provide additional nutrients for growing fruit plants.

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Effects of in situ grown green manuring intercrops in dibbled rice on weed growth, productivity and profitability

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An investigation to study possibilities of growing dibbled hybrid rice in unidirectional paired row planting pattern (15 cm x 15 cm x 30 cm) alongwith in situ sown green manuring intercrops *Sesbania rostrata* and *Vigna umbellata* in skipped rows was conducted at the College of Agriculture, Dapoli during *Kharif*, 2005 under both weedy and weed free situations. Weed free treatments were hoed with Japanese hoe thrice at 2, 4, and 7 weeks after sowing and hand weeded once at 6 WAS. Rice crop was fertilized by placement of Urea-DAP-briquettes (34.08% N, 8.6% P) of 2.7 g each in alternate squares of paired rice rows to 7.5 cm depth with special applicator 10 DAS.

The results revealed that under moisture saturated conditions, *Sesbania rostrata* grew satisfactorily which produced green biomass of 3.98 and 5.02 t ha^{-1} at 48 DAS under weedy and weed free conditions respectively as against 0.75 t and 1.09 t ha^{-1} in case of *Vigna umbellata*. Under weedy condition, though both green manured intercrops exhibited reduction in weed growth at 60 and 90 DAS, their use as mulch did not cause significant increase in neither weed control efficiency nor productivity of rice. However, weed free treatment green manured with *S. rostrata* exhibited maximum WCE (75%) and consequently productivity (58.2 q ha^{-1}) as against weedfree treatments with *V. umbellata* (WCE 70%, yield 50.9 q ha^{-1}) and no green manuring (WCE 60%, yield 49.3 q ha^{-1}). The former treatment topped the rank for B:C ratio (1.71) followed by the latter (1.66) with their respective net returns being Rs. 17,547 and Rs. 14,252 ha^{-1}. Thus the proposition of paired row planted dibbled rice alongwith in situ grown *S. rostrata* under weed free condition and its use as green manure with placement of N and P as Urea-DAP briquettes is need of an hour as against traditional puddled transplanted rice involving costlier and eco-hazardous practices like *Rab* (the process of preheating nursery soil by burning huge quantum of organics), puddling, broadcast fertilizer application and time consuming and labour intensive transplanting operation.

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Effect of cultural practices and weedicide on the yield of maize + potato intercropping system

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An experiment was conducted on the effect of cultural practices and weedicide on the yield of maize + potato intercropping system from 2004-05 to 2006-07 for three years at Tirhut College of Agriculture, Dholi farm of Rajendra Agricultural University, Bihar, Pusa, Samastipur. In this experiment variety of maize was Devki composite and variety of potato was Rajendra Alu-3. The experiment was conducted with 15 treatments viz., T_1-sole maize was weedy check, T_2-sole maize with one hand weeding at 30 days after sowing of maize, T_3- sole maize with two hand weeding at 30 days interval from the date of sowing, T_4-sole maize with one spray of atrazine a.i. @ 1 kg/ha, T_5- sole maize with one spray of atrazine a.i. @ 1 kg/ha along with one hand weeding at 30 days after sowing of maize. T_6-sole potato as weedy check, T_7- sole potato with one hand weeding at 30 days after planting of potato, T_8-sole potato with two hand weeding at 30 days interval from the date of planting of potato, T_9-sole potato with one spray of atrazine a.i. @ 1kg/ha, T_{10}-sole potato with one spray with atraziine a.i. @ 1.0 kg/ha along with one hand weeding at 30 days after planting of potato. T_{11}- maize + potato as weedy check, T_{12} maize + potato with one hand weeding at 30 days after sowing of maize, T_{13}- maize + potato with two hand weeding at interval of 30 days from the date of sowing of maize, T_{14}- maize + potato with one spray of atrazine a.i. @ 1 kg/ha, T_{15}- maize + potato with one spray of atrazine a.i. @ 1 kg/ha + one hand weeding at 30 days after sowing of maize. Potato was planted during first week of December and maize was sown one day after potato plantation. atrazine was sprayed one day after sowing of maize. Significantly higher yield of maize and potato and net return per hectare were recorded by the treatment maize + potato intercropping system with one spraying of atrazine followed by one hand weeding at 30 days after sowing of maize in comparison to the rest of the treatments. It was also observed that spraying of atrazine produced no adverse effect on the germination of maize and potato either as sole crop or in combination as maize + potato intercrop. The main advantage was that the field was kept weed free upto 60 days by adopting this treatment.

P-154 Effect of intercrops and weed control methods on weed dynamics and yield of wheat

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Intercrops when grown with main crop, besides diversifying the cropping pattern, also result in smothering of associated weeds. In view of this a field experiment was conducted during *rabi* 2006-07 to study the effect of four intercropping systems *viz.* wheat sole at 22.5 cm, wheat + mustard (4:2), wheat + linseed (4:2), and wheat + berseem (4:2) under three levels of weed control i.e., one hand weeding, isoproturon 1.0 kg/ha pre-emergence followed by 1 hand weeding and unweeded control. The experiment was conducted in split plot design having intercropping systems in main plots and weed control treatments in sub – plots. The soil of the experimental field was low in available nitrogen, medium in available phosphorus and high in available potassium with pH of 6.7.

The dominant weed flora of the experimental site comprised of *Medicago denticulata, Chenopodium album, Vicia sativa* and *Phalaris minor*. Berseem and linseed as intercrop in wheat reduced the dry biomass of weeds at 60 DAS as compared to wheat sole and wheat + mustard. The inclusion of berseem as intercrop in wheat significantly reduced the population of *P. minor* and *C. album* as compared to sole crop of wheat. The grain yield of wheat under sole crop (53.9 q/ha) was comparable with that obtained in wheat + berseem (50.0 q/ha).The wheat + berseem intercropping system also produced an additional yield of 84.23 q berseem green fodder and 40 kg berseem seed per hectare. Among the weed control treatments, wheat grain yield obtained from one hand weeding and isoproturon 1.0 kg/ha followed by 1hand weeding was significantly superior to unweeded control. The results indicated that intercropping system of wheat + berseem (4:2) is better in reducing the weeds and obtaining higher productivity as compared to the sole cropping of wheat.

P-155 Production and weed control of baby corn – ground nut crop sequence in soil solarization with tillage and moisture regimes

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A field experiment was conducted for two consecutive years (2003 & 2004) to study the effect of soil solarization with tillage and moisture regimes on weed dynamics and yield of baby corn - groundnut crop sequence at the Agronomy Field Unit, Main Research Station, UAS, Bangalore under irrigated conditions. The experiment consisted of solarization during Apr – May followed by baby corn and ground nut crop sequence and has 18 treatments *viz.* three tillage treatments in main plot (one ploughing + harrowing, thorough land preparation and unploughed control) and six moisture regimes with solarization in sub plots (irrigation up to FC, 40 mm, 20 mm and control-dry for solarization with non-solarized weedy and weed free check) in split plot design with three replications. After harvest of baby corn, land was prepared with shallow digging and each plots were divided into two to study the residual effect of solarization on ground nut. These were super imposed with one hand weeding and unweeded control treatments.

Husked baby corn and fodder yield were superior with thorough land preparation (112.9 q ha^{-1} and 47.20 t ha^{-1}) followed by one ploughing + harrowing which were significantly superior over unploughed control. Among the sub plot treatments, significantly lower husked baby corn and fodder yield was noticed in non-solarized weedy check (93.8 q ha^{-1} and 36.73 t ha^{-1}) as compared to all other treatments. Solarization with irrigation up to FC recorded higher husked baby corn and fodder yield (116.8 q ha^{-1} and 49.89 t ha^{-1}) followed by 40 mm irrigation for solarization and weed free check. In groundnut, pod, kernel and haulm yield were significantly superior with residual effect of solarization with thorough land preparation (25.54, 18.06 and 28.39 q ha^{-1}, respectively), solarization with irrigation up to FC (26.40, 18.64 and 28.46 q ha^{-1}, respectively) and with one hand weeding treatment (24.14, 16.89 and 26.65 q ha^{-1}, respectively) among tillage, moisture regimes and weeding treatments.

Soil solarization with unploughed control treatment recorded significantly higher number (81.7 m^{-2}) and dry weight (6.91 g 0.25-m^{-2}) of weeds at harvest in baby corn than thorough land preparation and one ploughing + harrowing. Among moisture regimes with solarization, non-solarized weedy check recorded significantly higher number (135.4 m^{-2}) and dry weight (13.05 g 0.25-m^{-2}) of weeds over all other treatments. Weed free check recorded the lowest number of weeds followed by solarization with irrigation up to FC and 40 mm. Similar results were also noticed in ground nut.

It was inferred from the above study, that thorough land preparation and irrigation up to field capacity are essential before solarization. Under extreme conditions one ploughing + harrowing and 40 mm of irrigation are required for effective solarization to enhance the productivity in baby corn – ground nut crop sequence.

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Effect of tillage and sowing management on weed dynamics, grain yield and conservation of resources in rice-wheat cropping system

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Field experiments were conducted on rice-wheat cropping system in sandy loam soils at Research Farm, JNKVV, Jabalpur (M.P.) for 2 years during 2004-05 and 2005-06 with the objectives effect of tillage and sowing management on weed dynamics, conserve the labour, time and diesel with the use of efficient farm machineries for tillage and sowing of both crops in a succession under irrigated agro-ecosystem. Four tillage and sowing methods for each crop viz. for rice cv. Kranti (direct seeding in dry fields, direct seeding of sprouted seeds in puddled field by drum seeder, manual transplanting, and mechanical transplanting) and for wheat cv. GW-273 (conventional till sowing, zero-till sowing, strip-till sowing and bed planting) were tested in strip plot design with 3 replications. Based on the mean data of both years weed population and weed dry weight were maximum (10.92/m^2 and 8.62g/m^2, respectively) in direct seeding in dry fields among all other methods in rice. While in wheat weeds flora did not differ due to tillage and sowing methods, but weed population and weed dry weight were minimum in zero- till sown (4.25 /m^2, 4.02 g/m^2) and strip-till sown (4.99 $m^2$and 4.03 g/m^2) and higher in conventional till sown (8.17/m^2, 6.88 g/m^2) and bed planted wheat (6.88 /m^2 and 6.02/ g/m^2). Gain yields of rice was comparable (46.93 to 47.85 q/ha) among all methods of sowing, while wheat produced significantly higher grain yields under strip till sowing followed by zero or conventional till sowing and bed planting in decending order. Consequently, strip till sown wheat after rice (grown under different tillage) produced higher combined grain yields for entire cropping system in term of wheat equivalent yields (82.03 to 84.54 q/ha) with greater values of NMR (Rs 37124 to 39172 /ha) and B:C ratio (2.30 to 2.37) than other combination of tillage and sowing methods of both crops. Direct seeded rice followed by strip-till or zero-till sown wheat consumed minimum time (32.12hrs/ha) and diesel (90.92 l/ha) by ensuring timely and cheep sowing without sacrificing the crop yields. Direct seeding of sprouted seeds of rice in puddled field with the help of drum seeder followed by strip or zero-till sown wheat needed minimum labour (152 man days/ha/year) and it proved to be an efficient tillage and sowing technique for labour scarce areas.

P-157 Utility of Parthenium for nutrients source and as tool for weed management strategy for sustainable crop and soil productivity

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Parthenium hysterophorus, an aggressive weed in Karnataka produces huge biomass. As per the 2004-05 survey by AICRP on Weed Control, University of Agricultural Sciences, Bangalore, 23.5% of total gross area of Southern Karnataka is infested with Parthenium and more of which is in wasteland - barren land (78 %), and less in cropped area (19 %). Maximum infestation of Parthenium was in monsoon followed by winter and summer in the order of southern transition zone, Eastern dry zone, southern and central dry zone. Parthenium provides a fresh biomass of 1.2- 5.0 kg/m^2 in monsoon, 1.5 – 2.0 kg/m^2 in winter and 0.2-1.6 kg/m^2 during summer having 2.6 % N, 0.23 % P and 1.4 % K (on fresh weight basis) comparable to traditional green manures - Glyricidia, sun hemp and FYM.

A field experiment was conducted during 2004-05 and 2005-06 to study the feasibility of using Parthenium as green manure in lowland rice at Kathalagere and aerobic rice at Hebbal, University of Agricultural Sciences, Bangalore. Here effort was made to know the utility of Parthenium as source of nutrients as well as to know the ill effect, if any on growth and yields in rice grown under two systems of rice culture – lowland and aerobic rice (direct seeded rice under upland with irrigation).

At Kathalagere, using Parthenium as green manure 10 t/ha + 75 % NPK through fertilizers recorded higher yield of summer transplanted rice (50-54 q/ha), which was statistically similar to that of Glyricidia and FYM either at 75% or 100% NPK through fertilizers (100 kg N, 50 kg P_2O_5, 50 kg K_2O/ha). At Hebbal, using Parthenium as green manure at 10 t/ha + 100 % NPK through fertilizers recorded higher yield of summer aerobic rice (32 q/ha) which was statistically comparable to Glyricidia /sun hemp and FYM. The residual fertility in terms of nitrogen in Parthenium treated plots was more by 14-30 kg/ha than other traditional manures.

The cost of using Parthenium as green manure was much lower at Rs.1500/ha compared to the cost of FYM at Rs. 5000/ha and thus provided a saving of Rs. 3500/ha over the traditional use of FYM. Thus the study indicated that management of Parthenium through utilisation as nutrient source can be achieved, apart from lowering the cost of production, sustainability in soil health and crop yields in rice. No adverse effect was observed in rice grown under two systems of rice cultivation due to the use of Parthenium as green manure.

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Eco-friendly management of problematic weeds through utilization as nutrient source in maize

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Volunteer weeds like *Chromolaena odorata*, *Parthenium hysterophorus* and *Cassia uniflora* produces huge biomass and contains sizeable nutrients which could be recycled for profitable and sustainable crop production similar to other traditional green manure *Glyricidia maculata* and Farm yard manure (FYM). Under this context, the biomass of these three weeds and *Glyricidia* were composted and evaluated for its crop response in relation to FYM, fertilizer doses and its combination in irrigated maize (*Zea mays* L.).

The field experiment was conducted during *Kharif* 2006 on sandy loam soil at AICRP on Weed Control, Main Research Station, University of Agricultural Sciences, Bangalore. The thirteen treatments comprising of three weeds' biomass composts *viz., Parthenium, Chromolaena and Cassia* in comparison with compost of *Glyricidia* and FYM, all at 10 t/ha were evaluated at two fertilizers levels - 75 and 100 % of recommended dose (RDF, 150 kg N, 75 kg P_2O_5, 40 kg K_2O/ha) and absolute control with out fertilizer and compost. Results revealed that integration of fertilizer dose along with *Chromolaena, Parthenium* and *Cassia* compost gave 23 to 39 % higher kernel yield than the corresponding fertilizer dose alone and compared equal to FYM and compost of *Glyricidia*. Further, combination application of 10 t/ha of compost of *Chromolaena* and *Cassia* with RDF gave significantly higher maize kernel yield (6213 and 6250 kg/ha, respectively) than 100 % RDF alone (4768 kg/ha) and compared equal to FYM (6018 kg/ha) and *Glyricidia* (6056 kg/ha). While, the cost involved in preparation of 10 tons of composts of weeds were Rs. 3,200/- as against Rs. 3,800/- in case of *Glyricidia* and Rs. 5000/- for FYM. Thus, there is savings of Rs. 1800/- for 10 tons of weed compost applied for one hectare of maize crop as compared to the use of FYM. This method is intended to save the cost of production of crops, besides serves as means to lower the biomass of weeds.

The matured composts of weeds didn't show any germination of its own weed seeds and its application did not have any suppressing effect on the crop growth and yield. This suggests that weeds producing huge biomass can serve as nutrients sources for sustainable crop production and as alternate strategy, an eco-friendly to manage these problematic weeds

P-159 Efficient recycling of weed biomass through vermitechnology

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Weed biomass is one of the potential sources of organic matter and nutrients if properly utilized. In recent times, increased emphasis has been put globally for integrated use of fertilizers and organic manures in view of energy crisis, escalating prices of fertilizer, environmental pollution as well as sustaining soil productivity. Acute shortage of conventional sources of organic manures such as animal dung, farm yard manure etc. necessitates the search for alternative sources of organic manures and plant nutrients. The favourable climatic conditions of the North Eastern Region in general and Assam in particular lead to the production of huge weed biomass of diverse species composition both in cropped and noncropped situations. The biomass production in weeds roughly ranges from 5-20 t ha^{-1} depending upon the weed species, season and growing conditions. In view of the above, the present study was undertaken to evaluate the vermicomposting potentiality of the weed species viz., *Mikania micrantha, Eichhornia crassipes, Cassia occidantalis, Lantana camera, Ipomoea carnea, Chromolaena odorata* and mixed weed biomass. The biomass of the respective weed species were collected and heaped under sun for a weed. The biomass of weeds was then chopped into pieces of 5-10 cm sizes. The chopped biomass were then placed in concrete pots of size 1m (L) x 0.75 m (B) X 0.5 m (D) in alternate layers with cow dung in the ratio of 60:40. A thin layer (2 inch) of soil was placed at the bottom of each concrete pot. After filling the pots, earthworm species, *Eisenia foetida*, was released to each pot at 2 kg t^{-1} of biomass. The maturity of the compost was judged visually. The harvesting of the vermicompost was done layer wise. Results showed that the biomass of different weed species could be converted to quality vermicompost within 45 to 75 days. The composting days was lowest with *Mikania micrantha* and highest with *Chromolaena odorata*. The nitrogen content in the vermicompost produced from different weed biomass ranged from 1.90 to 2.25, P content ranged from 0.89 to 2.10 and K content ranged from 1.20 to 2.42. Among the different weed species, the highest N, P and K content was recorded in the vermicompost produced from *Ipomoea carnea*.

P-160 Effect of *Parthenium* and *Chromolaena* as green manure and their compost on the availability of micronutrients

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Laboratory incubation experiment was conducted to study the impact of *Parthenium* and *Chromolaena* as green manure and their compost on the availability of micronutrients in paddy soils. Based on the content of total C of plant material organic material was applied at the rate of 0.5, 1.0 and 2.0 per cent level of organic carbon. Soil submergence caused increase in the availability of Fe and Mn and decreased that of Zn and Cu. DTPA extractable Fe and Mn increased with the period of submergence up to 60 days and then decreased. DTPA Zn ranges with 0.99 to 2.36 mg/kg, whereas the DTPA Cu ranges from 1.39 to 1.47 mg/kg at 30 days after flooding among different treatments. Increasing the level of organic carbon application increase the availability of micronutrients.

P-161 Utilization of *Cassia sericea* and *Cassia tora* as compost and green manure and response of maize in Alfisols of Bangalore

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Biomass of waste land weeds like *Cassia sericea* and *Cassia tora* is available in abundance and are mining the nutrients. In an effort to utilize these weeds as compost and green manure a field study was conducted to know the effect of green manure and compost on nutrients content in the soil, quality parameters of the compost and crop response in terms of yield in irrigated maize in Alfisols of Bangalore. The study revealed that the nitrogen content of the composts of these weeds was 1.83 to 1.78 percent and the C: N ratio was 11.27and 10.35 respectively. The contents of N, Ca and Zn were higher in *C. sericea* compost compared to *C. tora* and P,K,Mg, S, and B were higher in *C. tora*. During the decomposition process a significant reduction in lignin and cellulose content was noticed in composts of both these weeds and there was an increase in the humic acid and fulvic acid content. Field evaluation of these weeds as compost and green manure in maize crop revealed that application of compost of *C. tora* at the rate of 7.5 t $ha^{-1}$with 75 percent recommended fertilizer resulted in higher grain yield (5.72 t ha^{-1}) and was on par with farm yard manure. However highest stover yield of 15.22 t ha^{-1} was obtained with *C. sericea* as compost at 7.5 t ha^{-1} with higher uptake of nutrients also. Effect of these weed composts on the post harvest soil did not bring any change in the pH and EC. However, there was a slight increase in the organic carbon content in treatments receiving higher level of compost (7.5t.ha^{-1}). There were no significant differences in the available N, P_2O_5, K_2O, exchangeable Ca, Mg and S in the compost as compared to farm yard manure applied plots. Thus the study indicated that the biomass of *Cassia* spp. Can be used as green manure as well as compost in maize and compared equal to that of farm yard manure.

P-162 Utilization of *Parthenium hysterophorus* and *Eichhornia crassipes* as a bio-nutrient source in rice (*Oryza sativa* L.) crop

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A field experiment was carried out at Rajendra Agricultural University, Pusa, Samastipur, Bihar during *kharif* seasons from 2004 to 2006 to assess the weed utility as nutrient source in rice cultivation. It was observed that among organic surces the use of *Eichhornia* at 2.5 t/ha + FYM at 5t/ha recorded significantly higher grain and straw yields of rice followed by Parthenium 2.5 t/ha + FYM 5 t/ha and *Eichhornia* 2.5 t/ha + Poultry litter 1 t/ha. *Eichhorniia* or Parthenium either alone or in combination with other organic sources had a better utility as a bio-nutrient source. Among the inorganic levels, application of 100% RDF produced maximum grain and straw yields as compared to other nutrient levels. The interaction effects between organic sources and inorganic levels were found to be non significant.

P-163 Mineralization of nitrogen and phosphorus from Chromolaena and Parthenium green manures and their composts

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Laboratory incubation experiment was carried to study the changes in the ammonical extractable nitrogen and phosphorus under submerged and well drained conditions of paddy soil with the use of parthenium and chromolaena as green manure and their compost. Based on the content of total C of plant material organic material applied was at the rate of 0.5, 1.0 and 2.0 per cent level of organic carbon. In general NH^+_4-N and brays - P increased with the period of submergence, among different treatments maximum NH^+_4-N (83.71 mg/kg) was noticed on T_{10}: Mandya soil + chromolaena compost @ 2.0 % C whereas least (54.84 mg/kg) in T2: Mandya soil + parthenium as green manure @ 0.5 % C and brays –P recorded highest (24.34 mg kg^{-1}) in T4: Mandya soil + Chromolaena as green manure @2.0% and least (16.50 mg kg^{-1}) in T2:. Mandya soil + parthenium as green manure @ 0.5 % C on 120th day of flooding. Increasing the level of organic carbon application increase the NH^+_4-N and brays –P. Under well drained conditions the ammonical nitrogen contents of all the treatments decreasesd rapidly and nitrate content increased whereas brays phosphorus also increased.

P-164 Utilization of weeds as nutrient source in potato - finger millet cropping system

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A field investigation was carried out during 2002-2004 at Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore to assess the effect of *Parthenium hysterophorus*, *Chromolaena odorata* and *Lantana camara* as nutrient source in the form of compost or direct incorporation in potato – finger millet cropping system. The results revealed that the maximum potato tuber yield of 21.05 t ha^{-1} was recorded under 100% NPK integrated with 10 t FYM, which was statistically on par with substitution of 25% N as *Chromolaena odorata* incorporation (20.11 t ha^{-1}). It was followed by application of 25% N as *Parthenium hysterophorus* compost (18.27 t ha^{-1}) or *Lantana camara* incorporation (18.20 t ha^{-1}). In sequence crop of finger millet, residual fertility of 50% N as Lantana incorporation resulted in higher grain and straw yield of 4.56 and 11.21 t ha^{-1}, respectively. It was found to be on par with residual fertility of 100 % N as FYM application (4.77 t ha^{-1} and 11.72 t ha^{-1} grain and straw yield, respectively). Thus, this experiment revealed that the problematic invaded weeds can be utilized as alternate source of nutrients in Potato –Finger millet cropping system.

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Biocomposites from invasive weeds - *Parthenium hysterophorus* and *Lantana camara*

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Exotic species invasion has been identified as one of the biggest threats to biological diversity around the globe, second only to habitat destruction. Weeds, owing to inherent properties of efficient nutrient uptake and use, easily invade disturbed land with adverse effects on the ecosystem. They thus pose a serious challenge to sustainable management of forest ecosystems, and to the conservation of biodiversity.

Parthenium hysterophorus L., (Heliantheae: Asteraceae), commonly known as parthenium, congress grass, gajar ghas, fever few, white cap, white top, ramphool or carrot weed, is a herbaceous, annual and poisonous weed. It is a native to Mexico and adjacent USA. Parthenium has achieved the status of "Worst Weed" in India as it not only affects crop production, animal husbandry, and biodiversity but also poses serious health risks. Ever since the weed became a menace in India and other countries, efforts are being made to manage the weed by a number of methods such as Mechanical, Legal, and Biological etc. But so far no single method has been proved satisfactory, as each method has inbuilt limitations such as high cost, impracticability, environmental safety, temporary relief etc. These considerations demand to develop an effective method for management of this weed.

Similarly, *Lantana camara* L. (Verbenaceae) is a variable shrub native to tropical America introduced to most of the tropical and sub-tropical regions. It is a weed in a number of crops and is common in pastures, waste areas and roadsides. It is regarded as a cosmopolitan weed and in many countries it has been declared a noxious weed. It grows under varying conditions of climate and soil. It is drought resistant and regenerate quickly after cutting. Due to its profilic growth and wide adaptability, lantana has overrun large areas in India and developed into a serious weed.

Utilization of parthenium and lantana can also be an effective method for managing the weed. Owing to the presence of fibers, *Parthenium hysterophorus* and *Lantana camara* have exploitable potential to make value added products such as biocomposites. Biocomposites are good substitutes of solid wood depending upon the end use. Composite products have become popular for various purposes such as interior decoration, furnishing and as building materials. With the emergence of concern for the conservation of forest resources, the utilization of waste lignocellulosic material in the composites have assumed greater importance as an alternative of valuable wood material.

The present paper gives overview of the work carried out at Forest Research Institute, Dehradun for development of biocomposites from invasive weeds such as *Parthenium hysterophorus* and *Lantana camara.*

P-166 Seasonal cycle, hibernation and migration of *Teleonemia scrupulosa* Stal. (Heteroptera : Tingidae), a potential biocontrol agent of lantana weed at Saharanpur.

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Teleonemia scrupulosa Stal. is a potential biocontrol agent of Lantana weed. By its desapping habit and injection of saliva, it inflicts heavy damage to this weed which has been spread like a wild fire in many parts of India. *Lantana camara* and bug *T. scrupulosa* occur throughout the year at Saharanpur. Population fluctuation is correlated with the increase or decrease of temperature and humidity. Bug population decreases during July – August due to rain at temperature ranging from 23.32 °C to 33.20°C and R.H. 71.64 to 95.82%. Population increases during September to November at temperature 10.35°C to 32.62°C and R.H. 32.42 to 93.97%. Though, climatic conditions were almost same but low population in rainy months was also due to torrential raining and high mortality of bug population.

During December to January due to low temperature bug population pass the winter in almost inactive state. Mostly, they were in gregarious form on the ventral side of the leaves. During March to June bug population increases rapidly and attain peak before rain commences. Rain and cold weather both are lethal to bug population.

T. scrupulosa does not hibernate or aestivate though, during winter months December to mid February, its population decreases and found in clusters on ventral side of leaves. In an aggregation 3 – 20 bugs were seen. The bug is a good flier. Both local and distant flights are taken. When plants of one habitat are destroyed or dry up the adults migrate to other places. During sunny days, bugs feed on dorsal surface of leaves, stem and on inflorescence in morning and evening hours but due to mid day heat of May and June, these migrate to ventral side of leaves. Due to migrating habit lantana bug has now been established in many parts of India since 1941 when it was imported in F.R.I. Dehradun from Canbarra (Australia). The bug population needs to be mass multiplied in laboratory and release in field to control lantana weed.

P-167 Fish integration into rice culture- a promising means for weed management

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Rice-fish farming appears to be globally important in terms of (a) climate change, (b) shared waters and (c) biodiversity. Rice-fish system is also innovative agricultural systems with a variety of local designs adapted to: cultural attributes; appropriate rice and fish species for husbandry; different kinds of water-resource availability, timing and drainage; natural and artificial nutrient inputs for growth; the biological and chemical control of insect-pests, weeds and diseases; and soil and water conditions. Aquatic biotic diversity is low to moderate, due to the transformation of complex swamp systems into simple agro-ecosystems. Transforming wetlands and rice fields for rice-fish production tends to directly benefit food production and income, as well as farm integration. A rich variety of direct and mainly indirect beneficial and non-beneficial effects emanate from the interactions between rice and fish, with many indirect non-beneficial effects exacerbated by the intensification of rice-fish production.

The incorporation of rice-fish culture in IPM (Integrated Pest Management) and the creation of a favorable environment for aquatic organisms in rice fields offer far more promise than any further refinement of fish culture techniques. Weeds are an important production limiting factor of rice culture. However, intensity of the problem varies depending mainly upon soil and water conditions. Reports suggest that fish as an integral component with rice cultivation causes remarkable control of the weeds and increased yield of rice. The study was undertaken to evaluate the performance of introduction of fish into rice fields and the effect on weeds and total yield from the system. The study was carried out in the farmers' field and it was compared with rice monoculture with farmers' practice (manual weeding) of weed control or without weed control. Standard technique of constructing fish refuge around rice field was followed.

The weed species which have been recorded in the plots with or without weed control were submerged-suspended weeds belonging to *Ceratophyllum demersum, Utricularia bifida complex, Commelina diffusa, Ludwigia linifolia, Hydrolea zeylanica, Lindernia anagalis, L. crustacea, L. nummularifloia, Ludwigia adscendens, Nymphoides indica, Otellia alismoides, Pistia strateotes, Rotala indica, Monochoria vaginalis*, amongst broadleaved weeds and grasses like *Oryza rufipogon, Dicanthium annulatum, Digiteria setigera, Hymanachne acutigluma, Panicum repens, Paspalum distichum, P. scrobiculatum* and sedge like *Eleocharis acutangula, Scirpus juncoides* and *S. meritimus*. Introduction of fish resulted significant decrease in weed population and dry weight besides limiting the weed species diversity. There was significant improvement in yield components like number of panicles per unit area and number of grains per panicle. Grain yield found due to introduction of fish was 58.26 and 87.00 per cent higher than that in the farmers practice of weed control or without weed control, respectively. Additional income of Rs. 9600.00 approximately from the fish component was achieved.

P-168 Effect of rust bioagent - *Uredo* sp. on seed production, seed health and germination of silkleaf (*Lagascea mollis* Cav.)

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Rust fungi which possess high degree of host specificity and widespread dispersal within short space of time have huge potential to suppress weeds in croplands, pastures, roadsides, forestry, rangelands, and conservation areas. Severe attack of rust pathogen causes leaf death and defoliation of weed canopy. Ultimately, reduction in the weed biomass and/or weed density below economic threshold followed by further colonization of infested site with native vegetation determines the success of weed biocontrol. In natural ecosystems, rust pathogens may be ideal bioagents for controlling weeds in remote and inaccessible locations.

A study was conducted at NRCWS research farm, Jabalpur, India during kharif season of 2007 to evaluate promising rust bioagent Uredo sp. against Lagascea mollis which is a prominent broad leaved weed in Central and South India. Experiment was conducted in microplots (1mx1m). Spore suspension of bioagent (containing 10^6uredospores/ml) was sprayed on Lagascea mollis plants at 30 DAS. Controlled plots were maintained by protective spraying of propiconazole (systemic fungicide) at monthly intervals. Six replications were maintained for each treatment. Seeds of mature flower heads were collected time to time from both the treatments up to 90DAS. Total seed weight/plant and thousand seed weight were recorded on high precision balance. Seeds were further incubated at room temperature for 60days. Germination study of *Lagascea mollis* seeds was done in 90mm plates by providing congenial environments into growth chamber. A remarkable reduction (91.68%) in the seed production/plant was observed due to inoculation of Lagascea mollis by the rust bioagent. Thousand seed weight and seed germination of inoculated plants were reduced by 68.20% and 77.78% respectively. This heavy damage potential of rust bioagent may be exploited to reduce the seed production potential *Lagascea mollis* and its seed rain to soil.

P-169 Suppression of parthenium by botanical agents – standardization of technique

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Weeds competes with limited resources and reduces productivity of the crops, spoils aesthetic beauty in garden, causes nuisance if creeping weed infests electric or telephone poles. Parthenium pollen the crop later. Managing the parthenium is absolutely essential but costly. Non-availability of timely labour force and the awareness of chemical pollution causes dilemma of herbicide usage. Alternative technique to manage Parthenium weed is a welcome challenge.

With this background several experiments were conducted to assess the use of allelochemicals produced by botanical agents to suppress parthenium. *Lantana camara*, *Hyptis sulvelolensis* and *Cassia uniflora* most effective botanical agents. Allelochemicals aqueous extracts suppressed germination of parthenium at petri -dish condition at 1 %, but even at 20% extract spray pre or post had no effect, in fact stimulate the parthenium growth. Mulching of botanical agents suppressed Parthenium till 60 DAS, but no effect or stimulate the growth of Sunflower and Tomato respectively. Data suggests that live or continuous supplies of allelochemicals were needed to suppress the parthenium. Advantage of slow releasing pelleting of allelochemicals, role of soil pH on allelochemicals efficacy were discussed.

P-170 Role of parthenin in enhancing the biological control potential of *Zygogramma bicolorata*

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Neotropical compositae, *Parthenium hysterophorus* of South American origin, has emerged as a major weed of India in past few decades. The Mexican beetle, *Zygogramma bicolorata* was introduced in India in 1983 and since then has shown substantial potential in controlling the noxious weed. During augmentative release in Jabalpur it was seen that the beetle was causing appreciable control of the weed in several site but in several other sites the beetle were not causing appreciable damage in spite of number of augmentative releases. This was probably due to moving of the beetles to other site.Thus attempts were made to find a technology to make the beetles stay in the desired site.

It has been found that parthenin (sesquiterpene lactone) is a major compound present in the parthenium leaves and is largely responsible for attracting the beetles. Parthenin was extracted through the hexane chloroform purification method. Different concentrations of parthenin i.e., 5, 10 and 20 ppm were prepared in 5% ethanol and sprayed on parthenium patches in $1m^2$ area each with 3 replications. The beetle were released in and around the parthenin sprayed and unsprayed areas. By 24 hrs, it was found that though there was no significant difference in the population of beetle in the area sprayed with different concentration of parthenin yet there was a significantly higher number of beetles present in the parthenin sprayed areas as compared to control. There were 35.7, 47.3 and 54.0 beetles present in the parthenin sprayed patches of 5, 10 and 20 ppm respectively while there were 24.7 beetles in the control patches by 24 hrs. By 48 hrs also similar result were obtained. There were 36.7, 56.7 and 72.7 beetles in the sprayed patches of 5, 10 and 20 ppm respectively. By 72 hrs there was a decrease in the effect of the parthenin sprayed. There were 31.0, 45.7 and 67.7 beetles present in the parthenin sprayed patches of 5, 10 and 20 ppm respectively while there were 19.0 beetles in the control patches. Thus there were more beetles in the parthenin sprayed patches than the unsprayed patch. This information can be used to enhance the activity of beetles at the desired site.

P-171 Rearing of *Zygogramma bicolorata* during winter in poly-house

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Zygogramma bicolorata, a biocontrol agent of *Parthenium hysterophorus*, is found to be active in field conditions from April to October in and around Jabalpur. The beetles do not remain present in notable number during winter in the field. So attempts were made to mass rear the beetles in poly-house made of polyvinyl chloride (PVC) over the iron rod skeleton of surface area of 6 m^2. In these poly houses, beetles were released at the rate of 3, 4 and 5 pairs per m^2. No beetles were released in the control chambers. Initially it was observed that in closed polyhouse, the temperature went up to as high as 35^{0}C and humidity (about 90%) which was unsuitable for insect rearing. Therefore, a technique was standardized by making nylon net windows in the poly-houses to bring down the temperature and enable more aeration inside the chambers so as to maintain 26±2^0 C temperature and 65-80% humidity. Due to congenial temperature and humidity, the population built-up of the beetles was quick. In chambers with 5 pairs of beetle/ m^2 release, there were 6.6 eggs, 12.3 grubs and 0.8 adults per plant by 15th day. In chambers with 4 pairs of beetle/m^2 release, there were 7.3 eggs, 3.6 larvae and 1.5 adults per plant while in chambers with the initial release of 3 pairs of beetle/ m^2, there were 20.0 eggs, 11.8 larvae and 2.0 adults per plant by day 15. In the control chambers there were no beetle population and there was dense parthenium growth. 100 % defoliation was seen in chambers with 5, 4 and 3 pairs of beetle/ m^2 release by 25, 35 and 45 days respectively. New plants had to be added in order to continue with the rearing process. Thus employing this technique successful rearing of the beetles was possible under the conditions of extreme winter.

P-172 *Chrysocoris stolli* wolf, a sap feeder pentatomid bug on the weed in north western districts of Uttar Pradesh

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Chrysocoris stolli Wolf is a polyphagous phytosuccivorus bug, infests *Cassia occidentalies, Croton sparisiflorum*. The population feeds on leaves, seeds and inflorescence. The bug first probes suitable feeding site with the aid of sensory setae of the rostrum and then piercing is done by styletes and when feeding is over the bug withdraws its styletes and either move away from the feeding site or remained in near by vicinity. After feeding, rostrum and antenna are cleaned by antenna and rostrum cleaner device. The *C. stolli* occurs actively during March to October and hibernates from November to February. The number of adults as well as nymphs reaches on peak in September. In mid October the older nymphs 4th and 51h instars prepare for quick feeding and moulting to become adults. Seasonal occurrence of *C. stolli* was observed in relation to host plants and abiotic factors.

P-173 Mycoherbicidal management of waterhyacinth with *Alternaria alternata*: present status and future

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Mycoherbicides are special biotechnology products which contain fungal spore suspension or metabolites as nonchemical alternatives thereby reducing the input of harmful chemicals to control noxious weeds. The present communication emphasizes on the potential of *Alternaria alternata* as a mycoherbicide for the global weed – water hyacinth (*Eichhornia crassipes*). The fungus was collected from diseased plant parts of waterhyacinth during periodical survey of waterhyacinth infested water bodies. It was capable of causing leaf spots followed by severe leaf blight and dieback disease in waterhyacinth. An experiment was conducted under green house conditions to test the pathogenicity of *A. alternata* on three growth stages (small, medium and large) of waterhyacinth. Spore suspension of *A. alternata* (4.5×10^6 spores/ml) was prepared in sterilized distilled water and 0.01% Tween-80 using haemocytometer. Waterhyacinth plants were sprayed until runoff with spore suspension using atomizer. They were covered with transparent polythene bags and placed in growth chamber at 27^0 C and 75 – 90% relative humidity. The control plants were sprayed with sterile distilled water and 0.01% Tween-80. It was observed that larger growth staged plants were more susceptible to the disease and were infected early by the fungus as compared to middle and smaller growth staged plants. By the 5th day the pathogen caused 10.7 (± 0.8)%, 60.7 (± 2.6) % and 31.3 (± 1.4)% damage to waterhyacinth of small, middle and large growth stages respectively while by the 15th day the pathogen caused 31.3 (± 2.86)%, 59.3 (± 0.06)% and 76.0, (± 3.78)% damage to waterhyacinth of three growth stages respectively.

The fungus has the potential to be developed as mycoherbicide against waterhyacinth. Thus with proper formulation the fungus can be developed as a potential mycoherbicide of waterhyacinth for field application. Further, the potential of the secondary metabolite of the pathogen can also be evaluated for its herbicidal action against the weed.

P-174 Economics of wheat (*Triticum aestivum* L.) cultivation as influenced by cultural and chemical methods of weed management under alluvial plains of West Bengal

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An experiment was carried out on wheat (PBW-343) at Jaguli Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during *rabi* seasons 2004-05 and 2005-06 to compare the efficiency of some safer herbicides with manual weed management practices. The treatments included 4 different doses of metsulfuron methyl (@ 2,3,4 and 8 g/ha) each applied at 25 DAS, 2 different doses of 2,4-D Na salt (@ 0.5 and 1.0 kg/ha) each at 25 DAS, combination of herbicides followed by hand weeding at 40 DAS and the sole manual weeding at 20 and 40 DAS. The experiment was laid out on a randomized block design, replicated thrice. Two hand weedings recorded the best result in respect of total weed population, weed dry matter, weed control efficiency and grain yield. Combination of metsulfuron methyl @ 4g/ha at 25 DAS followed by one hand weeding (at 40 DAS) and 2,4-D Na salt @ 0.5kg/ha at 25 DAS accompanied by similar manual method of weeding showed promising result in respect of above criteria. Among the sole chemical treatments metsulfuron methyl @ 8g/ha resulted the best weed management treatment but it showed some phytotoxic effect on the wheat crop which finally hampered the grain yield. The highest net return and benefit-cost ratio was obtained with metsulfuron methyl @ 4g/ha at 25 DAS closely followed by 2,4-D Na salt @ 1.0 kg/ha at 25 DAS among the all herbicidal and cultural methods.

P-175 On farm evaluation of effect of integrated weed management on yield and economics in spring planted sugarcane (*Sachcharum officinarum* L.)

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An on-farm evaluation was conducted at six farmers field during spring season of 2002-03 and 2003-04 under north Bihar condition to work out the yield and economics of sugarcane as affected by different weed control treatments. The treatments comprised five weed control practices (weedy check, farmrs practice (two harrowing). Reommended practice pre-emergence use of atrazine 0.5 kg/ha + post emergence use of 2,4-D sodium salt 0.8 kg/ha + one mechanical weeding power weeder at 30 & 60 DAP) and two weeding by power weeder at 30 & 60 DAP *fb* manual row weeding. The experiment was laid out in a randomized block design with six replications. Minimum weed dry wt. (25.1 g/m^2) and maximum weed control efficiency (78.0%) and cane yield were recorded under two weeding by power weeder at 30 and 60 DAP *fb* manual row weeding which was significantly superior over all other treatments. Maximum additional income Rs. 11164/ ha over weedy check was found under two weeding by power weeder *fb* manual row weeding, which was 18.6, 32.8 and 36.2 per cent higher over treatment two weeding by power weeder at 30 and 60 DAP, recommended practice of weed control and farmer practice respectively.

P-176 Impact analysis of integrated weed management on sugarcane in the western zone of Tamil Nadu

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Integrated Weed Management (IWM) is a systematic approach to crop production using increased information to make better weed management decisions. Sugarcane is the leading commercial crop grown in Tamil Nadu, where weeds are one of the yield limiting factors and reducing farmers income significantly. The main objective of the study is to examine the impact of IWM on sugarcane yield and farmer's income, awareness and adoption level of various weed management practices etc., in the western zone of Tamil Nadu. In this region, exactly 100 sugarcane growers are investigated about different weed management practices. Survey results revealed that major weed groups identified in the sugar cane area comprised of broad leaved weeds (52.7%) followed by grasses (36.7%) and sedges (10.6%). Chemical weed management found to be cost effective (Rs.432.77), whereas, manual weeding is the costlier method, approximately five times (Rs.2500.16) that of chemical weed management. The adopters of IWM in sugarcane realized increased crop yield of 33.76 Mt/ha and increased farm income of Rs.33, 062/ ha than the non adopters. Binomial logit regression on adoption of IWM in sugarcane indicated that education, farm size, IWM on other crops in the region and frequent visits by the technical staff are found to influence the adoption level of IWM. Availability and cost of labour is the primary constraint in sugarcane production closely followed by lack of technical know-how and lack of equipments are the other rated constraints. Private sugar industries are the key disseminators of weed management in sugarcane. Progressive farmers and agricultural extension departments are the other major sources of information about IWM. Strengthening farm extension system and field demonstrations about weed management practices at proper time will ensure increased IWM adoption in the study area.

P-177 GIS techniques and making weed emergence maps

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A Geographic Information System (GIS) combines layers of spatially related information to better understand relationships that vary geographically. Arc GIS is a family of software products that form a complete GIS with integrated systems for geographic data creation, management, integration, and analysis. GIS provides the layout and drawing tools that present research results with visual documents. Graphically displayed data can have a profound effect on the conclusions drawn from a data set. Utilization of GIS will allow researchers to better understand how research results apply to our natural environment. Objectives of this to demonstrate GIS applications in weed management decision-making. An intensive weed survey carried out in different AICRP-WC centers situated in different states of the country. In this paper we have digitized state, district, crop and weed distribution of India. GIS presents information graphically, which may allow researchers to more fully investigate data resources and develop spatially accurate graphical data displays. Further we have generated queries to extract the meaningful information which is very inevitable for drawing optimum decisions for planning of better crop production.

P-178 Constraints of growth in agricultural farming with reference to transfer of technology, adoption level and weed management

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The paper attempts to study the constraints of growth in Agricultural farming in respect of transfer of technology, adoption level and weed management in five districts of Madhya Pradesh during the year 2006 and 2007. Study was undertaken to identify the various factors directly affecting or hindering adoption level in different crops with their knowledge and adoption level and degree of constraints responsible for productivity. It is based on micro level data obtained from a sample of 154 farmers residing in different villages of Jhabua, Dhar, Gwalior, Khargone and Khandwa districts of Madhya Pradesh.

The study revealed that lack of timely availability of certain inputs, inadequate supply of inputs, lack of knowledge regarding plant protection measures, doses fertilizers/ nutrients, lack of certain improved implements etc. adversely affected the adoption level of farmers have commonly used intercultural operation for weed control. Whereas the farmers having adequate knowledge of herbicides have used herbicides in crops but the adoption was found to be low, as compared to their knowledge. It is further concluded that the knowledge has strong relation with extent of adoption of herbicides. It is stated that adoption of any innovation is not possible without knowledge.

Similarly, data reveale that the productivity of crops was strongly associated with the constraints like uncertainty of rainfall/ irrigation, untimely availability of credit facilities, non availability of improved seed and fertilizer lack of technical know-how, lack of communication and low price of farm produce, non availability of quality of inputs etc. in study area.

This study indicates that in the breakthrough of technology adoption in crops, effective education and level of knowledge of the farmers in study area should be promoted to narrow down the adoption gap. Besides this, subsidiary occupations and regular extension on reducing the extent of adoption gap in crop production.

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Extent of awareness of farm women regarding pesticide residues in cereals, vegetables, milk and milk products

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Pesticides have contributed significantly in improving food security through increased food production and reducing post harvest losses. But due to the indiscriminate use of pesticides the air, water, soil and food commodities have become loaded with pesticide residues. Pesticide residues refer to the amount of pesticides, chemicals or its metabolites which remain in the food commodity after the effect of weathering and are toxicologically important. The situation is so alarming that even mothers milk is not free from pesticides. Consumption of pesticide contaminated food have put the survival of mankind in danger by causing various fatal diseases. It is, therefore, essential to make the people aware of the safe use of pesticide, health hazards caused by them and ways to get rid of the pesticide residues from food.

The present study on the above was undertaken to know the extent of awareness of farm women about pesticide residues and to find out the steps taken by farm women to decrease/ eliminate the pesticide residues. A sample of 120 farm women was randomly selected from Sahpura and Sihora block of Jabalpur district. The data were collected with the help of structured interview schedule. Farm women had medium and high level of awareness about pesticide residues and use of pesticides respectively. Friends, family members, radio and television were the important sources while village development officers and farm publications had a negligible role in creating awareness among farm women. Majority of farm women took the steps in order to clean dust from food commodities. Tips related to crop science and integrated pest management, soaking leafy vegetables in water before chopping, discarding 'malai' from boiled milk, pasteurizing milk for household use, not to put pesticide contaminated bedding material under milch animals were not followed by farm women. Higher the education, income, awareness about pesticide use, higher was the awareness about pesticide residues.

P-180 Evaluation of different weed control methods for sunflower on farmers fields

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Sunflower is an important oilseed crop of India. Presently India has fourth largest area under sunflower (2.1 m ha) in the world. Karnataka is the largest sunflower producing state in the country. It accounts for the 50 per cent of the total area under the crop and 30 per cent of the total output. Though this crop has high yield potential, its yield is very poor due to severe weed competition. Wider row spacing and slow initial growth of sunflower provide congenial environment for the growth of weeds. An average loss of yield in sunflower due to weed is estimated to be 26.5 per cent. Further weed problem becomes more serious on account of unavailability of labourers at proper time. To study the comparative performance of different weed control methods in sunflower, on farm trials were conducted during 2006 at 12 locations on farmers fields of adopted villages in Karnataka. The trials were conducted in randomized block design with three replications. Weed control treatments consisted of local check(T1), one hand weeding(T2), two hand weedings at 20 and 40 days after sowing (T3), pendimethalin @1kg ha^{-1} (T4) and fluchloralin@1kg ha^{-1} (T5). Sunflower hybrid KBSH-1 was sown in June month at 60 x 30cm spacing. Recommended package of practices were adopted to grow the crop.. The major weeds observed in the trial plots were *Cyperus rotundus, Digitaria marginata, Echinochloa colona Commelina bengalensis, Portulaca oleracea, Amaranthus viridis and Parthenium hysterophorus* etc. Herbicides fluchloralin was applied as pre-plant incorporation i.e. one day before sowing and pendimethalin was applied as pre-emergence i.e.2 days after sowing. Weed sampling was done at 50 days after sowing using 50cm x 50cm quadrate for recording weed density and biomass. Observations on yield and its parameters were recorded at harvest. All the herbicidal and hand weeding treatments significantly reduced both the population and biomass of weeds compared to local check. The total weed intensity (m^2), weed biomass and the highest weed control efficiency was recorded under two hand weedings followed by pendimethalin@1kg ha^{-1} . The lowest weed control efficiency (52.3%) was observed under one hand weeding. Among the herbicides, pendimethalin@1kg ha^{-1} resulted in the maximum reduction in weed intensity (7.99 m^{-2}) and weed biomass (3.47g m^{-2}) followed by fluchloralin. The lowest weed persistence index was noted with 2 hand weedings. Pendimethalin recorded the lowest weed persistence index(0.11), followed by fluchloralin(0.16). The maximum number of seeds per head(756 $head^{-1}$) was recorded with pendimethalin followed by fluchloralin(664 $head^{-1}$). The seed yield of sunflower was enhanced significantly by pendimethalin(18.5q ha^{-1}) which was at par with fluchloralin as compared with other treatments. The lowest yield was recorded with the local check and the magnitude of increase in seed yield with Pendimethalin was 80 per cent more over the local check. Growth of sunflower, which helped in better growth of the crop resulting in higher seed yield of sunflower. Net returns per hectare over local check was maximum(Rs.9105 ha^{-1}) with pendimethalin followed by fluchloralin and two hand weedings. The lowest net returns (Rs.3172 ha^{-1}) was recorded with one hand weeding due to lowest seed yield. Therefore, it is concluded that pre-emergence application of pendimethalin@1kg ha^{-1} may provide better and cost effective weed management in sunflower under Karnataka conditions.

P-181 Assessing farmers behaviour in adoption of improved technologies including weed management of vegetable crops in Madhya Pradesh

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The average productivity of a majority of vegetables in India is low (12 t/ha) compared to that in other countries of the world. It could be enhanced through adoption of improved vegetable technologies including weed management. Although several improved and hybrid varieties / weed management technologies / other technologies of vegetable crop have been developed, their adoption has not been very encouraging.

The knowledge of farmers on vegetable varieties and their behaviour in adopting these varieties and other technologies including weed management have been assessed. This study is based on a total sample of 100 farmers selected randomly in Jabalpur district of Madhya Pradesh. A majority of the farmers are reported to have high and medium level knowledge of improved technologies of tomato and cauliflower cultivation. However, only 17 per cent in Panager and 35 per cent in Amkhera of Jabalpur district are reported to be high adopters of the improved technologies including weed management in cauliflower. A majority of the farmers have expressed lack of control measures for weed, leaf curl in tomato, high cost of pesticide and fertilizer, lack of marketing, impure seeds and chemical, timely labour availability as major reasons for non-adoption of improved technologies. A significant correlation between extension contact and knowledge and adoption of improved vegetable technology has been found. It is suggested that there is a need to strengthen communication methods like TV and radio by extending the duration of farm programs and providing specialized training to the growers. Research efforts should be strengthened to develop multiple disease, pest and weed-resistant varieties and direct supply of these varieties to farmers. It is observed that co-operative farming may solve the problem of small farmers of post-harvest management and value-addition.

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Utilization of *Parthenium hysterophorus* as compost in wheat crop

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Parthenium by virtue of its luxurios growth behaviour and ability to compete with useful plants, pose serious problems, both in cropped and non-cropped situations. The weed contains higher amount of nutrient (%NPK) hence can be utilized as a potential source of organic manures. Amongst different options, management through utilization is the best way because this tactic instead of spending money on management, help the users to earn money by utilizing them and simultaneously to achieve control too. A field experiment was conducted during *Rabi* season of 2003-2004 and 2004-05 to study the effect of parthenium compost on yield attributes of wheat crop. The treatments consisting of five combination of *Parthenium* compost with FYM and inorganic nutrient in main plots and two weed control methods in sub-plots replicated thrice in a split-plot design. Experimental field was infested with *Medicago hespido, Chenopodium album, Vicia sativa* and *Cichorium intybus*.

Result revealed that different fertility treatments did not affect the population of individual weeds, total weeds and weed dry matters. Application of 2, 4-D 0.50kg/ha as post emergence significantly reduced the population and dry matter of weeds. Similarly yield attributes and yield were also not affected significantly due to different fertility combinations. However, parthenium compost alone significantly reduced the tiller numbers, 1000 grain weight and seed yield as compared to RDF. The experiment envisaged the possibility of saving inorganic fertilizer by utilizing parthenium as compost as incorporation to wheat crop under central Indian conditions.

P-183 Allelopathic potentials of *Ageratum conyzoides* L. extract on major weeds of onion (*Alium cepa* L.)

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In order to elucidate the bioactivity of *Ageratum conyzoides* L, an invasive species native from Brazil, laboratory bioassay studies were conducted to understand the allelopathic effect of dried plant extracts of *Ageratum conyzoides* L. on major weeds of onion. Significant reduction in germination, morpho-physical and biochemical parameters of different weed species was noticed with pre flowering *Ageratum conyzoides* extract at higher (10 per cent) concentration. Among the weed species, germination of *Cynotis cuculata* and *Portulaca oleracea* were inhibited most while morpho-physical characters of *Phylanthus niruri* followed by *Amaranthus viridis* and *Dinebra retroflexa* were reduced to the maximum extent. Lower sugar content was recorded in *Dinebra retroflexa* and *Portulaca oleracea whereas,* phenol content was significantly high in *Portulaca oleracea*. The study inferred that *Ageratum conyzoides* can be well exploited for its alleloptahic potential.

P-184 Allelopathic effect of *Ipomoea tricolor* L. extract on major weeds of onion (*Alium cepa* L.)

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The allelopathic potential of *Ipomea tricolor*, used in traditional agriculture to control weeds, need to be explored. An attempt was made through laboratory bioassay studies to know the allelopathic effect of dried plant parts of *Ipomoea tricolor* L. extract on germination, morphophysical and biochemical parameters of major weeds of onion. Preliminary studies indicated significant decrease in germination, morpho-physical and biochemical parameters of all weed species at higher (10 per cent) concentration with *Ipomoea tricolor* extract collected at pre flowering stage. Among the weed species, germination of *Cynotis cuculata*, *Dinebra retroflexa* and *Portulaca oleracea* while morpho-physical characters of *Phylanthus niruri* and *Dinebra retroflexa* were affected greatly. However, the weed species, *Cyanotic cuculata*, *Portulaca oleracea* and *Dinebra retroflexa* recorded lower sugar content and higher phenol content.

P-185 Studies on allelopathic potential of *Caesulia axillaries* on physiology and yield of wheat

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A pot culture experiment was conducted during *rabi* seasons of 2004-05 and 2005-06 to study the allelopathic potential of *Caesulia axillaris* L. on yield attributes and yield of wheat (*Triticum aestivum* L.. The results showed that *Caesulia axillaries,* a predominant weed of rice showed on allelopathic effect in succeeding wheat crop under rice-wheat cropping system. The grinded leaves of *Caesulia axillaries* @ 200 g per pot having capacity of 10 kg of garden soil increased the physiological and biochemical yield attributes viz. root weight, root volume, leaf area, specific leaf weight (SLW), chlorophyll a, b and total chlorophyll. The ratio of chlorophyll a and –b along with nitrate reductase activity (NRA) was also found to be increased due to allelopathic effect of *Caesulia axillaries.* Thousand grain weight and yield were also increased up to application of 200 g grinded *Caesulia axillaries* per pot. There was a significant reduction in physiological and biochemical yield attributes and yield beyond the application of 200 g grinded *Caesulia axillaries* per pot, indicating the synergistic and antagonistic effect at lower and higher concentration, respectively.

P-186 Allelopathic effects of *Cannabis sativa* on early growth stages of *Triticum aestivum* L.

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A laboratory experiment was conducted during 2003-04, to study the possible allelopathic effects of *Cannabis sativa* leaf leachate on germination and seedling growth of wheat (*Triticum aestivum* L.). The leaf leachate at very low concentration enhanced the early growth of wheat. Inhibition was observed in growth above 10% leaf leachate concentration. At 5% and 10% leaf leachate Redicle length and plumule length was observed 5.63 and 5.84 and 4.66 and 4.79 at 5 and 10% respectively. Cotyledon dry weight at 5 and 10% leachates concentration decreased by 24.59 and 23.35 mg, respectively. The length of embryonic axic, seedling vigour and vigour index showed the same trend as was radicle and plumule length. The leachate concentration exceeding from 10% decreased all growth parameters of *Triticum aestivum* indicating that *Cannabis sativa* leachate below 10% concentration might be used to increase the early growth stages of wheat.

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Allelopathic effect of botanicals on onion (*Alium cepa* L.)

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In an attempt to find out potential botanicals for weed control in onion growing fields, a lab experiment was conducted to screen the botanicals with no adverse effect on onion. Bioassay study on allelopathic effect of ten botanical extracts collected at pre and post flowering stages of botanicals viz., wheat (*Triticum aestivum*) straw, paddy (*Oryza sativa*) straw, *Chromolena odorata*, *Eucalyptus citrodora*, *Lantana camera*, *Ipomoea tricolor*, *Ageratum conyzoides*, *Clerodendrone thomsanae*, *Parthenium hysterophorus* and *Cassia sericea* with three treatments (Control, 5% plant extract, 10% plant extract) on onion seed germination and seedling growth was made. Significant differences with treatments on the per cent germination and seedling growth were recorded. Among the botanicals, four species viz., *Chromolena odoratum*, *Clerodendrone thomsanae*, *Parthenium hysterophorus*, *Cassia sericea*, caused significant reduction in onion seedling length and dry matter production. Further, the effect was significantly higher with increased concentration. Hence these species are not the candidate species (botanicials) for control of weeds in onion growing situations. On the contrary, remaining six species viz., wheat *(Triticum aestivum)*, paddy *(Oryza sativa)*, *Eucalyptus citrodora*, *Lantana camera*, *Impomoea tricolor* and *Ageratum conyzoides* did not significantly affect onion seed germination and hence could be further evaluated for allelopathic effect on weeds in onion growing fields. Further, botanical extracted at pre flowering stage had more deleterious effect on onion compared to post flowering stage.

P-188 Relation between light transmission ratio and the growth of jute weeds at different weed management options

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Field experiment was conducted in the sandy loam soil of Instructional farm (22.93°N and 88.53°E) of BCKV, Mohanpur, West Bengal for two years during the summer-rainy seasons of 2001-2002 to study the influence of light transmission ratio on growth behaviour of weeds associated in recently released variety of capsularis (JRC 698) jute. It was observed that the dry weights of weeds (DW) were directly correlated with the light transmission ratio (LTR) for all dates of observation. At 60 days after sowing (DAS) the relation was, DW_{60} = 158.64 x LTR – 2.59 (r = 0.829). Similarly, the other relations were, DW_{90} = 814.89 x LTR + 5.92 (r = 0.934) and DW_{120} = 898.58 x LTR – 95.56 (r = 0.832) for 90 and 120 DAS respectively. The straight line relation with high positive correlation values (0.83 to 0.93) between the weed growth and the LTR advocates that there should be both agronomic and breeding approach to minimize the light transmission ratio in jute resulting less competition from weeds. In the canopy of the present capsularis variety (JRC 698) with the existing agronomical practices, the LTR had definite relation with time (DAS). If the weeds are not controlled, the lowest LTR (0.22) was observed at 104 DAS. If the weeds are managed by two manual weeding (at 21 and 35 DAS), the lowest LTR of 0.03 was noted at 93 DAS; whereas, at herbicidal weed control (fluchloralin as pre-plant soil incorporation at 0.75 kg/ha) the lowest LTR (0.09) was recorded at 92 DAS. As the lowest values of LTR (0.03) signified the better canopy formation and proper growth of jute crop, so hand weeding was the better method of weed management as compared to Fluchloralin as pre-plant soil incorporation.

P-189 Effect of elevated CO_2 on the efficacy of different herbicides

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A pot culture experiment was conducted in Open Top Chambers (OTC), one with ambient CO_2 (360±20 ppm) and another with elevated CO_2 (550±30 ppm) Seeds of different weeds were sown in pots in three replicates. Different herbicides for different weeds were applied when the seedlings were 30 day old. The effect of herbicides on the mortality of weeds was tested under two CO_2 levels. The CO_2 enrichment decreased the efficacy of the herbicides as it was evident from the finding that the time taken for the complete death of the herbicide applied weeds was prolonged at elevated levels of CO_2. Variability of efficacy among the herbicides under high CO_2 was observed. The impact of high CO_2 on the efficacy was more on isoproturon (mortality was delayed by 9 days) followed by clodinafop (7days), 2,4-D (5days) and glyphosate (3days). The sulfosulfuron slightly retarded the growth of *Lathyrus sativus* for short period but did not cause death under both the conditions.

P-190 Evaluation of advanced generations of transgenic groundnut lines resistant to glyphosate

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Groundnut is important source of oil, food and nutrition. Unless good weed control is achieved, a substantial yield loss occurs. Glyphosate is an ideal herbicide without selectivity; kill plants by inhibiting EPSPS enzyme in shikimic acid pathway. Agrobacterium mediated *in planta* transformation technique adopted to develop transgenic groundnut lines. Glyphosate resistant groundnut plants (cul. TMV-2) developed by over expressing pEGAD-EPSPS with altered kinetics, which do not bind to glyphosate. Single leaf let glyphosate induced chlorosis bioassay system was used to assess the glyphosate resistance in groundnut transgenic lines of T_1 & T_2 generations. Repeated screening of transgenic lines was done with different concentration of glyphosate (1000ppm at 18 DAS; 1000-3000ppm at 30 DAS and 3000ppm 52 DAS) during the different growth stages under pot culture and soil conditions of T1 generation. The T_2 generation plants were screened for glyphosate resistance by spraying 1000ppm of glyphosate at 45 DAS. Over 96% wild type plants completely dried whereas only 30% of transgenic plants showed some degree of yellowing and leaf mortality. During 65 DAS, single leaflet of groundnut was swabbed by 3000ppm (1.2 kg ai/ha) glyphosate and resistant plants were confirmed by PCR with product size of 750 bp. The chlorophyll degradation was less in transgenic and also maintained higher membrane integrity compared to wild type when treated with glyphosate. Transgenic maintain the metabolism of shikimicacid thus accumulates less shikimicacid. Eighty-eight and 28 per cent shikimic acid accumulated in wild and transgenic plants after 96 hr glyphosate swabbing respectively.

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Effect of tillage and sowing management on weed dynamics, grain yield and conservation of resources in rice-wheat cropping system

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Field experiments were conducted on rice-wheat cropping system in sandy loam soils at Research Farm, JNKVV, Jabalpur (M.P.) for 2 years during 2004-05 and 2005-06 with the objectives effect of tillage and sowing management on weed dynamics, conserve the labour, time and diesel with the use of efficient farm machineries for tillage and sowing of both crops in a succession under irrigated agro-ecosystem. Four tillage and sowing methods for each crop viz. for rice cv. Kranti (direct seeding in dry fields, direct seeding of sprouted seeds in puddled field by drum seeder, manual transplanting, and mechanical transplanting) and for wheat cv. GW-273 (conventional till sowing, zero-till sowing, strip-till sowing and bed planting) were tested in strip plot design with 3 replications. Based on the mean data of both years weed population and weed dry weight were maximum (10.92/m^2 and 8.62g/m^2, respectively) in direct seeding in dry fields among all other methods in rice. While in wheat weeds flora did not differ due to tillage and sowing methods, but weed population and weed dry weight were minimum in zero- till sown (4.25 /m^2, 4.02 g/m^2) and strip-till sown (4.99 m^2 and 4.03 g/m^2) and higher in conventional till sown (8.17/m^2, 6.88 g/m^2) and bed planted wheat (6.88 /m^2 and 6.02/ g/m^2). Gain yields of rice was comparable (46.93 to 47.85 q/ha) among all methods of sowing, while wheat produced significantly higher grain yields under strip till sowing followed by zero or conventional till sowing and bed planting in decending order. Consequently, strip till sown wheat after rice (grown under different tillage) produced higher combined grain yields for entire cropping system in term of wheat equivalent yields (82.03 to 84.54 q/ha) with greater values of NMR (Rs 37124 to 39172 /ha) and B:C ratio (2.30 to 2.37) than other combination of tillage and sowing methods of both crops. Direct seeded rice followed by strip-till or zero-till sown wheat consumed minimum time (32.12hrs/ha) and diesel (90.92 l/ha) by ensuring timely and cheep sowing without sacrificing the crop yields. Direct seeding of sprouted seeds of rice in puddled field with the help of drum seeder followed by strip or zero-till sown wheat needed minimum labour (152 man days/ha/year) and it proved to be an efficient tillage and sowing technique for labour scarce areas.

P-192 Effect of day time on efficacy of combi and glyphosate against weeds growing in non-cropped area

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An experiment was conducted during Rabi season of 2007-08 at Research farm of JNKVV, to evaluate the effect of day time on the efficacy of combi and glyphosate against weeds in non-cropped area. The Experimental field was infested with rampant weeds like *Bracharia mutica, Alternanthera sesilis* and *Ageratum conyzoides*. Besides these, *Cynodon dactylon, Cyperus rotundus* marked their presence in small number. Thirteen treatments consisted of two doses of glyphosate (2.0 and 2.5 kg/ha) and combi (2.0 and 2.5 kg/ha) and three day time application including weedy check, were carried out in factorial randomized block design with three replications. All the treatments had marked influence on weed density, their dry weight and shoot length. Application of combi 2.5 kg/ha during noon time reduced the weed population, shoot length and dry weight of *Bracharia mutica* by 42.0, 25.53 and 39.13 percent within 60 days, where as the annual weeds like *Alternanthera sesilis* and *Ageratum conyzoides* were completely controlled within 8 days after application and proved superior over glyphosate at the same rate, which took more time for curbing growth of former and latter weeds.

P-193 Efficacy of post-emergence herbicide against weeds growing in non-cropped lands

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An experiment was conducted during Rabi season of 2007-08 at Research farm of JNKVV, to evaluate the efficacy of Post-emergence herbicides against weeds with different doses of application. Ten weed control treatments including weedy check and manual cutting were tested in randomized block design with four replications. The Experimental field was invaded with perennials rampant weeds like *Bracharia mutica* (84.90 %), and annual like *Alternanthera sesilis* (9.43 %) and *Ageratum conyzoides* (5.66 %). Besides these, *Cynodon dactylon*, *Cyperus rotundus* were present in small number at 30 days of experimentation in weedy check plots. All chemical weed control treatments significantly reduced the density of annual weeds and perennial grass, dry weight, shoot length. Among the weed control treatments, post emergence application of combi (35 % 2,4-D + 35 % glyphosate) at 2.5 kg/ha proved most effective in reducing the density of *Bracharia mutica* (29.7 %), shoot length (47.5 %) and dry weight (37.62 %) than other treatments with 90 days of experimentation. However application of combi at higher dose (3.0 kg/ha) curbed the density, dry weight and shoot length cent percent within 60 days of experimentation.

P-194 Better utilization of weeds through processing for human nutrition

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Green leaves are the primary source of vital nutrients but their consumption as food is often restricted due to presence of potentially harmful substances. Nutritionists recommended inclusion of at least 100 g leafy vegetables in human diet. In addition to cultivated greens, leaves/tender shoots of weeds are widely consumed by tribals, rural and urban people. Information about nutritive value, especially anti-nutritional substances in these unconventional greens is scanty.

Tender shoots of bhathua (*Chenopodium album* L.), a profusely growing weed in *rabi* fields, forms a popular vegetable consumed throughout winter. Investigations carried out in this laboratory revealed that bhathua, although rich in protein (35.30%) and minerals (19.12%), contains alarmingly high levels of oxalates (15-18%) and phenolics (3.48%). Dietary intake of oxalates is known to interfere in calcium metabolism and cause alkalosis, hypocalcaemia and acute uremia. Methods have been developed to remove harmful substances. Prolonged blanching of bathua foliage for 10 minutes followed by water rinsing removed 80% oxalates and 72% phenolics. Carefully prepared LNC from bathua contained 61% protein, 16% fat, 11% minerals and only 4% oxalates & 0.9% phenolics.

Bathua must be consumed cautiously especially by those having renal problems and tendency to develop kidney stones. Other weeds also need to be investigated for presence of harmful substances and to device suitable techniques for better utilization.

P-195 Weed flora of medicinal and aromatic plants nursery

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The cultivation of medicinal and aromatic crops is increasing due to increased demand of raw drug material. For cultivation of medicinal and aromatic species the large planting material is required. Hence, the large number of plants is to be prepared in the nurseries. The weeds are the problems in the nurseries and needs proper management. Therefore, the knowledge of weed flora of nursery of M& AP is essential for effective control. In view of this the present survey was carried out. The major weeds comprised of dicot weeds *viz., Ageratum conyzoides* L., *Agreratum hastoneum, Alternenthra phloxeroides* (Mart.), Griesb. (L.), *Alternenthra sessilis* (L.) R. Br. Ex DC, *Anagallis arvensis, Argemone mexicana* L., *Asphodelus tenuifolius, Blumea lacera* (Burm. F.) D.C., *Blumea mollis* (D.Don) Merr., *Chrozophora parviflora Klotzsch., Chenopodium album* L., *Cichorium intybus* L., *Convolvulus arvensis* L., *Coronopus didymus* (L.) E. Smith., *Datura stramonium* L., *Euphorbia hirta* L., *Fumaria indica* (Hassk.) Pugsley., *Galinsoga parviflora* Cav., *Lathyrus aphaca* L., *Medicago denticulata* Willd, *Melilous alba* Desr., *Melilotus parviflora* Desf., *Oxalis corniculata* L., *Parthenium hysterophorus* L., *Rumex dentatus* L., *Sonchus arvensis* L., *Solanum nigrum* L., *Spergula arevensis* L., *Spilanthes paniculata* Wall ex. D.C., *Sphaeranthus indicus* L., *Vernonia cinerea* (L.)Less., *Vicia sativa* L., and *Xanthium Strumarium* L. ex. *Schweinf.* Monococot weeds were *Echinochloa crusgalli, Digitarea adscedens* Henr., *Dinebra arabica, Cyperus rotundus* L., *Cyodon dactylon* Pers., *Dichanthium anulatum* Stapf. and *Phalaris minor* Retz. During Kharif the similar monocot weeds were found while the major dicot weeds comprised of *Ageratum conyzoides, Ageratum hastonium, Alternenthra sessilis, Eclipta alba, Amaranthus viridis, Amaranthus spinosus* L., *Parthenium hysterophorus* L., *Phyllanthus amarus, Solanum nigrum* L., *Euphorbia geniculata* Orteg., *Portulaca oleracea* L., *Trianthema portulacastrum, Sida carpinifolia* Mast., *Sida cordata* (Burm F.) Borss. and *Sida Rhombifolia* L. Most of these weeds also have medicinal values.