ABSTRACTS

National Symposium on Integrated Weed Management in the Era of Climate Change

NASC, NEW DELHI

21-22 AUGUST 2010

Indian Society of Weed Science

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CONTENTS

1

WILL HERBICIDE RESISTANT CROPS (HRCs) THREATEN ALTERNATE METHODS OF WEED MANAGEMENT?

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Among the Genetically Modified Crops (GMCs), the Herbicide Resistant Crops (HRCs) take the greatest share. Globally in 2009, the HRCs are cultivated on over 84 mha out of the total area of 134 mha under GMCs. The technology which was introduced commercially in 1996 has found unprecedented acceptance amongst the farmers worldwide. Soybean commands the maximum share followed by corn, canola, cotton sugar beet and alfalfa. Although the protocol is available for many herbicides, crops resistant to herbicides glyphosate, glufoisante, imidazolines and bromoxynil are a commercial success. The unprecedented levels of adoption of HRCs in such a short span of time is mainly due to the ease and convenience of better weed management using the technology which is simple and convenient. With a single application of a non-selective herbicide, the farmers are assured of solution to all the weed problems- a thing which was unheard of before. The technology also claims to be 'green' as it promotes cultivation of crops under minimum or zero tillage thus conserving and enriching the soil and also reducing environmental pollution by less use of fossil fuels. Timely planting of crops, reduced cost of cultivation, and increased productivity of crops are the main reasons for the increased acceptance of the technology by the farmers. On the flip side; however, there is concern over development of resistance to herbicides. Development of "super weeds", loss of biodiversity and more importantly the abandonment of alternate methods of weed control. Integration of preventive, cultural, ecological, mechanical and chemical methods of weed management, popularly referred to as IWM is considered as an ideal and sustainable solution to the ever-growing problem of weeds. Over-reliance on any one method has often led to creation of new problems. It is therefore very important to consider taking enough precautions and effective measures while using the HRC technology now rather than repenting later.

2

REGULATORY MECHANISM FOR PREVENTION AND MANAGEMENT OF INVASIVE ALIEN SPECIES IN INDIA

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India is a signatory member of both Convention on Biological Diversity (CBD) and the World Trade Organization (WTO). Article (8h) of CBD emphasizes on prevention of introduction of invasive alien species (IAS) that threaten other species, habitats or ecosystems, while the Agreement on Application of Sanitary and Phytosanitary Measures of the WTO aims to prevent establishment or spread of exotic pests of plants and animals, many of which have a potential to be invasive when introduced into new geographical areas. Most of the countries have specific quarantine regulations to restrict the movement of commodities known

to carry the risk of associated exotic pests/weeds. Invasive exotic species already established in a country cannot be categorized as quarantine pests unless they are under an official control programme. However, all potential invasive species yet not reported from India are quarantine pests and a thorough pest risk analysis (PRA) needs to be undertaken prior to any import of plants and planting material. Therefore, an analysis for the invasiveness potential should be undertaken prior to introduction of a new plant/ germplasm. The regulation of invasive alien pests/ plants in India is covered under the Plant Quarantine (Regulation of Import into India) Order 2003 which fulfills India's legal obligations under WTO and CBD. It lists 31 quarantine weed species under its Schedule VIII that are prohibited for entry into India. The Ministry of Environment and Forests (MoEF) is the nodal agency to deal with IAS for negotiations with CBD and the Ministry of Agriculture deals with their quarantine, survey and control. The MoEF is still in the process of developing policies and strategies for their management. In view of this, the problem of IAS assumes a larger dimension. There is indeed a dire need for a cohesive policy to deal with IAS at the ground level and this has been further highlighted in the Conference of Parties-8 meeting of CBD during March, 2006 at Curitiba, Brazil and during the Subsidiary Body of Scientific Technical and Technological Advice- 13 and 14 meeting of CBD during February 2008 and May 2010 at Rome, Italy and Nairobi, Kenya, respectively.

3

SEARCHING A NEW HERBICIDE MOLECULE: GREEN SYNTHESIS OF A NOVEL HERBICIDE

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Herbicides as the main weed control tool play an important role in modern agriculture. However, an inevitable problem associated with the use of herbicides is the occurrence of herbicide-resistant weeds. The use of chemical herbicides has increased consumer's concern due to carcinogenic effects, residual toxicity/ environmental pollution and high inputs. High cost further associated with the use of herbicides is a limiting factor in profitability of crops. For more sustainable and ecofreindly integrated weed management strategies, there is a growing trend for searching an alternative to herbicides vulnerable to evolution of resistant weeds. Therefore, it is necessary to develop efficient herbicides with novel structures and modes of action to overcome the resistance of weeds. Chalcone is an aromatic ketone that forms the central core for a variety of important biological compounds. They show antibacterial, antifungal, antitumor, and anti-inflammatory properties. Some chalcone demonstrated the ability to block voltage-dependent potassium channels. The presence of reactive á, â- unsaturated keto group in chalcones is found to be responsible for their biological activity. In the present work chalcones have been prepared by condensing ketone with different aromatic aldehydes in a cost effective way at room temperature. The present study was carried out to investigate the herbicidal activity of chalcones against germination of mustard seed. Analysis of variance showed that there was insignificant difference between all the synthesized chalcones and all the studied parameters were effective against the target monocot weed. There was significant effect on germination of seeds while effect of compounds was also significant for all studied parameters. The compounds *3-(4-Flourophenyl)-1-(4-methoxyphenyl)-propenone* and *1-(4-Chlorophenyl)-3-(4-flourophenyl)-propenone* were found as herbicide which could inhibit the growth of both root and shoot lengths at 50 to 1000 ppm. Several analogues showed maximum growth in root length while there is no significant effect on shoot length. However, all other interactive effects were insignificant for all studied parameters. A chalcone could be identified, which showed herbicidal activity against mustard seeds (dicot) at 50 ppm.

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GLYPHOSATE TOLERANT CROPS: IMPROVING PRODUCTIVITY IN A SUSTAINABLE MANNER

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Glyphosate is a post emergence, non-selective herbicide that kills plants by inhibiting the biosynthesis of aromatic amino acid, specifically by inhibiting EPSPS synthesis, a key enzyme in the shikimate pathways. The developments of glyphosate tolerant crops have been pursued since the early 1980s. Glyphosate resistance crops of soybean, cotton, corn and canola are already developed. For developing glyphosate resistant crops a gene from soil bacterium (*Agrobacterium,* strain CP4) encoding a glyphosate-resistant EPSPS synthase introduce into plants by ballistic technique. The glyphosate resistance rice has been developed by *Agrobacterium*-mediated multiple gene transformation; these transgenic rice will have great potential in term of environmental potential due to effective weed control. Glyphosate tolerant crops are positive impact on offering the farmer with a new wide spectrum weed control option, providing cost effective and environmental friendly weed management. In addition these crops have agronomic practices in term of offering compatibility with minimum or no till conservation system which helps in increasing soil moisture, while reducing soil erosion.

5

CATALYTIC SYNTHESIS OF NANOFIBERS FROM THE AQUATIC WEED *Nymphoides Cristatum* BY USING TEMPO MEDIATED OXIDATION METHOD

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The nanofibers synthesized from the natural aquatic weed *Nymphoides cristatum* using TEMPO mediated catalytic process. The obtained individual fiber diameter ranges from 5- 100 nm and length in several microns. The chemical treatment involves oxidation of fiber and mechanical treatments, includes sonication and disintegration. In the chemical treatment, weed fibers were oxidized with 2, 2, 6, 6 - tetramethylpiperidinyl 1-oxyl radical (TEMPO), sodium hypochlorite and sodium bromide, at pH 10. The impurities like hemicelluloses, lignin and pectin were removed by oxidation, followed by mechanical treatments to separate the optically transparent nanofiber. The TEMPO oxidized nanofiber was characterized by Fourier Transform Infrared Spectrophotometer (FTIR), Optical Microscope, Scanning Electron Microscopy (SEM) and Transmission Electron Microscope (TEM). The prepared fiber showed excellent physicochemical properties including adsorption capacity to metals and metal ions. The fibers can also be useful for the bio remediation of contaminated soils apart from soil nutrient enrichment.

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ALLEVIATING ATRAZINE HERBICIDE RESIDUE USING IRON BASED NANOPARTICLES

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Atrazine is one of the most widely used herbicide for the control of grassy and broadleaved weeds in maize, sorghum, sugarcane, timber plantations, etc. It has highly persistence (half life-125 days) and mobility in some types of soil, because it is not easily absorbed by soil particles and often causes contamination in soil and groundwater. In order to degrade the atrazine residues, we have attempted to use silver modified iron oxide ($Ag@Fe_3O_4$) nanoparticles using carboxy methyl cellulose as the stabilizing agent. The Fe_3O_4 and $Ag@Fe_3O_4$ nanoparticles have been synthesized and characterized by various instrumental methods like XRD, UV, FTIR, TEM, EDAX, AFM and particle size analyzer. Characterization studies ascertained the formation of nanoscale particles and the magnetic behaviour was studied by vibrating sample magnetometry. The rate of degradation of atrazine was measured by HPLC and the reaction products were identified by GC/MS. Increased concentration of nanoparticles gave maximum degradation of the herbicide i.e. after twelve hours 82% and 88% degradation of atrazine was recorded on application of 0.5g/L and 2g/L of $Ag-Fe_3O_4$ nanoparticles. Silver plays the major role in the reductive dechlorination of atrazine to various intermediates. The major purpose of using Fe_3O_4 is, it acts as support as well as metal carrier, and hence this method can be used for the complete degradation of atrazine and its metabolites from soil samples.

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RICE RESIDUE MANAGEMENT AND PLANTING TECHNIQUES ON HERBICIDAL EFFICIENCY IN RELATION TO WHEAT (*Triticum aestivum* L.) PRODUCTIVITY

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A field experiment was conducted at PAU, Ludhiana, during *rabi* 2004-05 and 2005-06. The studies revealed that surface application of rice residue 6 and 7 t/ha significantly reduced the growth and development of *Phalaris minor* as compared to incorporation and no rice residue treatments. Application of rice residue @ 7 t/ha also reduced the emergence of wheat seedlings. Growth parameters, yield attributes and grain yield of wheat were statistically at par with rice residue management techniques. Soil physio-chemical properties were slightly improved with surface application as well as incorporation of rice residues. Application clodinofop 60 g/ha, sulfosulfuron 25 g/ha and mesosulfuron + iodosulfuron 12 g/ha +2.4 g/ha significantly reduced the density of *P. minor* as compared to control and resulted significantly higher grain yield of wheat. Residues of herbicides were not detected in soil, grain and straw by the use of HPLC. Growth and development of *P. minor* as well as broad leaf weeds were significantly reduced with zero till sowing in standing stubbles, partial burning and bed planting than conventional tillage and zero tillage treatments. Growth parameters, yield attributes and grain yield of wheat with zero till sowing in standing stubbles and partial burning being statistically at par with bed planting were significantly higher than conventional tillage and zero tillage treatments. Conventional tillage and bed planting techniques slightly improved the physical properties of soil, whereas, chemical; properties of soil were slightly improved with zero till sowing in standing stubbles, partial burning and zero tillage techniques. Application of clodinofop 60 g/ha, sulfosulfuron 25 g/ha and mesosulfuron+ iodosulfuron 12 +2.4 g/ha significantly reduced the growth of *P. minor* and hence significantly increased grain yield of wheat than control. During the second year clodinofop 60 g/ha failed to control *P. minor* effectively as a result of which crop yield was reduced. Residues of herbicides were not detected in soil, grain and straw by the use of HPLC. Survey of weed flora in the districts of Patiala, Sangrur and Moga indicated that population and dry weight of *P. minor* were slightly higher under conventional tillage as compared to zero tillage, whereas, population and dry weight of broad leaf weeds were significantly higher under zero tillage as compared to conventional tillage technology.

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DIRECT SEEDED RICE: PROBLEMS, PROSPECTS AND THE WAY FORWARD

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Puddling is not always necessary for achieving higher grain yield in rice. Direct seeding, particularly in *basmati* rice can produce yields similar to manually transplanted rice provided effective weed management is achieved, niche areas are identified, appropriate sowing machinery is available and optimum irrigation scheduling is identified. Generally, direct seeded rice (DSR) is cost effective, more water-efficient and less labour-intensive. Manual transplanting in puddled fields is the single most traditional practice of growing rice in Punjab and Haryana. Puddling reduces water losses through percolation besides being very effective in controlling weeds. However, this has resulted in reduced soil fertility and increased soil compaction, involves higher labour costs, and plant population in this system, generally, remains lower than optimal. DSR can offer an alternative to transplanting that can reduce both delay and costs of rice establishment. Efficient use of water, higher tolerance of water deficit, less cracking, earlier crop maturity (7-15 days) and often higher profits are some of the advantages of direct seeding. To achieve optimum seed rate, drills with inclined plate devices or a cupped seed metering system with press wheels attached behind the tynes are required. Field uniformity with laser leveler is pre-requisite for success of DSR and therefore, it must be encouraged to make direct seeding a common practice in the near future. Sowing of primed and treated seed with seed cum fertilizer drill (as mentioned above) under unpuddle conditions at optimum soil moisture (similar to wheat) followed by planking or preferably using drills attached with press wheel may result into better germination, less weed infestation and huge water savings as it can be possible to withheld irrigation for initial 10-15 days after sowing. Different agronomic practices for DSR have been refined during the last five years and it was realized that sowing time between 10th to 15th June, a seed rate of 20 kg/ha and a depth of 2-3 cm for dry sowing *fb* irrigation and 3-5 cm for sowing under optimal moisture conditions were optimum for uniform germination and crop growth. Weed pressure generally remains more in DSR than transplanted rice. Aerobic grassy weeds like *Leptochloa chinensis* and *Eragrostis tenella* were more in direct seeded than puddled transplanted rice. Yield losses due to heavy weed infestation under DSR could be as high as 100%. To manage comparatively more serious problem of a wide variety of weeds in DSR, a battery of suitable herbicidal combinations will be required as a single herbicide can not be effective against such a complex weed flora. Pre-emergence application of pendimethalin 750-1000 g/ha *fb* sequential application of bispyribac-Na 25 g/ha at 15-25 days after sowing coupled with need based sequential application of any broadleaf herbicide (in case of more BLW) or tank mixed application of azimsulfuron(15-20 g/ha) or pyrazosulfuron 25 g/ha (in case of more sedges) may provide effective control of most of the weeds; however, it still needs further research under different locations. Mechanical or manual weeding may also be integrated with herbicides as it will be more convenient in line sown crop. Incidence of insect-pest and diseases are also expected to be considerably lower in DSR due to better passage of air through the crop canopy. The area under DSR or mechanized transplanting under unpuddle situations will increase in Haryana to offset increasing costs and scarcity of farm labour provided the technologies are further fine tuned and perfected.

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LONG-TERM EFFECT OF GREEN MANURING AND HERBICIDAL USE ON WEED DYNAMICS AND PRODUCTIVITY OF RICE-WHEAT CROPPING SYSTEM

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A permanent field experiment was initiated at CCS Haryana Agricultural University, Regional Research Station, Karnal, India in *kharif* 1999 for monitoring the effect of green manuring and herbicidal use in rice-wheat system on long-term basis. The experiment is now running in 12th year. The treatments included continuous (butachlor in rice and clodinafop in wheat) or rotational use of herbicides (butachlor, pretilachlor or anilofos in rice; clodinafop, fenoxaprop or sulfosulfuron in wheat in sequence over the years) along with weed free and weedy checks under green manured and non-green manured situations. Green manuring was done after wheat harvest and before rice transplanting. The observations during 2008-09 and 2009-10 indicate that clodinafop in wheat and butachlor in rice have provided effective control of weeds even after 11 years of continuous use. Rotational herbicides also performed well except some reduced efficacy of fenoxaprop in wheat. Infestation of grassy weeds, broadleaf weeds and sedges in rice decreased due to green manuring. The effects were more pronounced in case of grassy weeds particularly *Echinochloa crus-galli*. Infestation of *Phalaris minor* in wheat was comparatively more under green manuring than non-green manured plots; while broadleaf weeds were more in non-green manured plots. Grain yields of rice under green manuring were significantly higher than non-green manuring. The grain yields of wheat were also slightly higher under green manured plots; however, the differences were not always significant.

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EFFECT OF TILLAGE AND WEED CONTROL METHODS ON YIELD OF WHEAT IN DIRECT SEEDED RICE-WHEAT CROPPING SYSTEM

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A field experiment was conducted during rabi 2007-08 at NRC-Weed Science, Jabalpur (M.P.) to assess the effect of tillage and weed control methods on yield of wheat and weed dynamics in direct seeded rice- wheat cropping system. Weeds are the major problem in irrigated wheat. Many research workers have reported the predominance of *Phalaris minor, Avena ludoviciana* among the monocots and *Chenopodium album, Melilotus indica* among the dicot weeds in wheat. Weed problem in wheat could be managed effectively and economically by combining various control measures. However, cost of weed control in wheat could partially or completely be compensated by saving in the cost of tillage operations with zero till sowing of wheat. It is evident from the data that crop growth, yield attributes and yields were not influenced by any of the tillage packages adopted in wheat. But chemical weed control or IWM (clodinafop fb 2, 4-D

along with 1 HW) after all the tillage packages increased the growth parameters, yield attributes, grain and straw yields of wheat compared to weedy check plots. Weed control efficiency was higher under conventional tilled wheat after conventional tillage in rice (88.54%) and conventional tilled wheat after zero tillage in rice (88.43%) against zero tilled wheat after conventional tillage in rice and zero tilled wheat after zero tillage in rice (85.35% and 69.04%). IWM practice (clodinafop 0.06 fb 2,4-D 0.5 kg/ha + 1HW at 40 DAS) gave higher weed control efficiency (89.64%) than chemical control (76.03%) and also produced significantly higher grain yield of wheat than chemical control practice (clodinafop 0.06 fb 2,4-D 0.5 kg/ha).

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EFFECT OF TILLAGE AND SOURCES OF NITROGEN ON WEED DYNAMICS IN MAIZE-WHEAT CROPPING SYSTEM UNDER RAINFED CONDITIONS

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To study the effect of tillage and sources of nitrogen on yield and weed dynamics in the maize-wheat cropping system under rainfed conditions, an experiment was conducted at Regional Research Station for *Kandi* Area (Punjab Agricultural University), Ballowal Saunkhri (SBS Nagar), Punjab (India) during 2008-10. The experiment was laid out in split plot design with 3 replications with treatments: 3 tillage practices i.e. conventional tillage (CT), reduced tillage (50% of CT) and reduced tillage + chemical weed control in main plots and three sources of nitrogen i.e. 100% N through organic source, 50% N through organic + 50% N through inorganic and 100% N through inorganic source in sub-plots. Reduced tillage resulted into higher density and dry weight of weeds as compared to CT in maize (*Kharif*) while in wheat (*Rabi*) reduced tillage recorded low density and dry weight of weeds as compared to CT. However, when reduced tillage was integrated with chemical weed control, it drastically reduced the density and dry weight of weeds in both the crops. Weed infestation in *Kharif* season was comparatively higher due to higher rainfall during *Kharif* (490 mm) than *Rabi* season (40 mm). Among sources of nitrogen the weed infestation increased with increase in amount of organic source with lowest being in treatment where nitrogen was applied purely through inorganic source but the differences were statistically non-significant in both the seasons. The present study revealed that combination of reduced tillage + chemical weed control and 100% N though inorganic source resulted into lowest weed infestation and highest grain yield and BC ratio. On an average, the combination recorded lowest weed density, highest grain yield and BC ratio of 75.4/m^2, 2556 kg/ha and 2.05, respectively in maize and 42.3/m^2, 1705 kg/ha and 1.96, respectively in wheat.

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FARMING SYSTEM DESIGNS FOR SUSTAINABLE WEED MANAGEMENT

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The concept of IFM is more feasible for small-farm holdings and it serves as a tool for linking environmental safety with weed control besides offering scope for conservation of agro-biodiversity. The component elements of fish culture and poultry rearing in transplanted rice have been shown to compliment weed control by 30% besides imparting sustainability in terms of improved soil health and economic returns, at the Department of Agronomy, Annamalai University, India. The technology has been upscaled for adoption by farmers through on-farm demonstrations in 400 holdings of development partners spread over four districts of Tamilnadu. Under rain-fed upland conditions, integrating goat rearing, especially for grazing during the off-season complimented weed control by 45.17% and addition of goat manure to fields grazed upon by goats contributed for 31.34% weed control during the cropping season. Participatory research revealed that goat rearing reduced weed bio-mass by 23 to 29 %, in 500 farm holdings of fifteen villages. Technology for integrating a medicinal herb *Coleus amboinicus* with insect agents *Neochetina eichhorniae/bruchi* for the bio-control of water hyacinth has also been evolved and demonstrated in aquatic systems. Naturally regenerated stands of *Prosopis juliflora* in social sites are shown to be better managed by slashing and digging out roots followed by rehabilitative cropping with sunflower + cow pea.

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EFFECT OF PLANTING PATTERN AND STRAW MANAGEMENT ON HERBICIDE PERSISTENCE, PRODUCTIVITY AND QUALITY OF WHEAT (*Triticum aestivum* L.) AND ONION (*Allium cepa* L.)

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Two field experiments were conducted at the experimental farm of PAU, Ludhiana during rabi seasons of 2006-07 and 2007-08. The studies pertaining to the first experiment reveal that growth and development of *P. minor* were slightly reduced under Happy Seeder sown crop and zero till sowing in standing stubbles than bed sowing, zero tillage after burning and conventional tillage after partial burning. Growth parameters, yield attributes and grain yield of wheat were not significantly influenced by different planting patterns. Conventional tillage and bed sowing treatments slightly improved the physical properties of soil. Application of sulfosulfuron 25 g/ha, mesosulfuron + iodosulfuron 12 g/ha and pinoxadin 50 g/ha significantly reduced the growth and development of *P. minor* and hence significantly increased grain yield of wheat than unweeded (control). Hectolitre weight and sedimentation value were significantly higher in herbicidal treatments than control. Residues of sulfosulfuron 25 g/ha, mesosulfuron + iodosulfuron 12 g/ha and pinoxadin 50 g/ha were detected at 1 day after spray in soil at depth 0-15 cm but residues of herbicides were not detected in soil at other observational

periods and in grain and straw at harvest. The highest microbial population was observed under zero till sowing with Happy Seeder followed by zero till sowing in standing stubbles among planting patterns and in unsprayed plots among weed control treatments at all observational period. There was decrease in viable microbial counts at 15 days after spray and further the microbial population started to regain. Bioassay studies indicated no residual toxicity of pinoxadin on any test crop. However, application of sulfosulfuron and mesosulfuron + iodosulfuron showed toxicity on maize, bajra, sorghum and bottle gourd. In the second experiment the bulb yield of onion crop was not significantly influenced with planting patterns and rice straw incorporation levels. However, onion transplanted after rice straw incorporation yielded higher in flat sowing followed by bed sowing techniques. During both the years, application of oxyflourfen 225 g/ha recorded the maximum bulb diameter (60, 90 DAT and at uprooting time) which was statistically at par with pendimethalin 0.75 kg/ha and two hand weeding and these treatments were found to be significantly better than fluchloralin 1.125 kg/ha and unweeded control. Application of oxyflourfen 225 g/ha gave the highest bulb yield which was statistically at par with pendimethalin 0.75 kg/ha and two hand weeding. These treatments proved significantly better than fluchloralin 1.125 kg/ha and unweeded control. Also, bulb yield produced by fluchloralin 1.125 kg/ha was significantly better than unweeded control treatments. Soil samples of oxyflourfen 225 g/ha, pendimethalin 0.75 kg/ha and fluchloralin 1.125 kg/ha treated plots taken 1 day after spray showed residues of respective herbicides. Samples of onion bulbs at 30, 60, 90 days after spray and at uprooting stage showed no residues of applied herbicides. The highest microbial population was observed under flat and bed sowing after rice straw incorporation treatments and unsprayed plots among weed control treatments at all observational period. There was decrease in viable microbial counts at 15 days after spray as compared to that at 0 day after spray and further the microbial population stared to regain.

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EFFECT OF SEED RATE AND WEED MANAGEMENT ON WEED GROWTH AND YIELD IN LATE SOWN ZERO TILL WHEAT (*Triticum aestivum* L.)

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A field experiment was conducted during the winter seasons of 2007-08 and 2008-09 in sandy clay soils of Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University Varanasi to study the effect of seed rate and weed management on weed growth and yield in late sown zero till wheat. Treatments comprised of three seed rates viz. 100, 120 and 140 kg/ha in the main plot and five weed management treatments viz. 2,4-D Na salt 625 g/ha (POE), metsulfuron methyl 4 g/ha (POE), sulfosulfuron 30 g/ha + metsulfuron methyl 2 g/ha (POE), weed free and weedy in sub plot with three replications. The dominant weed flora infesting the experimental field were *Chenopodium album*, *Melilotus alba*, *Melilotus indica*, *Anagallis arvensis* and *Phalaris minor*. Broad leaved weed population was found more in the experimental crop as compared to narrow leaved weeds. Seed rate of 120 kg/ha recorded significantly higher grain yield in comparison to seed rate of 100 and 140 kg/ha. Amongst weed management treatment all the herbicidal treatments had statistically comparable grain yield to two hands weeding and statistically superior to weedy check. However, sowing of wheat with seed rate of 120 kg/ha and post emergence application of 2,4-D Na salt 625 g/ha was found to be more remunerative in late sown zero till wheat under the agro climatic condition of eastern Uttar Pradesh.

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WEED CONTROL THROUGH THE COMBINATION OF SURFACE RESIDUE AND BROWN MANURING IN ZERO TILLED RICE UNDER RICE-MAIZE CROPPING SYSTEM

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Recognizing the serious problems generated through the practice of conventional agriculture, efforts have sought alternate practices/technologies and approaches to the emerging challenges of sustaining productivity and environment. Among the various package of practices and technological alternatives, conservation agriculture clearly emerged a strategy which has the potential to contribute significantly in achieving goals of sustainable agriculture. The three basic guiding principles of conservation agriculture include, causing minimum soil disturbance through tillage practice, residue management and crop diversification. The second principle that includes residue management have shown positive influence on productivity as surface residue act as a mulch in conserving soil moisture and interfer emergence, growth and development of weed. Brown manuring have been largely adopted as resource conservation technique for controlling weed in zero tilled direct seeded rice. With the objective of adopting principles of conservation agriculture in rice-maize cropping system the experiments was conducted since 2008 at the research farm of Uttar Banga Krishi Viswavidyalaya to fine tune the practices of crop establishment in the both anchored and surface residue with a suitable machine in small fragmented land areas. Punch planter with different inclined plates was found effective to establish *kharif* rice within surface maize residue. Combination of surface maize residue and brown manuring (87%) was found superior over brown manuring alone (75%) in terms of weed control efficiency. In addition to this conservation of moisture by the surface maize residue especially during rain free period was reflected on the rice yield. However, rice plants in the maize surface residue plots attained LCC 3 (Leaf Colour Chart) earlier than other plots especially during 1st top dressing. The conversion of conventional agriculture to conservation agriculture is also triggering shifting of weed flora.

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EVALUATION OF CHICKPEA VARIETIES UNDER DIFFERENT PLANTING TECHNIQUES AFTER RICE

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A field experiment conducted during Rabi, 2007 at Research farm, PAU, Ludhiana to evaluate chickpea varieties under different planting techniques after rice consisting 24 treatment combinations including six planting techniques (zero tillage after removal of stubbles, reduced tillage, bed planting, zero tillage with happy seeder, zero tillage with Pantnagar till drill and conventional tillage + straw incorporation) and four varieties of chickpea (PBG 5, GPF 2, BG 1053 and L 550) was evaluated in split plot design with three replications. Soil of the experimental field was sandy loam which was normal in electrical conductivity and pH, medium in organic carbon, available nitrogen, phosphorus and potassium. The results revealed that all

the planting techniques were at par in yield and yield attributes of chickpea. Lower bulk density, higher infiltration rate and root mass density at 0-15 cm soil depth were recorded in conventional tillage. Root mass density confined up to 0-30 cm under zero tillage, whereas in other planting techniques it was up to 0-60 cm. In ' PBG 5', ' GPF 2' and 'L 550' it confined up to 0-60 cm, whereas in ' BG 1053' up to 0-30 cm depth. Higher saving of cost, energy and time were observed under zero tillage with and without paddy straw and reduced tillage over bed planting and conventional tillage. Variety 'PBG 5' and 'BG 1053' recorded yield and yield attributes higher than other varieties.

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WEED MANAGEMENT IN CONSERVATION AGRICULTURE BASED CEREALS IN EASTERN INDO-GANGETIC PLAINS OF RICE-WHEAT CROPPING SYSTEM

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Conservation Agriculture (CA) in cereal based cropping systems is continuing its successful development in Zero-tillage (ZT) and Direct Seeded Rice (DSR). We are continuing focus on introducing an integrated weed management strategy by targeting the management of site specific weeds. In Eastern UP, the problem of nut sedge (*Cyperus rotundus*.L) is the most serious. Other weeds including annual grasses and broad leaf are site specific. Similarly, *Physalis minima* is the most common weed of wheat. Other weeds are site specific but the proportion of *Phalaris minor* is more and increasing. This weed is a problem in both seasons. In fact, *P. minima* is a problematic weed of wheat, rice and maize. Work done during the last one year has shown that mixture of carfentrazone and clodinafop or mesosulfuron+ idosulfuron is effective when *Physalis* and *Phalaris*. Clodinafop or sulfosulfuron or mesosulfuron+idosulfuron are effective when *Phalaris* is occurring alone. Wherever *Physalis* is not a problem in otherwise a mixed flora, sulfosufuron or mesosulfuron+ idosulfuron are effective. The problem of perennial weeds is because of poor competition from existing lower yielding cereals, less use of inputs like nitrogen, rotation of sugarcane and relatively wet monsoon season. CA itself can help controlling these weeds because it targets early sowings due to zero/minimum tillage which allows better crop canopy and therefore less competition by such weeds. Use of pre-seeding herbicides like glyphosate prevents re-growth and with excellent canopy cover by crops they are not able to produce enough food material to support high population in the next season. While glyphosate have long been established for the control of such weeds but we need post emergence herbicides in cropped situation. Such herbicides are now available. This will make DSR as a viable option in the long run. Herbicides like pyrazosulfuron applied alone at 25 or 30g/ha or halosufuron applied 30-35 DAS at 60g/ha or bispyribac applied 20-30 DAS at 30g/ha can control nut sedge. None of these herbicides will control the complex weed flora dominated by nut sedge. Tank mixture of 20g pyrazosulfuron + 20g /ha bispyribac or halosulfuron is very effective against nutsege dominated complex weed flora of DSR. Some weeds like *Leptochloa chinensis* and *Eragrostis tenuifolia* are not controlled by bispyribac. For these weeds azimsulfuron or cyhalofop-butyl will have to be tank mixed with bispyribac. Oxadiargyl at 90 g/ha applied as tank mixture with bispyibac provided season long weed control of annual grasses which emerge after the treatment of bispyribac. Similarly in wheat *P. minima* is not controlled by the commonly used herbicides like 2,4-D or sulfosulfuron. Carfentrazone is the only herbicide that controls *P. minima* in wheat. This weed also appears in very high proportion in rice. Halosulfuron can control this weed along with the nutsedge when applied 25-30 DAS and can also be used in maize at 60 g/ha for effective control of nutsedge and *Physalis*,

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EFFECT OF CROPPING SYSTEMS ON WEED POPULATION

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Dynamics of weed populations in agriculture fields are influenced by environmental, soil characteristics, cropping systems and management practices. Manipulation of cropping systems to improve weed management requires a better understanding of the spatial and temporal dynamics of weeds, seed losses and seed production. To assess the effect of different cropping systems and various crop rotations on the weed population a field study was conducted at the Research farm, Department of Agronomy from 2000-01 to 2008-9 on loamy sand soil (Typic ustochrept), having pH 7.2, EC 0.40 dS/m, organic carbon 0.53 % and with available N 186 kg/ha, P 44 kg/ha and K 132 kg/ha. Ten cropping systems viz., rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.); maize (*Zea mays* L.)-wheat; maize-wheat-summer moongbean (*Vigna radiata* L.); maize-potato (*Solanum tuberosum* L.)-summer moongbean; maize-potato-onion (*Allium cepa* L.); Cotton (*Gossypium hirsutum*)-wheat; Cotton-African sarson (*Brassica carinata*); Cotton-*Gobhi sarson* transplanted (*Brassica napus* sub sp oleifera var annua); Summer groundnut (*Arachis hypogaea* L.)-Toria (*Brassica compestris* var toria) + *gobhi sarson*; Summer groundnut-potato-pearlmillet (*Pennisetum glaucum* L.) were evaluated in randomized block design. The crops were raised under recommended package of practices. The data recorded after ten cropping cycles (*rabi* 2008-09) is presented. The results showed that in rice-wheat system the grassy weeds population was 74 weeds/m^2, whereas the grassy weeds values drastically came down in other cropping systems varying from 10 to 22 weeds/m^2 in maize based cropping systems; 12-19 in cotton based cropping systems; 10-11 in groundnut based cropping systems. The *Phalaris minor* infestation was reduced discernibly from 36 in rice –wheat cropping system to 4-12 in other cropping systems. Likewise, change in broadleaf weeds was also noticed. Summer groundnut- toria+ *gobhi sarson* recorded lowest broadleaf weed population (10). The broadleaf weeds in rice-wheat system were also maximum (25). The results further revealed that *Phalaris minor* population is increasing in rice-wheat system whereas in all other cropping systems it has reduced. It may be attributed due to the change in the physical conditions of the soils on account of puddling. Different rotations that include crops with different life cycles such as maize, oilseeds, mungbean and fodder could lead to additional benefits of reducing the weed seed bank.

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GRAIN YIELDS OF WHEAT AS AFFECTED BY DIFFERENT TILLAGE PRACTICES, VARIETIES AND WEED CONTROL METHODS

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A field experiment was carried out at Research Farm of the Department of Agronomy, CCS Haryana Agricultural University, Hisar. during *rabi* seasons of 2008-09 and 2009-10. The experiment including three tillage practices (Zero tillage (ZT), conventional tillage (CT) and furrow irrigated raised bed system (FIRBS)) as main plot, three wheat varieties (WH 711, WH 1022 and PBW 343) as sub-plot and three weed control treatments (clodinafop *fb* metsulfuron @60 & 4 g/ha, weedy check and weed free treatments) as sub-sub plot, was laid out in a split-split-plot design with four replications. Recommended dose of N (150 kg/ha) through urea, P (60 kg/ha) through DAP and Zn (25 kg/ha) through $ZnSO_4$ as per package of practices for wheat were added in the experimental field. Clean seed of wheat variety WH- 711, WH- 1022 and PBW-343 were sown in experimental field with the help of seed drill at the rate of 100 kg seed/ha. Sowing under ZT and CT was accomplished with 11-tyne zero-till seed-cum-fertilizer drill while it was done with bed planter under FIRBS. All other agronomic practices were adopted as per recommendation of package of practices. Herbicides were sprayed as per treatments i.e. clodinafop at 60 g/ha 30 days after sowing (DAS) *fb* metsulfuron at 4 g/ha one week after clodinafop with the help of knapsack sprayer fitted with flat fan nozzles using 625 liters of water/ha. The data revealed that among tillage practices, higher grain wheat yield was recorded under furrow irrigated raised bed system (FIRBS) during both the years. The grain yield recorded under FIRBS out yielded the grain yield under CT and ZT by 40 and 316 kg/ ha, respectively. The grain yield was significantly affected by different wheat variety treatments. Highest grain yield was recorded under variety PBW 343 over WH 711 and WH 1022 during both the years. Application of clodinafop *fb* metsulfuron 60 & 4 g/ha resulted in higher grain yield as compared to the grain yield obtained under weedy check. The average grain yield recorded under clodinafop *fb* metsulfuron 60 & 4 g/ha during the both years was 4802 kg/ha, while the average grain yield under weedy check was 4235 kg/ha.

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CULTURAL AND CHEMICAL CONTROL OF *TRIANTHEMA PORTULACASTRUM* IN BERSEEM FODDER

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An experiment was conducted at Forage Research Farm, Punjab Agricultural University, Ludhiana during *rabi* 2008-09 and 2009-10 to study the efficacy of herbicides and cultural practices for the control of *Trianthema portulacastrum*. The experiment comprising of 10 treatments (pendimethalin 0.375 kg, oxyfluorfen 0.118 and 0.236 kg, butachlor 1.0 kg, trifluralin 0.48 kg, imazethapyr 0.050 kg/ha as pre-emergence, berseem + chinese cabbage, berseem + raya, berseem + ryegrass and weedy check) was conducted in

Randomised Block Design with three replications. The crop was sown in first week of October keeping plot size of 5 x 4 m during both the years. All other cultural recommended practices were applied uniformly for raising a good crop. The density of *T. portulacastrum* decreased significantly with all the herbicides and cultural practices over weedy check. Among the herbicides, butachlor 1.0 kg/ha and pendimethalin 0.375 kg/ha effectively controlled the *T. portulacastrum* and the weed control efficiency was 83.5 and 81.6 %, respectively. The other herbicides *viz.* trifluralin 0.48 kg/ha and imazethapyr 0.050 kg/ha produced fodder yield at par with unweeded check, whereas oxyfluorfen at both the doses though controlled *T. portulacastrum* but proved toxic to the crop.. The mixture of berseem + chinese cabbage or raya controlled the *T. portulacastrum* over weedy check due to the faster growth of raya and chinese cabbage resulting in smothering of this weed. However, the mixture of berseem + ryegrass was less effective in controlling the *T. portulacastrum* due to the slow growth of both the crops. The weed control efficiency was 44.8, 54.0 and 36.6 % with berseem + chinese cabbage, berseem + raya and berseem + ryegrass, respectively. The highest green fodder yield (1049.9 q/ha) and dry matter yield (158.4 q/ha) was obtained with butachlor 1.0 kg/ha closely followed by berseem + ryegrass, pendimethalin 0.375 kg/ha, berseem + chinese cabbage and berseem + raya. The herbicide application increased the uptake of nitrogen by the crop as compared to weedy check and berseem mixtures. The crude protein content of berseem fodder improved in all the herbicidal treatments ranging between 18.0 to 18.8 % as compared to 17.2 % in weedy check and 16.2 to 16.8 % in berseem mixtures.

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IMPACT OF CONSERVATION AGRICULTURE BASED RESOURCE CONSERVATION TECHNOLOGIES ON PRODUCTIVITY AND PROFITABILITY OF WHEAT IN EASTERN UTTAR PRADESH

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The greatest challenge of 21st century is to meet the rising food demand while maintaining sustainability of resource base. There has been tremendous emphasis on RCTs in India during the recent times. The future sustainability of farming will rest on adoption of RCTs developing, promoting and refining conservation agriculture (CA) based resource conservation technologies (RCTs) that require strong farmers' participation in finding answers to conservation agriculture. Hence, considering the importance, the efforts have been made to promote and refine the RCTs in wheat in farmers' participatory mode in eastern U.P. Altogether 258 co farmers' participatory on-farm trials on CA based RCTs were conducted during dry seasons of 2009-10 in Ballia ,Ghazipur and Chandauli district of Eastern UP in collaboration with BHU and CIMMYT with the objective to develop and refine CTs options i.e zero till (168), reduced till ZT drill seeded (42), double ZT (40), double ZT traffic control (4), happy seeder ZT (2), bed planting (2) in wheat for enhancing productivity and profitability by optimizing the use of resources and inputs. The grain yield of wheat in various CA based crop establishment techniques ranged from 2.6 to 5.00 t/ha. In Ballia village cluster, highest mean yield (4.40 t/ha) and net return (27,910 Rs/ha) was obtained from bed planting followed by ZT (3.87 t/ha), reduced till-ZT (3.82 t/ha), double ZT traffic control (3.76 t/ha),) and double ZT (3.76 t/ha). However, highest pooled B-C ratio was associated with double ZT traffic control (2.22) followed by double ZT (1.90), bed planting (1.68), ZT (1.48) and reduced till ZT drill seeded wheat (1.36).. The pooled gain in yield over farmer's

practice was 0.90 t/ha, 0.59 t/ha, 0.55 t/ha, 0.45 t/ha and 0.40 t/ha with bed planting, reduced till-ZT drill seeded, zero tillage double ZT, and double ZT traffic control, respectively. In Ghazipur village cluster, highest mean yield (3.23t/ha) and net return (40392 Rs/ha) of wheat was obtained from ZT followed by the bed planting (3.00 t/ha) and reduced tillage -ZT (2.93 t/ha). The highest pooled B-C ratio was associated with ZT (1.42) followed by bed planting (1.08) and reduced till-ZT (1.07). The pooled gain in yield over farmer's practice was, 0.67, 0.40 and 0.40 t/ha, with ZT, reduced till- ZT and bed planting, respectively. In Chandauli village cluster, highest mean yield (2.35 t/ha) and net return (23500 Rs/ha) was obtained from ZT with happy seeder followed by the ZT (2.30 t/ha) and net return (23091 Rs/ha). The highest pooled B-C ratio was associated with happy seeder ZT (1.34) followed by ZT (1.32). The pooled gain in yield over farmer's practice was 0.55 and 0.50 t/ha, with happy seeder ZT and ZT, respectively. The lowest yield and net return was recorded from conventionally tilled field. Conservation agriculture based resource conservation technologies minimize the use of external costly inputs (labour, seeds, fertilizer, pesticides and fuel uses), reduce cost of production, leading to increased wheat productivity and profitability at the farm front.

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ROLE OF RESOURCE CONSERVATION TECHNOLOGY IN WEED MANAGEMENT IN WHEAT

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There is no dearth of research findings managing weeds problem in wheat through resource conservation technologies like zero tillage and bed planting. The reports registered about 30% less germination of weeds particularly *P. minor* in wheat sown under no tillage conditions in rice-wheat cropping system. The success of zero tillage technology in wheat remained restricted to planting wheat following manual harvested rice crop. But in case of combine harvested rice (mostly in dwarf varieties) the left over residues create hindrances in sowing operations under no-tillage conditions. Under such situations no options are left other than removing the straw or burn in, which is banned due to adverse environmental effects. The farmers used to burn the combine harvested rice residues (disintegrated straw) followed by sowing of wheat with zero tillage machine. Farmers' participatory research was undertaken at village Baronda (Kurukshetra) using turbo-seeder (also called happy seeder) the new machine for wheat sowing in the fields having *in-situ* loose straw as a result of combine harvested rice. Though seed germination occurred similar to zero tillage sowing but the emergence above the straw could be seen 2-3 days later than the control. The loose straw lying in the field proved beneficial in two ways i.e. it acted as mulch conserving moisture and impeded sunlight restricting the germination of weed seeds lying in the undisturbed soil in between the wheat rows. There was more than 50% less germination of weed seeds beneath the rice mulch and the growth of emerged weeds was very slow which could not compete with wheat crop. Though there was suppression of weeds but certain agronomical practices like application of fertilizers on straw are yet to be standardized and need further research.

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INFESTATION AND MANAGEMENT OF OROBANCHE IN BHIWANI DISTRICT OF HARYANA

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Orobanche aegyptiaca L., locally called as 'margoza, 'rukhri' or 'ak-ka-mama' is becoming serious parasitic weed of mustard in south-west Haryana and Bhiwani district in particular, reducing crop yield significantly. It has caused enormous losses in the dry belt of the district where mustard used to be a remunerative crop. Many farmers abandoned growing mustard due to heavy infestation of Orobanche. Survey of the affected fields revealed that infestation was greater under light soils where no canal irrigation was applied. Seed treatment with various oils at the time of sowing was not found effective. Similarly, application of trifluralin or pendimethalin applied as pre-plant-incorporation or pre-emergence was not able to lower the infestation of *Orobanche*. Application of various fertilizers, micro-nutrients, cakes (mustard, neem or castor) had no desirable effect in mitigating the harmful effects of *Orobanche*. There is limited choice with farmers for crop rotation using chickpea, castor or barley to substitute mustard for low investment and remunerative crop. Similarly, selection of different varieties of mustard was also of little use in avoiding *Orobanche* parasitism. Variations in sowing time also had inconsistent results as there were discrepancies in *Orobanche* emergence under different years. Under the present situation farmers are advised to apply 25% higher fertilizers to compensate for the losses caused by *Orobanche* or crop rotation, where possible.

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SEED DORMANCY AND LONGEVITY OF *Phalaris minor*

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Phalaris minor is the most troublesome weed of wheat in Haryana as well as in north India. Evolution of resistant biotypes to isoproturon in 1992 and cross- and multiple resistances to ACCase and ALS inhibiting herbicides after a decade of their use further compounded its management strategies using herbicide alone. *P. minor* seed longevity, dormancy and its emergence behaviour under different conditions could provide some clues for integrating the knowledge of seed biology in an integrated approach to lower the harmful effect of its preponderance in rice-wheat cropping system. Under rice-wheat cropping system (unaerobic conditions) viability of *P. minor* seed was lost within two years, but under cotton-wheat rotations (aerobic conditions), it was even quicker. Freshly harvested seed are dormant under lab conditions, but dormancy is broken by the next growing season; the behaviour is different under soil conditions. Experiments were conducted under controlled conditions to assess dormancy of freshly harvested seed and their viability when stored under room temperature. Seed of *P. minor* collected from different parts of Haryana State (isoproturon susceptible, resistant and partial resistant) and from Bihar (pristine biotypes) were grown under pots repeatedly over the years and harvested seed stored from 3 to 15years was subjected to germination test under pots and Petri dishes during 2008-09. Freshly harvested seed in April 2010 were placed on soil

surface and 2.5 cm depth, removed at fortnight intervals from soil for 4 months and subjected to germination test and compared with lab stored seed in a BOD incubator at 16°C. Seed stored under lab conditions from 1993 to 2000 lost viability. The susceptible biotype seed harvested from 2001 and 2002 had no germination in pots, but 20 to 50% germination was recorded in Petri dishes. Seed collected from 2004 to 2007 had 67 to 97% germination under pots and 77 to 100% under Petri dishes. Germination was less in susceptible biotype from Hisar under pots than Petri dish and other biotypes (Pristine, partial resistant and resistant). Freshly harvested and lab stored seed were dormant, but seed placed in soil (0 and 2.5 cm depth) lost dormancy quickly. Germination increased from 22 to 93% from soil surface and 62% for seed placed at 2.5 cm depth for 75 days. Germination initiation was lower for seed placed at 2.5 cm depth compared to surface, but increased after 3 weeks in Petri dishes. The results have direct implications for managing seed rain and survival under field conditions.

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HERBICIDE RESIDUES IN ENVIRONMENT

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The effect of prolonged and overuse of herbicides on soil results in human health hazards and pollutes the environment. Apart from this herbicide application also alters the ecosystem. The essential bacteria which fix nitrogen in soil and fungi facilitating the nutrient uptake by plants are inhibited by most herbicides. If we look at the reports on herbicide residues, majority of the reports reveal contamination of drinking water, soil and terrestrial systems, food and agricultural produces, aquatic and marine products, phytotoxicity to succeeding crops and those where contaminated water is used for irrigation, influence on human health and environment. Majority of the toxicological studies reported for several agrochemicals on animal model ends with an indication towards the dreaded diseases like cancer. Early stage screenings are incorporated as indicative tests for favourable environmental properties (soil persistence, phytotoxicity, leaching ability). The herbicide residue analysis in India about herbicide residue studies is 5%, compared to insecticide residue studies of 15%, fungicides studies of 5%, and herbicide efficacy studies of 10% compared to insecticide efficacy studies of 20% residual analysis. Now-a-days to overcome the residual problems we need, national wide monitoring and surveillance program on herbicide residues in soil, water, food and feed samples by connecting different laboratories in India. E-CAD (Electronic Capturing of Analytical Data) and harmonization of the results between the labs in a network program is essential. Assessment of residue levels in biota with special attention to aquatic species and animal tissue as indicatives of environmental contamination should be thrust area. Identifying and testing potential methods are an alternative to ameliorating problems associated with the use of herbicides. Introducing of new biotechnology based developments and a concept to minimize the use of herbicides is required. Biological weed control methods will become an important tool of future. Designing and development of allelochemicals tools, finally we can achieve organic agriculture to prevent environmental and human hazards.

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WEED SEED BANK RESPONSE TO HERBICIDES IN MAIZE (*Zea mays* L.)

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Weed control practices like herbicide application also impact on the weed seed bank in the soil. Weed seed bank information can be a useful tool for integrated weed management. Understanding the weed seed bank dynamics can also be used to guide the management practices. Experiment conducted on weed seed reserves in the soil on weed problem in corn (*Zea mays* L.) production was assessed for 6 consecutive years. In one system 2.2 kg/ha of atrazine pre-emergence was applied annually. In the other system, a mixture of 1.7 kg/ha of atrazine plus 2.2 kg/ha of alachlor was applied pre-emergence, followed by post emergence application of 2,4-D. After the sixth cropping year, the overall decline in the total number of red root pigweed (*Amaranthus viridis*) and common lambsquarters (*Chenopodium album*) seeds was 99 and 94% respectively. Very few weeds produced seeds during the first 5 years, and no weed seeds were produced during sixth year where atrazine was applied annually.

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THE BIOLOGICAL CONTROL OF HIMALAYAN BALSAM (*Impatiens glandulifera*) IN THE UK

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Trade liberalisation and rapid globalisation have led to the increased spread of invasive alien species (IAS) across the globe over recent decades. IAS are recognised as the second greatest threat to biodiversity next to habitat loss, and can inflict irreversible damage to ecosystems with incurred costs measured in billions of pounds. One such species, *Impatiens glandulifera* (Balsaminaceae) commonly known as Himalayan balsam, is a highly invasive annual herb native to the western Himalayas and now established as a weed in 23 European countries, 10 states in the USA, parts of Canada and New Zealand. Since its introduction into the UK as a garden ornamental in 1839, *I. glandulifera* has spread rapidly through the country using riparian habitats as corridors for its spread. The plant can reduce native plant diversity, retard woodland regeneration, out-compete native plants for space, light and pollinators and increase flood risk. Current traditional control methods are fraught with problems and often unsuccessful due to the need to control the plant on a catchment scale. The success of alien plant species can be attributed, in part, to the absence of natural enemies in the introduced range compared to the native range (the Enemy Release Hypothesis, Keane & Crawley, 2002). In the native range, the plant would be attacked by an array of both generalist and specialist natural enemies including herbivores and plant pathogens that keep the plant in equilibrium with the surroundings ecosystem. As an exotic weed *I. glandulifera* should be amenable to a classical weed biological control programme. This natural tool has been used as an effective measure to manage weeds worldwide with over 1000 releases to-date. However, in Europe classical biological control has only

recently received attention as a potential tool for the control of invasive non-native weeds over the last ten to fifteen years. This is mainly due to the fact that European IAS rarely affects agriculture systems. Earlier the focus on invasive species in Europe was concentrated mainly on the ecology and life history of study species with the central theme rarely applied management and control. However, with a strong shift towards the preservation of biological diversity and habitats, the control and management of invasive weeds have received increased focus in the UK and mainland Europe. Classical biological control attempts to re-address the balance of nature by introducing host-specific, co-evolved herbivores and pathogens from the plant's native range which will provide control to the invasive, non-native populations. Often when released from such natural enemies, plants with weedy traits can become prolific invaders by shifting resource allocation from defence to growth with increased fecundity. Since 2006, funded by a consortium of UK sponsors, populations of Himalayan balsam have been surveyed throughout the plants native range (the foothills of the Himalayas) and numerous natural enemies have been collected and identified. In particular two plant pathogens (a stem and leaf infect rust species and a *Septoria* leaf spot) and two stem boring beetles have considerable potential as biological control agents. This paper will review the research conducted to-date and examine the future testing procedures which will be conducted on potential agents to ensure they are host specific to the target and thus safe for the release and subsequent control of Himalayan balsam in its introduced range.

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COMPETITIVENESS OF *KHARIF* SORGHUM CULTIVARS AGAINST WEEDS

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Weeds are a major deterrent in increasing the sorghum productivity, especially during rainy season due to wider row spacing, slow initial crop growth rate, and congenial weather conditions for weed growth. The development of competitive sorghum cultivars would provide a safe and environmentally benign tool for integrated weed management. Field experiments were conducted during *kharif* 2009 to evaluated 11 sorghum cultivars including 6 hybrids (CSH 16, CSH 23, CSH 14, SPH 1596, SPH 1606, SPH 1616) and 5 varieties (CSV 15, CSV 17, SPV 462, CSV 23, SPV 1616) for weed suppression/tolerance under three weed pressures (weedy check, Inter-row cultivation+ hand weeding at 30 days after sowing (DAS), and weed free check- Inter-row cultivation twice (30 and 45 DAS) + hand weeding at 30 DAS). The field was infested mainly with broad-leaved weeds (66.6%) (*Parthenium hysterophorus* (24.7%), *Tribulus terrestris* (11.9%), *Euphorbia hirta* (8.77%), *Digera arvensis* (7.15%), *Corchorus olitorius* (6.1%), and others (*Amaranthus viridis, Ageratum conyzoides, Trianthema portulacastrum, Alternanthera sessilis, Euphorbia geniculata, Cleome viscosa, Achyranthes aspera, Cyanotis axillaris,* (7.72%), followed by grasses (27.8%) (*Brachiaria ramosa, Chloris barbata, Dactyloctenium aegyptium* (15.07%), *Digitaria sanguinalis* (9.06%), and others (*Echinochloa colona, Dinebra retroflexa, Panicum repens* (3.57%) and sedges (5.6%) (*Cyperus rotundus*). Inter-row cultivation+ hand weeding at 30 DAS significantly reduced the population of broad-leaved weeds and grasses but the population of *Cyperus rotundus* increased. Sorghum cultivars differed substantially in their competitiveness. CSH 23, SPH 1596, CSV 15 and SPV 462 recorded lower weed dry biomass (112-116 g/m^2) as compared to other genotypes (131-210 g/m^2). Weed competition reduced the grain yield of all genotypes ranging from 22.6% with CSH 16 to 50.90% with CSV 23. Genotypes CSH 16, SPH 1616 and SPV 462 (with 20.60-25.01% yield reduction) were relatively more tolerant to weed infestation.

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DETERMINATION OF RESIDUES OF HALOSULFURON-METHYL AND ITS METABOLITES IN SOIL – DISSIPATION UNDER NATURAL CLIMATIC CONDITIONS IN DIFFERENT SOILS

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A high performance liquid chromatographic method by U.V. detection was developed to determine the residues of halosulfuron methyl in soil. The dissipation study was conducted in four different soils to determine the dissipation rate of halosulfuron-methyl 75% WG. The four different soil used were sandy loam, loamy sand, sandy clay and clay soils. The herbicide formulation was sprayed on the randomly designed soil plots of sandy loam, loamy sand, sandy clay and clay soils. The applied dosages were T_0 – untreated control, T_1 – halosulfuron @ 75 g/ha and T_2 @ 150 g/ha. Representative soil samples were collected from 0 - 15 cm depth on 0 day (2 hours after the application) and on 10, 20, 30 and 50 days for the determination of residues of halosulfuron and its metabolite by a validated HPLC-UV method. The rate constant (k), DT_{50} and DT_{90} values were calculated from the residues data obtained. The recovery for halosulfuron and its metabolite chlorosulfonamide acid in water and soil was in the acceptable range (70-110%). The limit of quantitation (LOQ) was established for both halosulfuron and its metabolite chlorosulfonamide acid. The residues were confirmed by LC-MS-MS technique.

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EFFECT OF TEMPERATURE AND MOISTURE ON PERSISTENCE OF IMAZETHAPYR AND TRIFLURALIN

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Temperature and moisture are main factors of crop production and these factors influence herbicide persistence by affecting different herbicide degradation in soil. To study the persistence of trifluralin and imazethapyr affected by different temperature and moisture regime, an experiment was carried out under lab and screen house conditions at CCS HAU Hisar. Bioassay technique was used to quantify the persistence by employing sensitive plants. Oat and mustard plants were selected for trifluralin and imazethapyr bioassay, respectively. Soil treated with these herbicides at different rates (trifluralin 0.0, 0.125, 0.25, 0.50, 1.0 and 2.0 kg/ha and imazethapyr 0, 10, 20, 40, 80, 160 g/ha) after incubation at 15, 25, 35 and 45°C temperature regimes in incubator and moisture incubations at 50%, 75% FC and FC at room temperature for one month. Persistence of herbicides affected by different temperature and moisture regimes at different herbicide rates was measured by comparing the germination, shoot and root growth, fresh and dry weight of control treatment, at different intervals. With increase in temperature incubation of different imazethapyr rates; all growth parameters of mustard except germination increased, indicating that increased temperature showed

decreased persistence of imazethapyr, with minimum persistence between 35°C and 45°C. Whereas, trifluralin showed minimum persistence at 25°C and maximum at 15°C as revealed by different growth parameters of oat. Moisture incubations also influenced herbicides persistence. Increase in moisture incubation of different rates of trifluralin, increased growth of oat but not germination, indicating that persistence of trifluralin was directly related to moisture level. This suggests anaerobic degradation of trifluralin with maximum persistence at 50% FC and minimum at FC. But imazethapyr persistence was minimum at 75% FC indicating aerobic degradation. In both herbicides, different growth parameters of test plants except germination, decreased with increase in herbicide rate at different temperature and moisture incubation pointing that there was increased persistence with increased herbicide rates.

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IMPORTNCE OF SOYBEAN WEEDS IN GOLESTAN PROVINCE - A CASE STUDY OF IRAN

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A weed survey of soybean fields was conducted in Golestan province during 2005-2006 based on clustered random-sampling manner. Thirty eight species of weeds belonging to 17 families were recorded in this study. Poaceae (10 species) and Cyperaceae (1 species) were the most families in soybean fields. The results of this study showed that 68% of weeds were annual and others were perennial, 71% of weeds were dicotyledon and rest were monocotyledon. *Cyperus rotundus* was the most common sedge and *Echinochloa colona (*L.)Link., the most important weed in grasses group. The most important weed in broadleaves group was *Amaranthus chlorostachys L.*. The relative abundance (calculated as the sum of relative frequency, relative field uniformity, and relative mean field density) was used to determine the importance rate of soybean weed. In general, *C. rotundus, E. colona, A. chlorostachy , Abutilon theophrasti* Medicus., *Euphorbia maculata* L., *Sorghum halepense* (L.)Pers., *Hibiscus terionum* L. *and Physalis alkekengi* L. had the highest abandance in province and their relative share of total relative abandace was 0.21, 0.1, 0.08, 0.07, 0.05, 0.05, 0.05 and 0.05, respectively.

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PLANT QUARANTINE AND THREAT OF INVASIVE ALIEN WEEDS

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Plant quarantine is a government endeavor enforced through legislative measures to regulate the introduction of seeds, planting material, plant products, soil, living organisms etc. in order to prevent inadvertent introduction of pests, pathogens and weeds harmful to the agriculture of a country/state/region and if introduced, prevent their establishment and further spread. Alien invasive weed as per Convention on Biological Diversity are the biggest threat to biodiversity next only to human resettlement. These species seem to invade habitats that have been already altered by humans, such as the agricultural fields, grazing lands,

human settlements and roadways. In the past alien or non native plant species were intentionally introduced for direct and indirect benefits without proper risk assessment regarding their becoming invasive under favorable conditions. Several exotic plant species have been established in India as weeds with the arrival of Portuguese, who introduced several economically important plants from Brazil, Mexico, parts of Africa and other places. In this process, seeds of many obnoxious weeds also got mixed up and firmly established and spread widely. Astonishingly the estimates put 18% of Indian flora as alien or non native, of which about 55% are American, 10% Asian, 20% Asian and Malaysian and 15% European and Central Asian species. Weeds are just like other crop plants in size, form, morphological and physiological characters and belong to the plant families to which crop plants belong. Considering the erratic and unpredictable behavior of weeds and the diverse agro-climatic conditions of the country, it is too risky to make any predictions about their establishment and importance. A weed species considered as of minor importance in one country may attain the status of major weed in another country. Therefore, it is necessary to prevent the introduction of exotic and potentially dangerous weeds that may come along with plant/plant material which are being imported. These facts bring home strikingly the significance of plant quarantine in order to restrain or regulate the introduction of exotic plant species and other pests into new areas. It is in this direction that the Government of India has strengthened the existing system and brought into force the Plant Quarantine (Regulation of Import into India) Order 2003. In this Order a list of 32 weeds of quarantine importance is listed and a prohibition on the import of commodities contaminated with those weeds is placed. In perfect tune with these measures, weed scientists were deployed at selected entry points to intercept consignments containing weed seeds. According to the special provisions for quarantine weeds (clause 3(12) and schedule VIII of Plant Quarantine Order, 2003, no consignment of seed or grain contaminated with quarantine weeds shall be permitted unless devitalized. Needless to stress the detailed risk assessment associated with the exotic weeds focus should be aimed at designing the safeguards in order to eliminate the contamination of seed material with weed seeds. This highlights the importance of generating data on biology of quarantine significant weeds and their identification characteristics to facilitate their interception when introduced along with the seed. However, more weeds, particularly the ones that are problematic in related countries, need to be subjected to weed risk assessment. Australia, New Zealand and USA have developed protocol for weed risk assessment and identification of quarantine weeds. Australia is using the weed risk assessment system to review phytosanitary risks associated with the importation of exotic plant species not yet established in the country. It is used specifically to assess the weed potential of such species.

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ECO-FRIENDLY APPROACHES FOR THE MANAGEMENT OF WATER HYACINTH IN KUKKARAHALLI LAKE OF MYSORE

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Water hyacinth is (*Eichhornia crassipes* (Mart.) Solms) considered as world's worst weed, invasive weed and biggest threat to natural environment. Eco-friendly approaches are the modern concept. This technology provides a long term effect and sustainable opportunity for the management of water hyacinth; however, it also provides scope to start new small scale industry. Eco-friendly approaches involve both

eradication and control measures to warfare impacts of water hyacinth in the natural aquatic ecosystems the primary objectives of water hyacinth management is to maintain the stability of an ecosystem in order to reduce the negative impacts of weeds on aquatic ecosystem and its productivity. To do this job successfully, a thorough understanding of various eco-friendly approaches in water hyacinth control becomes essential. Reuse and recycle method also play a major role in the management of water hyacinth as an effective and economical as organic compost, vermicompost, mulch material. It further adds a role to reduce the global climate change indirectly. The various eco- friendly approaches evolved to eradicate water hyacinth are grouped under six broader groups: physical, mechanical, biological, antitranspirant, allelopathic potential and reuse or recycle.

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ALLELOPATHIC INFLUENCE OF LEAF EXTRACTS OF *Hyptis Suaveolens* ON GERMINATION AND BIOCHEMICAL PARAMETERS OF *Parthenium hysterophorus* L.

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Interaction among the plants of same locality is obvious phenomenon in natural and agro - ecosystems. Weeds are the major problem in agriculture and cause huge yield losses. A successful establishment of a weed in any ecosystem is attributed to several reasons such as high growth rate, high reproductive potential, adaptive nature and allelopathy. *Parthenium hysterophorus* has gained notoriety mainly due to health hazards, such as nasobronchial allergy and contact dermatitis and is menace to agricultural productivity ecological interference. Allelopathy concerns the effect of one plant on another due to chemicals released by them or breakdown products of their metabolites. *Hyptis suaveolens* L. (family: Lamiaceae) is fast-growing herb found in dense clumps along roadsides in overgrazed pastures. *H. suaveolens* is used traditionally for the treatment of respiratory track infections, cold, pain, fever, skin diseases and as anticancer agent. To explore the allelopathic potential of *H. suaveolens* on *P. hysterophorus*, different concentrations 25, 50 and 75% of leaf extracts of *H. suaveolens* were made to determine effects on the seed germination and growth parameters of *Parthenium*. The order of inhibitory effect of immersion period was 15 d > 10 d > 5 d and exposure period was: 72 h > 48 h > 24 h. Leaf extracts (75%) of *H. suaveolens* significantly inhibited seed germination and growth parameters of *Parthenium* as compared to control. Maximum reduction (84 %) in seed germination was observed with 75% concentration of leaf extracts. The inhibitory effect was proportional to the concentrations of the leaf extracts, immersion period and exposure period. Fifteen day leaf extract of *H. suaveolens* (75%) was phytotoxic in comparison to 10 and 5 day leaf extract and caused the death of *Parthenium* shoots. Higher concentrations of leaf extracts of *H. suaveolens* significantly reduced chlorophyll and protein contents of *Parthenium* after 72 h exposure period. Further investigations are required to study the biochemical composition of allelochemicals of *H. suaveolens* for the management of obnoxious weed *Parthenium*.

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ROLE OF CROP GENOTYPES IN INTEGRATED WEED MANAGEMENT

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In recent years, there has been an increasing reliance on modern herbicides leading to reduction in traditional techniques of weed control. Despite several decades of herbicides introduction and use in high input agricultural production system, weeds continue to be a persistent threat to economic crop production. One result of greater reliance on herbicides is the emergence of population of weeds which are resistance to products designed to control them. Because of complexity in weed community, integrated approaches to weed management may help in minimizing yield losses and improve weed control in agricultural crops. Integrated weed management lay greater emphasis on combination of weed management practices and scientific knowledge in a way that consider the cause of weed problems rather than managing existing weed problems. It addresses to ecological niches and their modification unfavourable for weeds growth. The two key elements of an integrated weed management system (IWMS) are: (1) the use of multiple control tactics and (2) the integration of weeds biology knowledge into management system. Therefore, IWM strategies imply broader approaches than relying on one or two weed control tactics. Integrated strategies, while diversifying the selection pressure, provide an opportunity to the farmers a broader range of management options. The economic thresholds are usually considered as a critical component of IWM system. However, a primary argument against economic threshold application in weed management is the future effect of weed seed production by weeds below threshold densities .Further, the instability of yield losses has been another limitation to the economic threshold. Enhancing the ability of crops to compete with weeds is an important component of IWM systems .This can be accomplished by providing the best possible environment for crop growth in combination with practices that reduce the density and vigor of weeds. Differential weed competitive ability has been observed among commonly grown crop genotypes. Characteristics commonly associated with crop competitiveness with weeds included rapid germination and root development, rapid early vegetative growth and vigor, faster canopy closer and high leaf area index, profuse tillering or branching, greater plant height and allelopathy. The most consistent conclusion from several studies has been that vigorous growth characteristics enhance weed competitiveness by affecting light quantity as well as quality beneath the crop canopy. Allelopathic cultivars may help in reducing weed seed bank in rhizosphere through toxic effects on weed seed germination. Although, most crop varieties encompasses one or more of these features, but have not yet been fully understood and successfully employed in IWM system. This paper attempts to analyze the attributes associated with weed competitiveness in commonly grown crops and also their possible integration in an IWM system.

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EFFECT OF RISE IN TEMPERATURE ON GERMINATION RESPONSE OF SOME WEEDS

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Seed germination is the outcome of an interactive effect of environmental factors and innate seed characteristics of a plant species. While the environmental effects include factors like soil moisture, soil pH, soil salinity, alkalinity, soil temperature and light conditions; the innate characteristics involve physiological status of the seed. Studies on weed seed germination as affected by such factors are in progress in this laboratory. The data on germination response of some weeds as affected by rise in temperature forms the theme of this paper. Amongst the kharif weeds, both species of *Echinochloa* i.e. *E. colona* as well as *E. crus-galli* germinated over a temperature range of 25-35°C, the optimum temperature being 25°C. Germination of the two species was; however, differentially affected by age of the seed. *Eclipta alba* showed germination at a temperature range of 15-30°C, the optimum temperature again being 25°C. Presence of light was obligatory for germination response of these seeds. A temperature optimum of 40°C day/30°C night was found optimum for *Digitaria bicornis*. Amongst the rabi weeds *Rumex dentatus* seed germinated at a temperature range of 10-20°C; 15°C being the optimum temperature for its germination. In addition the presence or absence of perianth affected seed germination. Germination tests on *Melilotus indica* revealed an obligatory requirement of low temperature (5°C) for a minimum of 72 hours for imbibition and germination of the seeds. In addition to direct effects of temperature on germination, it could also cause indirect effects by affecting soil moisure or salinity or alkalinity of the soil. An assessment of overall interactive effects of temperature with other factors would reveal the effect of rise in temperature on germination, emergence and infestation in existing/ newer areas.

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WEED DYNAMICS IN MAJOR CROPPING AND NON-CROPPING SYSTEMS

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Weeds are more adaptive to change in climatic conditions than crop plants and this major trait is helpful in their survival and proliferation. Cropping systems and ecology play major role in weed dynamics. Weed infestation is largely influenced by soil type, moisture availability, crop association and agronomic practices followed in crop cultivation including weed control methods. Association of weed flora with crops, underground water quality and amount of rainfall and soil fertility status was found to have a distinct pattern on infesting weed species. Weed flora is more diverse under rainfed cultivation, whereas only few dominant weeds infest under intensive cultivation where herbicides forms a major plank of weed management practices. Intensive cultivation lead to dominance of annual whereas reduce till results in

greater prevalence of perennial weeds. Intensive cultivation and irrigation had significant effect on *Desmostachya bipinnata, Zizyphus nummularia, Artemisia scoparia* and several other weeds, whereas *Celosia argentea* and *Commelina* sp. were not affected. Grassy weeds dominated with the advent of high yielding dwarf wheat varieties which were more responsive to fertilizer and irrigations. Use of isoproturon for the control of grassy weeds in the nineties resulted in the evolution of *Phalaris minor* resistance and again completing the cycle of grassy weeds dominance. New herbicides recommended for the control of gassy weeds resulted in the dominance of *Rumex dentatus, R. spinosus, Convolvulus arvensis, Malva parviflora, Medicago denticulata, Melilotus indica* and *Lathyrus aphaca.* Another decade of use of grassy and broadleaf herbicides again had the dominance of *P. minor* due to cross/ multiple-resistance to these herbicides. *Polypogom monspeliensis* also emerged in a big way in wheat fields where sulfosulfuron or meso+iodosulfuron was used and soils were saline, low in fertility. In case of paddy continuous use of grassy herbicides evolved dominance of broadleaf weeds viz. *Ammania auriculata/ baccifera, Sphenochlea zeylanica, Ludwigia sp., Marsilea quadrifida* and *Caesulia axillaris* under flooded conditions. Upland rice on the other hand plenty of broadleaf weeds along with grasses. *Leptochloa chinensis* occurred under both upland and lowland paddy fields. *Eragrostis* species emerged one of the serious weed with *L. chinensis* and *Brachiara* sp. in upland paddy fields. *Trianthema portulacastrum* became dominant not only in millets, but also in upland rice. *Digera arvensis* and *T. portulacastrum* have become the most dominant weeds in rainy season pulses/oilseeds. In case of non-cropped situation where Parthenium hysterophorus took over the local vegetation for almost two decades, competition led to shift in weed flora to *Chenopodium* spp., *Cannabis sativa, Helianthus annuus, Prosopis juliflora, Suaeda fruticosa, Saccharum spontaneum* and *Amaranthus hybridus. Amaranthus* is very serious due to abundant seed production and sever competitor with crops moving fast from roadside to adjacent crop fields.

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STATUS, DISTRIBUTION AND IMPACT OF INVASIVE SPECIES *Ipomea carnea* Jacq. IN JAMMU REGION

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Ipomea carnea was introduced to India from South America at the begning of the nineteenth century for ornamental purpose and has been cultivated partly for its beautiful flowers but also for its ability form ideal living fences. It is widely recognized as alien invasive plant species and has been listed among the world worst invaders in India. The rapid growth rate, spread and adaptability from aquatic to xerophytic habitats indicate that this invasive plant may potentially become another ecological disaster like water hyacinth. It is a perennial weed belonging to the family Convolvulaceae. However, now it has been repeatedly noticed forming large naturalized population in India and is rapidly spreading throughout the sub continent. *Ipomea carnea* can today be considered a pan-tropical weed that exhibits highly developed attributes.

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THREAT OF WEEDY RICE UNDER DIRECT SEEDED RICE

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Weedy rice has emerged as an acute problem in areas where puddled transplanting is being replaced by direct-seeding of rice (DSR) such as in Sri Lanka, Malaysia, Thailand, Vietnam and Korea. In India, the interest of shifting from puddled transplanting to DSR is increasing owing to labor and water shortage, rising labor wages, escalating fuel prices, adverse effects of puddling on soil health, and higher cost of production of current method. Based on the experiences of countries where DSR is widely adopted, it is likely that weedy rice could become a major threat for rice production in India under DSR system with its wider adoption. Therefore, ecologically based management strategies need to be developed in advance to avoid yield losses in DSR. Weedy rice belong to the same genus *Oryza sativa* (L.) as that of cultivated rice but it spread very fast because of its unique characteristics like early and heavy seed shattering, dormancy for a longer period, faster germination, longer flowering duration, vigorous growth and more capability to survive in the adverse climatic conditions. It is highly competitive with rice crop and causes severe yield losses ranging from 5 to 100%. Weedy rice also reduces milling quality of rice if get mixed with rice seeds during harvesting. Weedy rice population is affected by the time and method of crop establishment, seed purity and characteristics of rice cultivars, tillage practices, seeding depth, water management, weed control methods and harvesting methods. Weedy rice is very difficult to control with only single method because of similar phonological, morphological and genetic characteristics with that of the cultivated varieties. So we need integrated weed management strategies which integrates many "little hammers" instead of single "large hammer" to target at several phases of the life cycle of weedy rice. Some of these many little hammers include (1) preventive methods such as planting high quality weedy rice free seed, cleaning of machines to reduce weedy rice spread to non infested areas; (2) cultural methods like stale seed bed technique, crop rotation, minimum or no tillage, water seeding technique, co-culturing of cover crops e.g. *Sesbania* for 30-35 days for smothering effect, rouging, use of weed-suppressing and submergence tolerant varieties; (3) mechanical methods such as use of mechanical weeder or other implements to eliminate weedy rice; (4) chemical methods; and (5) biotechnological approaches such as use of herbicide resistant varieties.

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IMPACT OF CLIMATE CHANGE ON WEEDS

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Climate change is now a widely accepted phenomenon. There are concerns that global CO_2 enrichment will directly or indirectly affect weeds and crop yields through global warming and its associated changes in climate such as alteration in precipitation, wind pattern, rise in sea level and more flood and drought. Plants with C3 photosynthetic pathways are expected to benefit more than C4 from CO_2 enrichment. However, rising temperature due to elevated CO_2 may give competitive advantage to C4 plants than C3. This differential response of C3 and C4 plants to elevated CO_2 and temperature has important implications on crop/weed competitive interaction because of the fact that majority of weeds are C4 and most crops are C3. Climate change may bring changes in weed population and in their phenology. Many weed species may expand their range and spread to new areas. Elevated temperature may also allow some sleeper weeds to become invasive. Published evidence seems to suggest that invasive species may become more of a threat in changing climate because of their strong response to elevated CO_2 and changing climate compared to other native species. Moreover, some weed species which directly impact human health through allergic reactions, skin irritations, or internal poisoning have shown positive response to changing climate particularly to elevated CO_2 concentration by producing higher plant biomass, pollens or poisonous compounds. Climate change may likely have a direct or indirect impact on the chemical, mechanical and biological control methods by reducing their effectiveness on weeds. For example, it has been reported that herbicide efficacy is likely to reduce under elevated CO_2. Effectiveness of the herbicide may also be altered by change in temperature, wind speed, soil moisture and the atmospheric humidity. The control of perennial weeds by chemical or mechanical methods may become more difficult under elevated CO_2 if increased photosynthesis stimulates greater production of rhizomes or tubers or other storage organ. Climate change may also alter the development, morphology and reproduction of pests which can change the efficacy of bio-control agents for weed suppression. We need to address the anticipatory changes in weed biology and dynamics with climate change in order to develop flexible integrated weed management practices which are based on a foundation of knowledge of weed biology and ecology. Specifically, the paper aims to discuss the effects of climate change on 1) crop-weed competitive interaction under single (CO2 or temperature) or multiple factors (e.g. CO2 and temperature or CO2 and moisture stress); 2) invasiveness; 3) weed management, and 4) human health.

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STUDIES ON WEED MANAGEMENT IN ZERO-TILL DIRECT SEEDED RICE

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A field experiment was conducted during *kharif* season 2009 on sandy clay loam soil at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh to evaluate the different weed management options for zero-till direct seeded rice. Eleven treatments *viz.*, W_0-weedy check, W_1-weed free, W_2-bispyribac + azimsulfuron (25 g + 17.5 g a.i. ha^{-1}), W_3-pendimethalin @ 1 kg/ha (pre-emergence) fb azimsulfuron @ 35 g/ha + NIS (0.25%), W_4-pyrazosulfuron @ 20 g/ha (pre-emergence) fb bispyribac @ 25 g/ha + NIS (0.25%), W_5-penoxsulam @ 22.5 g/ha + NIS (0.25%), W_6-bispyribac @ 25 g/ha + NIS (0.25%), W_7-propanil @ 3.0 kg/ha + trichlorpyr @ 0.5 kg/ha + NIS (0.25%), W_8-sesbania co-culture with rice fb pendimethalin @ 1 kg/ha (pre-emergence) fb 2,4-D @ 0.5 kg/ha fb 1 HW at 40 DAS, W_9-Sesbania (as cover crop) fb 2, 4-D + glyphosate to knock down sesbania fb rice sowing fb bispyribac @ 25 g/ha + NIS (0.25%) and W_{10}-cow pea (as cover crop) fb 2,4-D + glyphosate fb rice sowing fb bispyribac @ 25 g/ha + NIS (0.25%) were evaluated. The important weed species were *Echinochloa colona* (L.) Link, *E. crusgalli* (L.) Beauv, *Cynodon dactylon* (L.) Pers, *Cyperus rotundus* L., *C. iria* L., *Commelina benghalensis* L. However, other weed flora consisted *Phyllanthus niruri* L., *Eclipta alba* (L.) Hassk, *Ischaemum rugosum* Salisb. and *Physalis minima.* Highest weed density and dry weight was recorded in weedy check, while minimum in bispyribac + azimsulfuron (25 g + 17.5 g/ha) followed by pendimethalin 1 kg/ha (pre-emergence) fb azimsulfuron 35 g/ha. Penoxsulam 22.5 g/ha at 15 DAS effectively reduced the dry matter accumulation by *E. colona.* Bispyribac + azimsulfuron (25 g + 17.5 g/ha) effectively reduced the dry weight of *E. crus-gulli, C. dactylon* and *C. benghalensis.* Amongst weed management methods the highest yield attributes and yield was obtained with bispyribac + azimsulfuron (25 g + 17.5 g/ha) followed by Pendimethalin 1 kg/ha (pre-emergence) fb azimsulfuron 35 g/ha and bispyribac 25 g/ha. Highest grain yield of 3.97 ton/ha was obtained from weed free treatments which was closely followed by W_2-bispyribac + azimsulfuron (3.54 ton/ha), W_3-pendimethalin fb azimsulfuron (2.51 ton/ha) and W_6-bispyribac (2.43 ton/ha).

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COMPARATIVE EFFICACY AND ECONOMICS OF HERBICIDES AGAINST WEEDS IN PUDDLE SEEDED RICE

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Weeds are the major biotic constraints responsible for low productivity of rice reducing the yield up to 80%. Herbicides effectively control the weeds and cut down the energy requirement of rice cultivation.

Keeping the problems of build up of problematic weeds, resistant biotypes and shift in weed flora with continuous use of same herbicides *viz.* butachlor and pretilachlor (most commonly used herbicides for weed control in transplanted rice), it is imperative to evaluate and find out other herbicide molecules, preferably with alternate mode of action, for effective control of weeds to ensure better crop yield in paddy. Field experiment was conducted during *kharif* 2005 at Experimental Farm, Department of Agronomy, CSK HPKV, Palampur, comprising 9 treatments *viz.* butachlor 1.5 kg/ha, pendimethalin 1.5 kg/ha, oxyfluorfen 0.250 kg/ha, pyrazosulfuron 0.002 kg/ha, pretilachlor 0.750 kg/ha, cyhalofop 0.09 kg/ha, fenoxaprop 0.15 kg/ha with weed free and weedy check in Randomized Block Design with three replications. The soil of the experimental site was silty clay loam in texture, low in organic carbon and medium in available nitrogen, phosphorus and potassium with pH 6.1. All the herbicides except butachlor, pretilachlor and oxyfluorfen (applied as Pre.) were applied as post emergence with knapsack sprayer using 750 L/ha of water. The results revealed that all the weed control treatments were proved superior in reducing the total weed population and their dry matter accumulation significantly compared with weedy check. Complete weeds control was achieved in weed free plots which were superior over rest of the treatments. Among herbicidal treatments, cyhalofop 90 g/ha, pyrazosulfuron 20 g/ha and oxyfluorfen 250 g/ha being statistically at par with each other, significantly reduced the total weed count and their dry weight over rest of treatments and recorded weed control efficiency of 92.5, 88.9 and 91.2%, respectively. Effective control of weeds by these treatments resulted in significantly higher paddy yield, equivalent to weed free check. The percent increase in grain yield by these superior herbicidal treatments ranged from 111.3 to 116.4% over unweeded check. Highest value of net returns (Rs. 18535/ha) with B:C ratio of 2.1 was obtained with application of oxyfluorfen 250 g/ha followed by cyhalofop 90 g/ha and pyrazosulfuron 20 g/ha obtaining net returns of Rs. 18008 and 17640/ha with B:C ratio of 2.0 and 1.9, respectively.

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HERBICIDE RESISTANCE IN WEEDS IN RICE-WHEAT SYSTEM – PRESENT STATUS

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Rice-wheat, one of the most important cropping systems in India covers an area of about 10.3 m ha and is responsible for national food security. The continuous adoption of this system along with sole dependence on monoherbicide for weed control has led to the emergence of problems like degradation of resources, weed flora shift and evolution of herbicide resistance in weeds. Littleseed canarygrass (*Phalaris minor)* is a *rabi* season grassy weed that has evolved multiple resistance across three modes of action of herbicides (photosystem II, ACCase and ALS inhibitor). The emergence of multiple herbicide resistance is an emerging threat to wheat production in north-western Indian Plains. A few farmers in Haryana and Punjab having infestation of multiple herbicide resistant populations are facing significant yield reductions in the absence of effective alternative post-emergence herbicides. Studies on the quantification and characterization of herbicide resistance in *P. minor* have revealed that some of the populations had GR_{50} (50% growth reduction) values for clodinafop > 12 times greater than that of the most S (susceptible) population. Population resistant to clodinafop exhibited cross-resistance to fenoxaprop (fop group), tralkoxydim (dim group) and pinoxaden (den group). Similarly, population resistant to sulfosulfuron showed cross-resistance to mesosulfuron and pyroxsulam. However, the populations resistant to six groups (phenyl urea, sulfonyl urea,

aryloxyphenoxypropionic, cyclohexene oxime, phenylpyrazole and triazolopyrimidine sulfonamide) were susceptible to triazine (metribuzin and terbutryn) and dinitroaniline (pendimethalin) herbicides. Also, the multiple herbicide resistant populations showed sensitivity to glyphosate and paraquat. The yield reductions due to multiple herbicide resistant populations can be contained with pre-seeding application of glyphosate and paraquat in combination with pendimethalin or terbutryn in zero-till wheat. Since, the introduction of new mode of action herbicides has slowed down; therefore the concerted efforts are required to prolong the life of the available herbicides. The long-term resistance management strategies should include the integration of chemical and non-chemical means of weed management.

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STUDIES ON EFFICIENCY OF TRIASULFURON 20 WG FOR WEED CONTROL AND GRAIN YIELD IN TRANSPLANTED RICE (*Oryza sativa* L.)

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A field experiment was conducted during *Kharif* season of 2009 at Agricultural Research Station, Kathalgere, Channagiri taluk, Davanagere district, Karnataka state to find out the efficiency of triasulfuron for weed control and grain yield in transplanted rice. Among the herbicides, Almix @ 4 g/ha caused the higher phytotoxicity followed by triasulfuron @ 24 g/ha and resulted in stunted growth of the rice plants. Triasulfuron @ 24 and 12 g/ha and hand weeding twice recorded significantly lower density and dry weight of weeds at all growth stages of the crop as compared to other treatments. Hand weeding twice was found very effective against weeds up to 60 DAT, thereafter its effect was suppressed and triasulfuron @ 24 g/ha has become more effective. Grain and straw yields were higher in triasulfuron @ 12 g/ha (6494 and 6930 kg/ha, respectively). It was followed by hand weeding twice (6479 and 6893 kg/ha grain and straw yield, respectively). Among weed control treatments, the lower yield of grain and straw was recorded by pyrazosulfuron 10 WP @ 25 g/ha (5828 and 6206 kg/ha, respectively). Weed control efficiency was higher in triasulfuron @ 24 g/ha followed by its 12 g/ha rate (93.67 and 91.45 %). Hand weeding twice was found on par with these two treatments with the WCE of 88.56 %. Significantly lower seed yield of all three test crops as obtained in pyrazosulfuron @ 25 g/ha followed by almix @ 4 g/ha was mainly due to the residual effect of these herbicides which resulted in lower germination and lower dry matter accumulation. Triasulfuron @ 12 g/ha resulted in higher B:C ratio (1.90) which was followed by triasulfuron @ 10 g/ha (1.89) and 24 g/ha rate (1.86).

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EFFECT OF GROWTH REGULATORS AND HERBICIDES ON GLADIOLUS

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Gladiolus has gained popularity in many parts of the world owing to its unsurpassed beauty and is also known as "the queen of bulbous flower". In India also, its commercial cultivation is gaining popularity due to export potential and prevalence of congenial growing conditions in various parts of the country. However, weed infestation is one of the main factors limiting its production and quality. A field experiment was carried out to evaluate the effects of growth regulators (control, pre-planting dip of corms in 100 ppm GA3 solution for 24 hrs, pre-planting dip of corms in 500 ppm thiourea solution for 24 hrs) and nine weed control treatments on gladiolus cv. 'American Beauty'. The nine weed control treatments were weed free; weedy check; atrazine 3.0 kg/ha at 1-2 days after planting (DAP) followed by (fb) one hand hoeing (HH) at 120 DAP; atrazine 1.5 kg/ha at 1-2 DAP fb one HH + atrazine 1.5 kg/ha at 120 DAP; atrazine 0.75 kg/ha at 1-2 DAP fb one HH + atrazine @ 0.75 kg at 120 DAP; trifluralin 2.0 kg/ha at 1-2 days before planting (DBP) fb one HW at 120 DAP; trifluralin 1.0 kg/ha at 1-2 DBP fb one HH + trifluralin 1.0 kg/ha at 120 DAP; oxyfluorfen 0.50 kg/ha at 1-2 DAP fb one HH at 120 DAP; oxyfluorfen 0.25 kg/ha at 1-2 DAP fb one HH + oxyfluorfen 0.25 kg/ha at 120 DAP. Pre planting dip treatment of gladiolus corms with GA3 (100 ppm) and thiourea (500 ppm) markedly improved the quality and production of spikes as well as corms. More uniform sprouting, better flowering, better cormel production, more suppression of weeds and higher additional return were additional benefits of GA3 over thiourea. Among herbicidal treatments, atrazine 3.0 kg/ha (either in single dose or in two equal splits) was observed comparatively more efficient in controlling weeds, but caused phytotoxicity to crop plants. Among the rest of the herbicidal applications, most consistent acceptable reduction in dry weight accumulation in weeds and their intensity was provided by oxyfluorfen 0.25 kg + 0.25 kg/ha closely followed by oxyfluorfen 0.5 kg/ha and trifluralin 2.0 kg/ha.

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INTEGRATED WEED MAANGEMENT IN GROUNDNUT (*Arachis hypogaea* L.)-WHEAT (*Triticum aestivum* L.) CROPPING SYSTEM IN NORTHERN KARNATAKA

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A field experiment was conducted in the fixed site at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka during kharif and rabi seasons from 2002 to 2009 to study the effect of integrated weed management in groundnut-wheat cropping system. The experiment consisted seven treatments with three replications. In groundnut, alachlor 1.5 kg/ha PRE + 2 IC at 30 and 40 DAS + 1 HW 45 DAS; pretilachlor 1.5 kg/ha Pre + 2 IC at 30 and 40 DAS + 1 HW 45 DAS; pendimethalin 1.5 kg/ha PRE + 2 IC at 30 and 40 DAS + 1 HW 45 DAS; butachlor 1.5 kg/ha PRE + 2 IC at 30 and 40 DAS + 1 HW 45 DAS were compared with weed free, weedy check and farmers' practice. In wheat, 2,4-D (Na) 1.0 kg/ha; triasulfuron 15 g/ha; metsulfuron-methyl 4 g/ha; and isoproturon 1.0 kg/ha were applied 20 DAS and compared with weed free, weedy check and farmers' practice. The predominant weeds observed in the experimental site were: *Cynodon dactylon, Panicum spp., Digitaria marginata, Dactyloctenium aegyptium, Eragrostis Sp., Echinochloa colona, Dinebra retroflexa* (grasses), *Euphorbia hirta, Tribulus terrestris, Phyllanthus niruri, Commelina benghalensis, Parthenium hysterophorus, Alternenthera sessilis, Cassia sericea* (BLW) and *Cyperus rotundus* (sedges). In groundnut all the treatments differed for their efficacy against weeds. Weed free was best in terms of crop growth and weed control followed by butachlor based treatments which resulted in highest pod yield of 2353 kg/ha compared to 1300 kg in weedy check plots. Groundnut herbicides had no phytotoxicity on succeeding wheat crop. In wheat, all the herbicidal treatments lowered weed count and biomass compared to untreated control. Weed free check was best, followed by triasulfuron 15 g/ha applied 20 DAS. Wheat grain yield differed significantly among weed control treatments. Highest wheat yield of 3182 kg/ha was recorded under weed free, which was at par with triasulfuron followed by isoproturon and 2,4-D treatments. In groundnut maximum net income was obtained with butachlor 1.5 kg/ha followed by pretilachlor, alachlor and pendimethalin at 1.5 kg/ha integrated with intercultural operations and hand weeding.

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STANDARDIZATION OF APPLICATION TIME AND RATE OF IMAZETHAPYR FOR WEED CONTROL IN URDBEAN [*Vigna mungo* (L.) Hepper]

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An experiment was conducted during *kharif* 2008 at Punjab Agricultural University, Ludhiana to study the efficacy of imazethapyr against different weeds in two urdbean varieties i.e. Mash 114 and Mash 338. The experiment was conducted in split plot design by keeping weed control treatments in main plots and varieties in sub-plots. Imazethapyr was evaluated at different doses i.e. 50, 75 and 100 g/ha applied at 15 or 25 days after sowing (DAS) along with unweeded and two hand weeding (20 and 40 DAS) treatments. Pods/plant were found to be the highest with imazethapyr @ 100 g/ha at 15 DAS which was; however, at par with two hand weeding, but significantly higher than all other weed control treatments. Application of imazethapyr at 100 g/ha 15 DAS provided the highest grain yield (1268 kg/ha). Imazethapyr 75 g/ha 15 DAS and imazethapyr 100 g/ha 25 DAS were statistically at par in grain yield with imazethapyr 100 g/ha 15 DAS and two hand weeding done at 20 and 40 DAS. These treatments controlled weeds effectively. Imazethapyr was found to be safe to both urdbean varieties. The grain yield of varieties did not differ significantly.

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BIOEFFICACY AND PERSISTENCE OF ATLANTIS (MESOSULFURON + IODOSULFURON) APPLIED IN WHEAT AS INFLUENCED BY SOIL MOISTURE LEVELS AND SOIL TYPES

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A field experiment was conducted at the Student Research Farm, PAU, Ludhiana during *rabi* season of 2005-2006 to study the bio-efficacy of Atlantis 3.6 WDG for weed control in wheat. The study revealed that all doses of Atlantis 3.6 WDG (mesosulfuron + iodosulfuron) i.e. 12 g, 18 g and 24 g/ha were at par with respect to yield and yield attributes of wheat, irrespective of variable soil moisture levels present at the time of their application and all treatments gave an effective kill of weeds resulting in 100 % reduction in weeds dry matter accumulation as compared to unsprayed control treatment. Residue in different types of soils (silty clay loam, sandy loam and sandy) was not detected at application rate of 12 g/ha; however at 0 day after spray residue of mesosulfuron + iodosulfuron applied at 24 g/ha was detected in sandy soil when estimation was done with HPLC. Herbicide applied to wheat showed no adverse effect on germination and growth of succeeding *kharif* crops including summer moong, cotton, okra and sesbania. However, the reduction in fresh weight of pearlmillet was 48.2, 59.9 and 68.0 % and of maize it was 31.9, 54.1 and 58.9 % at 12 g, 18 g and 24 g/ha of mesosulfuron + iodosulfuron, respectively which was applied to preceding wheat for the control of grassy and broad leaved weeds.

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BIOLOGY AND CONTROL OF *Cressa cretica L.*

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A field experiment on biology and control of *Cressa cretica* was conducted during rabi 2006-07 and 2007-08 in a randomized block design, with four replications in natural infested farmers fields in A.P. Water Management Pilot area of Patha Reddy Palem village of Guntur district. *Cressa cretica* is an annual slender herb belonging to family Convolvulaceae. Germination/emergence of *Cressa* was observed immediately after harvesting of paddy (i.e. in the first week of December) as it completes its germination within 15-20 days depending on field conditions. It grows to a height of 15-20 cm and flower initiation starts 30-45 days after germination and produces on an average 223 seeds/plant. Post emergence application of glyphosate 2.0 kg/ha, 2,4 – D Na salt 1.0 kg/ha, paraquat 0.6 kg/ha, oxyflourfen 0.12 kg/ha, urea 20 %, common salt 20 % alone and tank mixing of glyphosate 1.0 kg + 2,4-D Na salt 1.0 kg/ha, 2,4-D Na salt 1.0 kg/ha + paraquat 0.6 kg/ha were valuated for controlling this problematic weed during both the years. Results revealed that post emergence application of tank mixing of glyphosate 1.0 kg + 2,4-D Na salt 1.0 kg/ha before flowering recorded significantly the higher mortality of 82 % at 30 days after spraying over other treatments and the cost of this treatment is Rs. 911 /ha.

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BIO-EFFICACY OF DIFFERENT HERBICIDES FOR WEED CONTROL IN CARROT (*Daucus carota* L.) AND RADISH (*Raphanus sativus* L.)

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A field study on bio-efficacy of different herbicides for weed control in carrot (*Daucus carota* L.) and radish (*Raphanus sativus* L.) was conducted during *rabi* 2007-2008 at Punjab Agricultural University, Ludhiana. Soil of the experimental site was loamy sand, normal with respect to pH and EC, low in organic carbon and available N, medium in P and high in K. Pre-emergence application of pendimethalin at 0.375, 0.562 and 0.75 kg/ha; trifluralin at 0.6, 0.9 and 1.2 kg/ha; alachlor at 1.25, 1.875 and 2.5 kg/ha; oxyfluorfen at 0.117, 0.147 and 0.176 kg/ha; hand weeding at 20 days and unweeded control were evaluated in RBD in two separate trials for each crop. All the herbicidal treatments reduced weed dry matter significantly as compared to unweeded control; weed control efficacy increased with every increase in herbicide dose. Uncontrolled weeds reduced radish root yield by 10.7-27.1 % while corresponding figures in case of carrot was 11.5- 26.2 %. Trifluralin 1.2 kg/ha recorded the highest radish root yield and was at par with trifluralin 0.9 kg/ha, pendimethalin 0.75 kg/ha, alachlor 1.25 & 2.5 kg/ha, oxyfluorfen 0.147 & 0.176 kg/ha and hand hoeing. Oxyfluorfen 0.147 kg/ha recorded highest carrot root yield which was at par with oxyfluorfen at 0.117 and 0.176 kg/ha, pendimethalin 0.562 and 0.75 kg/ha, alachlor at its all levels and trifluralin 1.2 kg/ha. None of the herbicides influenced the root quality, total soluble solids and isothiocyanate content of radish, total soluble solids and ß-carotene content of carrot. Microbial population of soil was higher at lower doses of herbicides compared to their respective higher doses. Herbicides residue in crop roots at harvest were below the detectable limit.

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EFFECTIVE MANAGEMENT OF UPLAND AND LOWLAND PADDY WEEDS

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Direct seeding may be a better option for rice cultivation, which eliminates the need for nursery raising and transplanting, reducing labour cost by about 30% in addition to substantial reduction in total amount of water used as compared to transplanting of rice. However, a shift from transplanting to direct seeding of rice may aggravate the weed problem. Hence, it was planned to evaluate different pre- and post-emergence herbicides to provide wider options to farmers for weed control. A field experiment was conducted at CCSHAU College of Agriculture Farm, Kaul, Haryana during *kharif* 2005 and 2006. The experiment comprising seven weed control treatments *viz.* weedy check, weed free check, pendimethalin at 1.5 kg/ha (pre-emergence), cyhalofop at 90 g/ha. (15-20 DAS), pretilachlor + safener at 0.5 kg/ha (pre-emergence), pendimethalin at 1.5 kg/ha (pre-emergence) fb one hand weeding at 30 DAS and dhaincha (*Sesbania aculeata*) fb 2, 4-D at 0.5 kg/ha (30 DAS) in sub-plots and crop establishment methods puddle, unpuddled, zero-tillage and dry seeding as main plot treatments was laid out in a split plot design. The dry weight of total weeds was not influenced significantly by planting methods throughout the crop period during 2005 and 2006. At 90 DAS, pendimethalin 1.5 kg/ha (PE) fb one hand weeding at 30 DAS and *Sesbania fb* 2,4-D resulted into significantly lower dry weight of weeds as compared to other treatments. Among different herbicidal treatments, pendimethalin at 1.5 kg/ha (PE) *fb* hand weeding (30 DAS) produced significantly higher number of effective tillers, grain per panicle and 1000-grain weight compared to other weed control treatments, which was closely followed by *Sesbania fb* spray of 2,4-D. The rice yields due to herbicidal treatments were more than the weedy check but lower than weed-free conditions during both the years. Among weed control treatments, the grain yield of rice following the treatment of pendimethalin at 1.5 kg/ha fb one hand weeding at 30 DAS was almost 36% more than weedy check and about 7% lower than weed free plots.

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EFFICACY OF ALTERNATE HERBICIDES AGAINST ISOPROTURON RESISTANT BIOTYPES OF *Phalaris minor* IN WHEAT

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A field experiment was conducted during *rabi* 2009-2010 at the Research Farm of Department of Agronomy, PAU, Ludhiana to evaluate the efficacy of alternate herbicides for controlling isoproturon resistant *P. minor*. The alternate herbicide *viz.* Atlantis 3.6 WDG (mesosulfuron+ iodosulfuron) 12 g/ha, Total 75WG (sulfosulfuron + metsulfuron)30 g/ha, Leader 75WG (sulfosulfuron) 25 g/ha, Topik 15 WP (clodinafop) 60 g/ha, Axial 5 EC (pinoxadin) 50 g/ha, Treflan 48 EC (trifluralin) 1.2 kg/ha and AEF 04-6360-8%+DIC 1468-14%-22% at 1.25 g/ha (commercial product) were applied to wheat crop growing in association with 18 biotypes of

P. minor. Plant height was maximum (74.1cm) with application of trifluralin which was at par with AEF+DIC treatment and significantly higher than all the other herbicidal treatments. The difference in yield attributes i.e. ear length and effective tillers were found to be non-significant amongst all the herbicidal treatments. The application of AEF+DIC gave significantly higher grain yield (45.1 q/ha) than control (39.7 q/ha), but it was at par with all other herbicidal treatments. Among the tested biotypes, the crop attained significantly higher plant height in case of biotype B16 (76.2 cm). Lowest plant height (69.9 cm) was attained from the crop associated with the biotype B13 and it was at par with that of B1, B2, B3, B4, B7, B8, B10, B11, B12, B14 and B17 which ranges from 71.0-72.3 cm. Effective tillers per metre row length were significantly higher in wheat associated with B18 (91.4) which was at par with B1, B2, B3 B4, B6, B7, B8, B10, B14, B16 and B17 which range from 87.5-91.2. The differences in ear length of crop among all the biotypes were non-significant. Wheat crop associated with biotype B5 produced significantly higher grain yield (45.11 q/ha) as compared to wheat associated with all the tested biotypes except B1, B14, B16, B17 and B18.

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EFFICACY OF WEED MANAGEMENT ON WEED DYNAMICS AND SOYBEAN (*Glycin max* (L) Merril.) YIELD UNDER WESTERN MAHARSHTRA

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Soybean is mainly grown during *kharif* season on medium to deep black soils of western Maharashtra, which by virtue of its higher water holding capacity; do not turn up in working condition hindering the timely weeding and intercultural operations. The non availability of labour leads to poor management resulting into 30 to 77 % yield losses. Hence, the evaluation of newer herbicide molecules is needed to study its bio efficacy and phytotoxicity along with yield advantage. A field experiment was conducted on soybean cv. JS–335 during 2008 and 2009 at integrated farming system research project, MPKV, Rahuri in a randomised block design. The herbicidal treatments comprised newer molecule imazethapyr 10 SL (10 IPR) at 500, 1000, 1500 and 2000 ml/ ha and compared with market available imazethapyr (Pursuit), hand weeding at 15 and 30 DAS and weedy check. Weed count and phytotoxicity observations were recorded at 15, 30 and 45 days after application. The important weed flora of the experiment field comprised of grassy weeds viz. *Echinocloa colona, E. Crus-galli, Dinebra arabica, Digitaria sangunalis and Brachiaria mutica. Cyprus rotundus* was one of the important sedge observed in the experimental field. The dominant broad leaved weeds were *Euphorbia geniculata, Euphorbia hirta, Commelina communis, Commulina benghalensis, Digeria arvensis, Phyllanthus niruri, Xanthium sp., Parthenium hysterophorous, and Cynotis axiallaris.* Amongst the all weeds broad leaved weeds were dominated through out the crop growth period followed by grasses and sedges. The weed density was significantly lower in total sedges (0.74 and 0.62), total grasses (3.77 and 2.53) and total broad leaved weed (BLW's) (4.72 and 1.93) weeds m^{-2} with application of imazethapyr (10 IPR) 2000 ml/ha followed by 1500 ml/ha rate. Similarly the highest weed control efficiency was recorded with application of imazethapyr (10 IPR) 2000 and 1500 ml/ha; both were superior over rest of the treatments. There were no phytotoxicity like yellowing, chlorosis, necrosis, hyponasty and epinasty was observed within 0–10 days on visual observation (0–10 scale). The highest grain yield (17.25 q/ha) was recorded with imazethapyr (10 IPR) 2000 ml/ha followed by its lower rate of 1500 ml/ha (16.69 q/ha) which was significantly higher over rest of the treatments and weedy check (12.31 q/ha).

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STUDIES ON CHEMICAL AND INTEGRATED WEED MANAGEMENT IN *KHARIF* GROUNDNUT

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The field experiments were conducted during *Kharif* 2007 on red sandy loam soil at Agriculture research station, Chintamani, University of Agriculture sciences, Bangalore to study the effect of pre and post-emergence herbicides on *kharif* groundnut. The experiment was laid out in randomized block design with three replications. There were eight treatment combinations comprising different weed management practices including farmers practice. Pre-emergence application of pendimethalin @ 1 kg ai/ha along with post emergence application of quizolfop ethyl @ 50 g/ha and imazethapyr @ 75 g/ha were done. Among herbicidal treatments pre-emergence application of pendimethalin @ 1 kg/ha in combination with post-emergence application of quizailfop-ethyl @ 50 g/ha recorded significantly lower weed population and dry matter and better crop growth. Regarding the yield, pre-emergence application of pendimethalin at 1 kg/ha in combination with post emergence application of quizalofop at 50 g/ha recorded significantly higher pod yield (1531 kg/ha) and a higher benefit cost ratio (2.43) as compared to other treatments. The practical inference of the experiment were that the chemical weed control by pre-emergence application of pendimethalin @ 1 kg/ha and post emergence spray of quizalfop @ 50 g/ha or imazethapyr @ 75 g/ha at 25 DAS of groundnut in the kharif season controlled weeds effectively and significantly increased the yield of groundnut, but with substantial increase in the cost of cultivation compared to farmers practice.

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EFFECT OF DIFFERENT WEED CONTROL TREATMENTS IN NURSERY RAISING OF ONION

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Onion faces severe competition with the weeds at its initial stages of crop growth in nursery due to its inherent characteristics such as short stature, non branching habit, sparse foliage, shallow root system and extremely slow initial growth. Hand weeding in onion nursery is laborious, time consuming and expensive due to close spacing. Therefore, a field experiment was conducted during 2005-06 and 2006-07 at Krishi Vigyan Kendra Research Farm, Sonepat to evaluate weed control efficiency of different weed control treatment in nursery raising of onion. The treatments comprised different levels of three herbicides *viz.* methabenzthiazuron (0.50, 0.75 and 1.00 kg/ha), fluchloralin (0.75, 1.00 and 1.25 kg/ha), pendimethalin (1.00, 1.25 and 1.50 kg/ha), hand weeding and weedy check (control) were replicated thrice and arranged in randomized block design. All the herbicides used significantly reduced weed population over unweeded control. Observations recorded on seed germination percentage, number and weight of weeds/m^2 and weight of seedlings revealed that application of pendimethalin two days after seed sowing @ 0.75 to 1.25 kg/ha controlled weed significantly and produced as good seedlings as obtained from hand weeding treatment.

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INTEGRATED CONTROL OF WATER HYACINTH (*Eichhornia crassipes* (Mart.) Solms

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Water hyacinth (*Eichhornia crassipes* (Mart.) Solms – Laubach: Pontederiaceae) is one of the most troublesome aquatic weeds all over the world. In India, it has spread to all types of water bodied throughout the country and is believed to occupy over 2,00,000 ha of water surface. Excessive infestation of the weed deleteriously after water traffic, fishing potential, infrastructure for pumping, hydroelectricity generation, water use and biodiversity. Other damages include water loss due to evapotranspiration and an increased population of vectors of human diseases like malaria, encephalitis, schistosomiasis, filariasis. Integrated weed management (IWM) strategies are having a significant impact on water hyacinth control in Tamil Nadu. Water hyacinth had been reduced by over 70% within a period of 3 years. This has been achieved mainly through biological control, manual removal, quarantine regulations, and management of nutrient enrichment. Through manual removal, 60 landing beaches in Lake Veeranum were kept free of water hyacinth. Through biological control, two weevils, *Neochetina eichhorniae* and *N. bruchi*, have established with adult populations of up 30 per plant. There has been a significant reduction in water hyacinth plant population density, from 45 to 7 plants per 0.5 m^2, and large reduction in surface area covered and biomass. Maintenance and construction of wetlands have been used to minimize nutrient loading in lakes, ponds, rivers and satellite lakes. The management of water hyacinth in rivers and ponds that are acting as potential sources of infestation has recently begun.

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INTEGRATED WEED MANAGEMENT – THE WAY AHEAD

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Weeds have been associated since human started selective cultivation. By nature weeds are more adaptable with vigorous growth and prolific weed production for their survival. The losses caused by weeds are enormous, not only for their competition with crops and reduced yield or quality of the produce, but also for their nuisance in un-cropped areas and impact on human health. Chemical weed control introduced in the fifties and sixties changed the scenario with effective killing of weeds. The next three decade saw rapid rise in the use of herbicides for different crops and an easy, economical and efficient tool with farmers resulted in manifold increase in food production. But reliance on herbicides alone was not without a price as 350 weeds have become resistant to herbicides of several chemical classes spread over 60 countries. Though USA tops the list with 130 resistant weed species, the notoriety of resistant weeds is not without severe impact in many small and less developed countries thus reducing the scope of herbicides alone as a choice tool for effective weed management. Herbicide resistant weeds will further spread to more areas and

evolve with newer herbicides for their continuous use, challenging weed scientists for their effective management. An integrated approach where herbicide plays a pivotal role is the only way ahead for effective weed management. Use of weed free crop seed, field preparation methods (clean machinery), use of well rotten farm yard manure without weed seed, method of sowing, seed rate, planting time, varietal selection, scheduling of irrigation, amount and time of fertilizer application, herbicide selection based on field infestation of weeds, proper rate, time and method of herbicide application, herbicide rotation and mixture, use of adjuvants, mechanical weeding, monitoring and rogueing, field sanitation including bunds and water channels, weed trap during threshing, checking weed seed migration from field to field through produce, machinery including inadvertent role of man and animals and crop rotation are the major constituents of integrated weed management. Adaptation of these techniques over the years also lowers weed pressure and at time use of herbicide use can be escaped to reduce cost of cultivation without any effect on yield. Integrated weed management also lowers the carbon foot print and is environmentally benign with minimum risk of weed flora shift and evolution of resistant weed biotypes. The future demands that the farmer need to be more innovative to lower the menace of weeds by adopting new agronomic tools in an integrated manner for effective and efficient weed management.

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WEED MANAGEMENT IN WHEAT

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An experiment was conducted with the objective to study the efficacy of different weed control methods and to evaluate the most suitable and economical treatment combinations for controlling weeds in wheat. Weed intensity and dry matter of weeds at harvest were significantly lower in weed free (WF), pendimethalin PRE 1.0 kg/ha +HW, pendimethalin PRE g 0.75 kg/ha +HW. Maximum dry matter and weed intensity was observed in weedy check (WC). The growth of wheat measured in terms of height, number of functional leaves, number of tillers per plant and dry matter accumulation per plant was influenced by WF and followed by pendimethalin 1.0 kg/ha + HW. Beneficial effects on growth characters of plant in different treatments mentioned above resulted in enhancing yield contributory characters *viz.* ear bearing plants, number of spikelets per ear, number of grains per ear and thousand grain weight. Maximum values for yield attributing characters were observed in weed free up to 60 DAS followed by pendimethalin 1.0 kg/ha with one hand weeding at 40 DAS. The grain (42.50 q/ha) and straw yield (52.54 q/ha) of wheat was maximum in WF followed by pendimethalin 1.0 kg/ha + HW. The gross monetary returns were maximum in weed free up to 60 DAS (Rs. 39,801/ha) followed by pendimethalin 1.0 kg/ha + HW (Rs. 39041/ha). Maximum net monetary returns were obtained due to pendimethalin 1.0 kg/ha + HW (Rs. 22284/ha) followed by pendimethalin 0.75 kg/ha +HW (Rs. 20,990/ha) and WF (Rs. 20875/ha). Benefit:cost ratio (2.32) was maximum in pendimethalin 1.0 kg/ha + HW 40 DAS.

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EFFICACY OF IMAZETHAPYR FOR THE CONTROL OF WEEDS IN MUNGBEAN [*Vigna radiata* (L.) Wilczek]

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A field experiment was conducted during *kharif* 2008 at Punjab Agricultural University, Ludhiana to study the efficacy of imazethapyr against weeds in different mungbean varieties. Imazethapyr was tested at different doses i.e. 50, 75 and 100 g/ha applied at 15 or 25 days after sowing (DAS) along with unweeded and two hand weeding (20 and 40 DAS) treatments in three mungbean varieties namely PAU 911, ML 818 and ML 267. The experiment was conducted in split plot design by keeping weed control treatments in main plots and varieties in sub-plots. Imazethapyr at 75 and 100 g/ha at 15 DAS proved to be superior treatments for reducing weed dry matter as compared to other treatments. Yield contributing characters like pods/plant and 100-seed weight were higher with imazethapyr at 75 and 100 g/ha at 15 DAS than all other imazethapyr treatments but were on par with two hand weeding (20 and 40 DAS). Application of imazethapyr at 100 g/ha 15 DAS recorded the highest grain yield (1513 kg/ha), which was, statistically on par with that of imazethapyr 75 g/ha 15 DAS (1502 kg/ha) and two hand weeding (1471 kg/ha). Imazethapyr sprayed at different doses and at different times was safe to all the three mungbean varieties and the varieties did not differ significantly in grain yield.

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PRODUCTIVITY OF DSR (*Oryza sativa* L.) IN RELATION TO SOWING TIME, VARIETIES AND WEED CONTROL

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A field experiment was conducted at Punjab Agricultural University Ludhiana, during *kharif* 2008. The soil was loamy sand, low in organic carbon and available N, medium in available P and K. The field experiment comprised 24 treatment combinations *viz.* six sowing dates (direct seeding on 0 (June 5), 7, 14, 21 and 28 days after nursery sowing (DANS); transplanting 28 days after nursery sowing), two varieties (PR 115 and PAU 201) and two weed control (3 hand weeding at 20, 40, 60 days and pendimethalin 0.75 kg/ha pre-emergence followed by bispyribac-sodium 0.030 kg/ha as post emergence) were evaluated in a split plot design. Transplanted crop produced higher crop dry matter, longer panicle with more number of grains and accumulated lower weed dry matter as compared to direct seeded crop. However, grain yield was at par with direct seeding 0 DANS, but significantly higher than direct seeding on 7, 14, 21 and 28 DANS. Direct seeding of rice cv. PR 115 on day of nursery sowing produced grain yield similar to transplanted crop. Rice cv. PR 115 and PAU 201 did not show any marked differential influence on weed population and dry matter. Rice cv. PAU 115 gave significantly higher grain yield than PAU 201 when both were direct seeded at the time of nursery sowing. Pendimethalin 0.75 kg/ha *f.b.* bispyribac 0.03 kg/ha gave effective control of grasses and sedges. However, it recorded significantly higher dry matter accumulation of broadleaf as

compared to hand weeding treatment. Three hand weeding gave significantly higher grain yield than pendimethalin 0.75 kg/ha *f.b.* bispyribac 0.03 kg/ha. In economic terms; however, herbicidal treatment was better than three hand weeding. Direct seeding on day of nursery sowing of rice variety PR 115 coupled with herbicides or hand weeding gave rice grain yield similar to transplanted crop of same age. Direct seeding of PR115 had similar potential as under transplanting conditions, but direct seeding of PAU 201 did not show similar grain yield potential than transplanted. Transplanted crop recorded higher per cent recovery of brown, milled and head rice as compared to direct sown crop. PAU 201 recorded higher recovery of brown rice and head rice than PR 115. Hand weeded plots recorded higher recovery of brown and head rice than herbicide treated plots. Protein content of grain did not vary among direct seeding and transplanted crop, varieties and weed control treatments. It was concluded that DSR could produce grain yield similar to transplanted crop, provided it is raised with right combination of sowing time, variety and weed control.

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AZIMSULFURON 50 DF – A NEW HERBICIDE MOLECULE FOR WEED CONTROL IN TRANSPLANTED RICE

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A field experiment was carried out during *kharif* 2006 to and *kharif* 2009 in red loamy soil at Agricultural Research Station, Kathalagere, Channagiri taluk, Davangere district coming under the southern transitional zone of Karnataka. The present investigation was taken up to know the bioefficacy of azimsulfuron 50 DF and other weedicides in comparison with hand weeding on weed control, crop safety and grain yield of transplanted rice. The experiment was laidout in RCBD with 10 treatments every season. Application of azimsulfuron at 30.0 g/ha followed by one hand weeding at 40 DAT recorded three seasons mean higher grain and straw yield of paddy (6540 and 6844 kg/ha, respectively), followed by six seasons mean higher grain and straw yield in hand weeding twice at 20 and 40 DAT (6277 and 6763 kg/ha, respectively) mainly due to effective control of *Cyperus sps., Scirpus roylei, Fimbristyles miliacea*e, *Ludwigia parviflora, Lindernia sp.* and *Glinus oppositifolia* among the weedicidal treatments. Application of azimsulfuron at 30.0 g a/ha followed by one hand weeding at 40 DAT recorded lower density and dry weight of total weeds. Azimsulfuron at 27.5 g a/ha and 2,4-DEE at 2 kg/ha recorded lower grain and straw yield mainly due to ineffective control of weeds during the crop growth period.

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COMPARATIVE EFFICACY AND ECONOMICS OF HERBICIDE MIXTURES AGAINST MIXED WEED FLORA IN WHEAT

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The acute problem of both grassy and broad leaf weeds is not uncommon, which often results in huge yield losses and makes the weed management issue more complex. Various herbicides have been used for controlling weeds in wheat, but efficiency of chemical methods based on a single herbicide treatment may be unsatisfactory because of their narrow spectrum of weed control. So, for wider spectrum weed control, with less total active ingredient it is desirable to incorporate the strength by mixing two herbicides into one complementary mixture. Considering the above facts, the present investigation was carried out at Experimental Farm of Department of Agronomy, CSK HPKV, Palampur during *rabi* 2005-06. The 9 treatments consisting of tank mix application of isoproturon+2,4-D (1.0+0.75 and 1.5+0.75 kg/ha), sulfosulfuron + 2,4-D (0.025 + 0.75kg/ha), clodinafop + 2,4-D (0.09 + 0.75 kg/ha), mesosulfuron + iodosulfuron (0.012 + 0.0024 kg/ha), pendimethalin+2,4-D (1.5+0.75 kg/ha), metribuzin+2,4-D (0.2+0.75 kg/ha) with weed free and weedy check were tested in RBD with three replications. The soil of the experimental site was silty clay loam in texture with pH 6.1 and medium in available nitrogen, phosphorus and potassium.

Weeds in unweeded check reduced the crop yield of wheat to the tune of 63.3% over the best treatment. All the weed control treatments led to significant reduction in the total weed population and weed dry matter accumulation as compared to weedy check. Tank mix application of sulfosulfuron+ 2,4-D (0.025+0.75 kg/ha) behaving statistically alike to weed free completely controlled all the weeds (100% control) and marked their superiority over other weed control treatments in term of obtaining significantly higher grain yield (172.2 and 167.7 % higher over weedy check, respectively). However, application of clodinofop+ 2,4-D (0.09+0.75 kg/ha) was the next best treatment combination in significantly reducing the total weed count and their dry matter with weed control efficiency of 93.0% and was at par with these superior treatments for recording significantly higher grain yield (3245 kg/ha). The highest net returns (Rs. 25932/ha) with B:C ratio (2.9) was obtained with application of sulfosulfuron + 2,4-D (0.025+0.75 kg/ha) and was followed by clodinofop+ 2,4-D (0.09+0.75 kg/ha) with net rturns and B:C ratio of Rs. 24909/ha and 2.7, respectively.

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INTEGRATED WEED MANAGEMENT STUDIES IN MAIZE UNDER MID-HILL CONDITIONS OF HIMACHAL PRADESH

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A field experiment was conducted during *kharif* season of 2003 and 2004 at Experimental Farm of Department of Agronomy, CSK HPKV, Palampur in silty clay loam soil, having medium in organic carbon and medium in available nitrogen, phosphorus and potassium to find out the best integrated practice for weed control among these nine treatments *viz.* atrazine 1.5 kg/ha (Pre.) or early post (10 DAS), hoeing (15 DAS), halod and earthing up (30 DAS), hoeing 15 DAS + halod and earthing up (30 DAS), atrazine 1.5 kg/ha (Pre.) or early post (10 DAS) + halod and earthing up (30 DAS), atrazine 1.5 kg/ha (Pre.) +hoeing (15 DAS) + earthing up (30 DAS) with weedy check. The field experiment was laid out in RBD with 3 replications. Weeds were reduced significantly in all weed management treatments over weedy check. On an average, weeds in unweeded check caused yield reduction in maize to the extent of 53.3% over the best treatment where all the weeds were controlled most effectively. Effective control of weeds by significantly reducing the population and dry matter of total weeds was achieved with the application of atrazine either as pre or early post emergence (10 DAS) with halod and earthing up; atrazine 1.5 kg/ha (Pre.) with hoeing (15 DAS) and earthing up (30 DAS); hoeing 15 DAS with halod and earthing up (30 DAS); and halod & earthing up (30 DAS), ultimately attributed to obtain significantly higher grain yield over rest of the treatments. Higher weed control efficiencies (93.1 to 94.6 %) with lower weed index (up to 4.4 %) were recorded with these treatments. From economics point of view, while the highest net returns of Rs.20410 and 19650/ha was obtained with either the application of atrazine as pre or early post (10DAS) with halod & earthing up, respectively, the highest B:C ratio of 2.30 was obtained with the application of atrazine 1.5 kg/ha (Pre.) followed by atrazine 1.5 kg/ha (10 DAS).

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INFLUENCE OF WEED CONTROL ON QUALITY AND ECONOMICS OF STRAWBERRY (*Fragaria* x *ananassa* Duch.) CV. CHANDLER

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Investigations were carried out on weed control in strawberry during 2007-08 which revealed that weed free treatment proved significantly superior in improving the quality traits of fruit which was at par with black polythene mulch treatment and oxyfluorfen @ 0.55 kg/ha. Maximum fruit length (31.31mm), fruit diameter (22.70 mm), fruit weight (12.26 g), fruit yield (182.0 q/ha), highest total soluble solids (6.83^0 Brix), total sugars (4.72 %) and ascorbic acid (71.05/100 g) of fresh berries were obtained under weed free plots. Black polythene mulch treatment also proved economical with benefit-cost ratio of 1.56 as compared to other weed control methods.

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INTEGRATED WEED MANAGEMENT IN TRANSPLANTED ONION (*Allium cepa L*)

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A field experiment was conducted during *rabi* season on the farmers field at Kuralahally Chickballapur Dist., Karnataka to find out the better weed management practices in transplanted onion. The soil was sandy loamy texture and medium in fertility. The experiment consisted of 16 treatments replicated thrice. The treatments include four pre emergence herbicides alone (oxyfluorfen 23.5% EC, metolachlor 50% EC, pendimethalin 30 % EC and butachlor 50% EC) and integrated with one hand weeding (HW) at 45 days after transplanting (DAT) and only hand weeding at different crop growth stages, all compared with weed free and unweeded check. The experiment was laid out in randomized complete block design (RCBD). The predominant weed flora observed in experimental plots was *Eragrostis ciliensis, Dactyloctenium aegyptium, Dicanthium annulatum, Digitaria marginata, Cynadon dactylon, Galensoga parviflora, Cenebra didyma, Aamaranthus viridis, Oxalis latifolia, Commelina benghalensis, Euphorbia geniculata, Legasca mollis* and *Cyperus rotundus*. Uncontrolled weed growth throughout the crop growing period caused 76 % reduction in bulb yield. Pre emergence application (6 DAT) of oxyfluorfen @ 0.09 kg/ha + HW at 45 DAT has resulted in significantly lower weed population (39/m^2) and their dry weight (15.32 g/m^2) and recorded higher bulb yield (159.73 q/ha), net returns (Rs. 40867/ ha) and B:C ratio (1.77) compared to un weeded check. (weed population; 412 /m^2, weed dry weight; 264 g/m^2, bulb yield; 40.8 q/ha, net returns; Rs. 3376/ha and B:C ratio; 0.17). The next best treatments which recorded at par yield as that of oxyfluorfen were pre emergence application of pendimethalin @ 0.75 ka/ha + HW at 45 DAT and metolacholar @ 0.75 kg/ha at 45 DAT. No phyto-toxicity symptoms of these herbicides were observed on crop.

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SMOTHERING POTENTIAL OF CANOLA GOBHI SARSON (*Brassica napus* L.) CULTIVARS AGAINST WEEDS AS INFLUENCED BY NITROGEN LEVELS

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The field experiment was conducted at Punjab Agricultural University, Ludhiana during the *rabi* season of 2008-09. The soil was loamy sand in texture, low in available N and medium in available P and K. The field experiment comprised of 16 treatment combinations *viz.* four nitrogen levels as main plot treatments (100, 125, 150 and 175 kg N/ha), two cultivars (GSC 6 and Hyola PAC 401) and two weed control methods (weeded and unweeded control) as sub plot treatments. The experiment was laid out in a split plot design with three replications. The crop registered significantly higher value of seed yield (19.29 q/ha) and protein content (18.80 %) with the application of 125 kg N/ha, with further increase in nitrogen up to 150 and 175 kg

N/ha the increase was non-significant. The weed population and dry matter accumulation data revealed decreasing trend with increasing level of nitrogen except at 30 DAS, though differences were non-significant. Among the cultivars, the difference in weed population and dry matter accumulation was non-significant. There was no difference in competitive ability of both cultivars. Hyola PAC 401 yielded (20.21 q/ha) higher because of its higher yield potential than GSC 6 (18.87 q/ha). Hand weeding treatment registered higher values of yield attributes *viz.* plant height, dry matter, LAI, primary and secondary branches/ plant, number of siliquae/plant, which resulted in higher seed yield (20.67 q/ha) as compared to unweeded control. Protein and oil content were inversely proportional with each other. Oil content decreased with increase in nitrogen level recording maximum value (41.32 %) at 100 kg N/ha, whereas protein content increased with increase in nitrogen level recording maximum value (20.42 %) at 175 kg N/ha.

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WEED DYNAMICS AND YIELD OF FENUGREEK (*Trigonella foenum-graecum* L) AS INFLUENCED BY IRRIGATION AND WEED MANAGEMENT PRACTICES

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A field study on weed dynamics and yield of fenugreek (*Trigonella foenum-graecum* L) as influenced by irrigation and weed management practices was conducted during 2006-07 and 2007-08 at SDAU, Sardarkrushinagar (Gujarat) to find out effective weed control measure along with proper irrigation schedule. The experiment comprising three levels of irrigation (0.6, 0.8 and 1.0 IW/CPE ratios) in main plot and six weed control treatments (weedy check, weed free, hand weeding at 20 and 40 DAS, HW at 20 + IC at 40 DAS, application of pendimethalin @ 0.75 kg/ha (PE) and application of pendimethalin @ 0.75 kg/ha (PE) + IC at 40 DAS) in sub plots was carried out in split plot design with four replications. Irrigation at 1.0 IW/ CPE ratio resulted significantly higher weed population, dry weight of weeds, and yield of fenugreek over 0.8 and 0.6 IW/CPE ratios during both the years and in pooled analysis. At maturity, besides weed free treatments, the lowest dry weight of weed, number of monocot weed/ m^2as well as highest weed control efficiency was recorded with hand weeding (HW) at 20 and 40 DAS but lowest number of di-cot weed/m^2 and weed index as well as higher seed and straw yield was recorded with pre emergence application of pendimethalin @ 0.75 kg /ha + IC at 40 DAS during both years. Therefore, in terms of yield and weed indices the pre emergence application of pendimethalin @ 0.75 kg/ha + IC at 40 DAS and HW at 20 and 40 DAS were as effective as weed free treatment. Thus, it is inferred that application of irrigation at 1.0 IW/ CPE ratio and weed control with pre emergence application of pendimethalin@ 0.75 kg/ha + IC at 40 DAS is better for realising higher yield of fenugreek.

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COMPARATIVE EFFICACY OF HERBICIDES FOR CONTROLLING GRASSY WEEDS IN RAINFED WHEAT IN SUB-MOUNTAIN OF HIMACHAL PRADESH

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Past experience in wheat in India has shown that the continuous use of one herbicide lead to development of herbicide resistance and shifting of weed flora. Therefore, to decrease the selection pressure against weed species, it is important to evaluate the new herbicides for their effectiveness against weeds. Keeping this in view, the present study was conducted during *rabi* 2005-06 at Experimental Farm of Deptt. of Agronomy, CSK HPKV, Palampur in RBD with 10 treatments in three replications. The treatments tested were isoproturon 1.5 kg/ha, sulfosulfuron 0.025 kg/ha, clodinofop 0.09 kg/ha, pendimethlin 1.5 kg/ha, mesosulfuron 0.015 kg/ha, diclofop 0.75 kg/ha, fenoxaprop 0.15 kg/ha, metribuzin 0.2 kg/ha with weed free and weedy check. The soil of the experiment site was silty clay loam in texture with pH 6.1 and medium in available nitrogen, phosphorus and potassium. All the herbicides except pendimethalin and metribuzin (applied as pre.) were applied as post emergence (30-35 DAS) with knapsack sprayer using 750 L/ha of water. All the weed control treatments were proved to be significantly superior in reducing the count and dry matter of total weeds over unweeded check. The weed growth in term of total weed density and weed dry matter production were significantly lowest in weed free plots. Among various herbicide treatments application of sulfosulfuron 0.025 kg/ha, clodinofop 0.09 kg/ha and metribuzin 0.2 kg/ha significantly reduced the total weed density and weed dry matter accumulation over other weed control treatments, reflected in getting significantly higher grain yield (79.6, 80.9 and 63.1% higher over weedy check, respectively) with higher weed control efficiencies of 95.9, 93.5 and 94.1%, respectively. The maximum net returns of Rs. 22439/ha was obtained with the application of clodinofop 0.09 kg/ha followed by sulfosulfuron 0.025 kg/ha (Rs. 22395/ha) with B:C ratio of 2.5 and 2.4, respectively, which was lower than with isoproturon 1.5 kg/ha (2.7) having net returns of Rs. 22100/ha.

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CROP PRODUCTIVITY AND GROWTH OF ASSOCIATED WEEDS IN RELATION TO WEED MANAGEMENT PRACTICES IN SESAME

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Farmers rely predominantly on manual weeding as a traditional method of weed control in oilseeds in general and sesame in particular. Being expensive, labour intensive and time consuming, this necessitates for an alternative cost effective economically viable weed management practice that can serve as a substitute for manual weeding. To evaluate the selectivity and efficacy of some pre-emergence herbicides on the productivity of sesame and growth of associated weeds, field experiments were conducted during 2004 to 2006 at Oilseeds Research Farm of Punjab Agricultural University, Ludhiana (30°56′N, 75°52′E and 247 m msl) under semiarid subtropical conditions. There were eight treatments consisting of alachlor (1.5 kg/ha), fluchloralin (1 kg/ha) and trifluralin (1 kg/ha) alone and in combination with one hand weeding 4 weeks after sowing, hand weeding 3 WAS and unweeded control. The dominant weeds in the field were *Commelina, Digiteria, Eleusine* and *Cyperus* species. All the weed control treatments significantly reduced the population and dry weight of weeds and increased seed yield over weedy check. Seed yield of sesame was negatively correlated with dry matter of weeds. An R^2 value of 0.95 indicated that dry matter of weeds alone accounted for nearly 95% of variation in seed yield of sesame. Integration of hand weeding with herbicide application though resulted in higher seed yield, but the net income and B:C ratio were lower when compared with application of herbicide alone. The highest economic returns were recorded with pre-emergence application of alachlor @ 1.5 kg/ha and this treatment was found to be as effective as manual weeding in reducing the weeds population and obtaining similar seed yield. To validate the research results under actual farmers' management practices, the farmers' participatory demonstrations were conducted at 17 locations in 6 districts of Punjab by applying hand weeding 3 WAS, pre-emergence application of alachlor @ 1.5 kg/ha and unweeded check in the treatment plots. The results revealed that alachlor (1.5 kg/ha) treated plots resulted in effective weed management and gave 43.4 and 3.0 % higher seed yield as compared to unweeded control and hand weeding 3 WAS, respectively. This study identifies cost effective herbicide based weed management through pre-emergence application of alachlor @ 1.5 kg/ha as an alternate to manual weeding in sesame.

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EFFECT OF SCHEDULING OF IRRIGATION, WEED MANAGEMENT AND NITROGEN LEVELS ON WEED GROWTH IN RICE UNDER AEROBIC CONDITIONS

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A field study was conducted at Agricultural Research Station, Kampasagar, Nalgonda district of Andhra Pradesh during the *kharif* season of 2008 and 2009 to find out the effect of irrigation schedules, weed management practices and nitrogen levels on weed density (WD), weed dry matter production (WDMP) at different growth stages and nutrient uptake by weeds in rice grown under aerobic condition. The experiment was laid out in split-split plot design with two irrigation schedules (irrigation once in 2 days (30 mm at 0.5 bar soil moisture tension) and irrigation given once 7 days up to vegetative stage (50 mm at 1.0 bar soil moisture tension) and once 4 days interval during reproductive stage (40 mm at 0.5 bar soil moisture tension) as main plots, three weed management treatments (pre emergence application of pendimethalin @ 1 kg/ha fb cono weeding at 30 DAS and one HW at 45 DAS, pre emergence application of pendimethalin @ 1 kg/ha fb 2, 4 D Na salt @ 1 kg/ha at 40 DAS and HW at 20 and 45 DAS) as sub plots and three nitrogen levels (120, 150 and 180 kg N/ha) as sub-sub plots. The major weed flora observed in experimental plot was *Echinochloa colona*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Cyperus rotundus* (Monocots). *Eclipta alba*, *Trianthema portulacastrum* and *Amaranthus viridis*, (Dicots). Weed density and weed dry matter were significantly lower in irrigation scheduled at 7 days interval during vegetative stage and 4 days interval during reproductive stage at 20 DAS, whereas at harvest, WD and Weed DMP were significantly lower in irrigation once in 2 days and reverse trend was observed with NPK uptake by weeds. Among weed management treatments, pre emergence application of pendimethalin @ 1 kg/ha fb cono weeding at 30 DAS and one HW at 45 DAS recorded significantly lower WD, weed DMP and NPK uptake by weeds than the pre emergence application of pendimethalin @ 1 kg/ha fb 2, 4 D Na salt @ 1 kg/ha at 40 DAS which in turn recorded significantly lower values of above said weed parameters than HW at 20 and 45 DAS. Increase in nitrogen level from 120 to 150 and 180 kg N/ha significantly increased the WD, weed DMP and NPK uptake by weeds.

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WEED CHARACTERISTIC AND CANE YIELD OF SUGARCANE AS INFLUENCED BY PHOSPHORUS MANAGEMENT IN *KHARIF* RICE-AUTUMN SUGARCANE CROPPING SYSTEM

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Field experiments conducted during the year 2004-05 and 2005-06 at Regional Sugarcane Research Station Farm, Navsari Agricultural University, Navsari. Results revealed that application of 40 t/ha pressmud biocompost to preceding *kharif* rice crop increased the millable cane yield, but weed population and dry weight of weeds did not differ significantly due to different phosphorus management treatments applied to the preceding crop of rice. While, application of 100% recommended dose of phosphorus (54.59 kg P/ha) to sugarcane raised without intercrop of greengram resulted in significantly higher millable cane yield. The lowest weed population (monocots and total weeds) and their dry weight at 90 DAP and at final earthing up were noted under no application of phosphorus to sugarcane raised with intercrop of greengram.

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EFFICACY OF HERBICIDE APPLICATION METHODS IN TRANSPLANTED RICE

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Four herbicide application methods viz. (i) Herbicide mixed with sand @ 150 kg/ha (recommended method), (ii) Spray of herbicide, (iii) Mixing of herbicide oozing from a container kept at entry point with irrigation water, (iv) Herbicide application using empty corked bottle with two holes in the cork (method commonly followed by the farmer) were evaluated in transplanted rice at the farmers' field under low land conditions in Punjab during kharif seasons of 2007 & 2008. Variety PAU 201 was transplanted between June 20 and 30. Recommended dose of pretichlor 50 EC@ 1500 ml/ha was applied with the specified method on the day of transplanting. A plot size of 1250 sq.m was kept for each treatment. Study was conducted at five locations during each year. Crop was harvested between 20 & 27 October. All the four methods of herbicide applications proved statistically at par for controlling weeds and paddy productivity. However, numerical differences followed the same pattern for all the characters recorded. Method No. 3 (Mixing of herbicide oozing from a container kept at entry point with irrigation water) was found to be most economical but slightly less efficient than others, whereas, Method II (spray of herbicide) was most expensive. The marginal increase in the cost of herbicide application with method IV (herbicide application using empty corked bottle with two holes in the cork) was compensated by higher productivity with the former method. It can, thus, be concluded that application of herbicide using empty corked bottles with two holes in the cork (method commonly followed by the farmer) is economical and as efficient as the recommended method of mixing herbicide with 150 kg sand/ha.

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ROLE OF ORGANIC MATERIALS FOR MANAGEMENT OF WATER HYACINTH

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Field experiment was conducted at university of Mysore, during April - June 2010 to study the effective and economic method for managing water hyacinth (*Eichhornia crassipes*) at Kukkarahalli lake of Mysore, with the locally available low cost materials like clay soil, red soil, fresh cow dung slurry and *Coleus amboinicus* leaf extract. The experiment was conducted in two experimental designs with four replications. The experimental design (I) treatments consisted of different organic materials *viz.* C-control, R_1-Red soil @ 2:1 ratio with water, R_2- clay soil @ 2:1 ratio with water, T_1-clay+red+ cow dung @ 2:1 ratio with water. Among the organic materials treatments, T_1- attributes more number of dried leafs. The experimental design (II) treatments consisted of different organic materials *viz.* C-control, R_1-Red soil +5ml leaf extract @ 2:1 ratio with water, R_2- clay soil +5 ml of leaf extract @ 2:1 ratio with water, T_{1-} clay + red+ cow dung + 5ml of leaf extract @ 2:1 ratio with water. The experiment two was conducted with same ratio with addition of 5 ml of *Coleus* leaf extract's attributes like complete drying of the plant within a day after the application. Organic materials like application of clay act as an antitranpirant and *Coleus* leaf extract exhibit the allelopathic potential.

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WEED CONTROL IN SUGARCANE RATOON CROP

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A field experiment was conducted on sugarcane ratoon crop to develop suitable weed management practices during spring season of 2007-08 and 2008-09 at Sugarcane Experimental Area, (Ladhowal) Punjab Agricultural University, Ludhiana. Treatments were applied to ratoon crop immediately after harvesting of plant crop in the Ist week of February during both the years. The experiment was comprised of fourteen treatments including weedy check (control treatment) and manual weeding at Ist, 4th and 7th week after ratoon initiation replicated thrice in randomized block design. The highest weed dry matter was recorded in control treatment (184 g/m^2). All other treatments recorded significantly less weed dry matter as compared to the control. The highest pooled cane yield of 74.3 t/ha was obtained when metribuzin (Sencor) was applied @ 1.4 kg/ha as pre-emergence followed by 2,4-D @ 1.6 kg/ha at 45 days after ratoon initiation (DARI). The weed dry weight was significantly reduced to less than one third (52.7g/m^2) compared to control (184.0 g/m^2) when metribuzin was applied @ 1.4 kg/ha as pre-emergence followed by 2,4-D @ 1.6

kg/ha at 45 DARI. Atrazine applied @ 2 kg/ha as pre-emergence followed by 2,4-D @ 1 kg/ha at 45 days after ratoon initiation proved equally effective as metribuzin @ 1.4 kg/ha f.b. 2,4-D @ 1.6 kg/ha at 45 DARI. Spraying the sugarcane ratoon crop with atrazine @ 2 kg/ha followed by 1.0 kg/ha of 2,4-D 45 DARI or metribuzin @ 1.4 kg/ha as pre-emergence followed by 2,4-D @ 1.6 kg/ha at 45 DARI gave net returns of Rs. 80,599/- and Rs. 79,753/- respectively which was 56.7% and 55.1% higher over the control. The results concluded that pre- emergence application of either atrazine @ 2.0 kg/ha followed by 2,4-D @ 1.0 kg/ha 45 days after ratoon initiation or metribuzine @ 1.4 kg/ha followed by 2,4-D @ 1.6 kg/ha 45 days after ratoon initiation can be used for effective weed control in sugarcane ratoon crop.

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STUDIES ON BIO-EFFICACY OF IMAZETHAPYR FOR WEED CONTROL IN SOYBEAN [(*Glycine max* L. (Merrill)]

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A field experiment comprising imazethapyr (a post emergence herbicide) applied at 15 and 25 days after sowing (DAS) with three doses of 50, 75 and 100 g/ha, pendimethalin 0.45 kg/ha (pre-emergence) + hand weeding (40 DAS), two hand weeding (20 + 40 DAS) and unweeded control was conducted at Punjab Agricultural University, Ludhiana during 2008 in a randomized block design. All the herbicide treatments did not influence plant height, seeds/pod and 100-grain weight significantly. The highest pods/plant were recorded in imazethapyr 75 g/ha applied 25 DAS which were significantly higher than with imazethapyr 50 g/ha and unweeded control, but statistically at par with all other weed control treatments. All weed control treatments recorded significantly higher grain yield than unweeded control. The highest grain yield of soybean was recorded with imazethapyr 100 g/ha applied 15 DAS which was statistically at par with imazethapyr 100 g/ha at 25 DAS, imazethapyr 75 g/ha 15 or 25 DAS and two hand weeding, but significantly higher than all other treatments. The lowest weed dry matter accumulation was recorded in imazethapyr 75 g/ha 25 DAS which was statistically at par with imazethapyr 100 g/ha applied at 15 or 25 DAS, imazethapyr 75 g/ha applied 15 and two hand weeding, but significantly higher than all other treatments. The highest net returns and B:C ratio were recorded in imazethapyr 75 g/ha applied at 15 DAS.

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CROSS RESISTANCE AGAINST PINOXADEN IN *Phalaris minor* Retz.

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Phalaris minor Retz. is a major weed of wheat fields in Haryana. It evolved resistance to phenyl urea herbicide, isoproturon, an inhibitor or Photosystem-II, after a continuous use of this herbicide for over 15 years in an area where rice-wheat has been the rotation system. Acetyl coenzyme A inhibitors (ACCase) fenoxaprop-P-ethyl and clodinafop-propargyl belonging to the category aryloxyphenoxy propionates were recommended for the management of this weed in 1998. While signs of evolvution of cross-resistance to fenoxaprop started to appear within 3-5 years of continuous use, reports of evolution of cross resistance to

clodinafop appeared later. Pinoxaden, another ACCase inhibitor belonging to a category phenylpyrazolin was announced in 2006 for managing resistant biotypes belonging to category aryloxyphenoxy propionates. Twenty six biotypes of *P. minor* were collected from different regions of Haryana in April 2009. These were tested for efficacy of fenoxaprop (120 g/ha), clodinafop (60 g/ha) and pinoxaden (50 and 100 g/ha). Three out of 26 biotypes were highly resistant, 12 were moderately resistant and 11 were susceptible to fenoxaprop. Fourteen biotypes were highly resistant and 12 were moderately resistant to clodinafop and none of the biotypes was susceptible to clodinafop. *P. minor* biotypes (Chanarthal, Ambala-Badi, Uchana, Kutail, Jind-Raseedan and Kaithal) were moderately resistant to pinoxaden. Seven biotypes out of 26 were tested for efficacy of this by deriving GR_{50} values from dose response curves on growth, by membrane permeability tests and by pigment retention tests. The GR_{50} value was 10 g/ha against biotype from HAU Hisar, and was in the range of 28-35g/ha against biotypes from Uchana, Ambala and Nangla. The GR_{50} value against biotype from Chanarthal was 12 times higher i.e. 120 g/ha. The variability in GR_{50} values is indicative of its variable efficacy on different biotypes. While it could provide moderate control of some populations, it was not effective against some populations. The data is supported by pigment retention tests and ion efflux tests.

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INTEGRATED WEED MANAGEMENT IN TRANSPLANTED CELERY (*Apium graveolens* Linn.)

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A field experiment was conducted at Students Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during *rabi* 2008-09 to study the performance of different herbicides at varying doses, *viz.* pendimethalin 0.5 kg, 0.75 kg and 1.0 kg/ha and trifluralin 0.75 kg, 1.0 kg and 1.25 kg/ha and oxyfluorfen 0.15 kg, 0.17 kg and 0.20 kg/ha applied after transplanting and combination of lowest dose of each herbicide followed by one hand weeding 40 days after transplanting (DAP) in comparison to two hand weedings (at 20 and 40 DAP) and unweeded control in transplanted celery. All the herbicides and two hand weeding treatments significantly reduced total weed population and their dry weight as compared to unweeded control. The lowest dose of oxyflourfen integrated with one hand weeding was most effective in reducing the population and dry weight of weeds and gave maximum weed control efficiency (91.9 %). The integration of oxyfluorfen 0.15 kg/ha with one hand weeding at 40 DAT produced maximum number of branches (47.2) and umbels (78.8) per plant. The maximum (13.0 q/ha) seed yield of celery and net return (Rs. 32292/ha) were obtained with oxyfluorfen 0.15 kg/ha followed by one hand weeding. The seed yield of oxyfluorfen 0.15 kg/ha integrated with one hand weeding was statistically similar to pendimethalin 1.0 kg/ha, pendimethalin 0.5 kg/ha supplemented with one hand weeding, oxyfluorfen 0.20 kg/ha as well as two hand weeding treatments. Different weed control treatments did not influence the essential oil content in seed significantly.

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EVALUATION OF PRE AND POST EMERGENCE HERBICIDES FOR RAINFED GROUNDNUT THROUGH INTEGRATED WEED MANAGEMENT APPROACH

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An experiment was conducted at Weed Control Scheme, Department of Agronomy, Junagadh Agricultural University, Junagadh during rainy season of 2005, 2006 and 2007 to study the performance of pre and post emergence herbicides along with hand weeding and interculturing for rainfed groundnut. Results indicated that higher pod and haulm yields of groundnut, lowest dry weight of weeds and weed index, higher weed control efficiency, maximum gross and net realization during individual years as well as on pooled basis were recorded by hand weeding and interculturing done at 15, 30, 45 and 60 DAS followed by pre emergence application of pendimethalin 1.0 kg/ha coupled with HW and IC at 30 DAS and post emergence application of quizalofop-ethyl 40g/ha at 25 DAS combined with HW and IC at 45 DAS .

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MANAGING WEEDS IN DIRECT SEEDED RICE

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Rice is the most important cereal crop in India and is mainly grown as puddled transplanting. Due to scarcity of labour and degradation of soil resources now emphasis is being given on direct-seeded-rice (DSR) in place of conventional puddled transplanted rice. However, the success of DSR is mainly dependent on the effective weed management as weeds are the serious problem in this aerobic system of rice cultivation. The losses caused by weeds in this system are severe compared to transplanted system. Therefore, development of effective weed management strategies for DSR is needed. DSR is generally infested by diverse type of weed flora. However the major challenge is to control grassy weeds and even to control grassy weeds combination of herbicides is needed. Herbicides found effective against grass weeds are pendimethalin, cyhalofop-butyl, fenoxaprop-P-ethyl, propanil, bispyribac and penoxsulam whereas triclopyr, carfentrazone, halosulfuron, bensulfuron, azimsulfuron, 2,4-D and chlorimuron+metsulfuron are effective against broadleaved weeds and sedges. Supplementing the herbicide application with one hand weeding around 40-45 days after sowing improves weed control and rice productivity. Further adopting integrated weed management (IWM) consisting of integration of herbicide application with stale seed bed technique, use of competitive varieties, water management, use of weed free seed and manual weeding will provide the sustainable weed management for DSR.

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EFFECTS OF GENOTYPE AND WEED MANAGEMENT ON WEED COMPETITIVENESS OF AEROBIC RICE

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The field experiments were conducted during *Kharif* 2008 and summer 2009 at the department of Agronomy, GKVK farm on red sandy loam soils to study the effect of weed management on weed competitiveness of aerobic rice genotypes. It was laid out in factorial RBD design during two seasons with four genotypes *viz.*, MAS 946-1 (G_1), MAS 868 (G_2), MAS 26 (G_3) and MAS 109 (G_4) and weed management practices such as inter cultivation at 30 and 45 DAS (W_1), pre emergent application of pyrazosulfuron-ethyl @ 25 g/ha with hand weeding at 30 DAS and intercultivation at 45 DAS (W_2) hand weeding at 30 and 45 DAS (W_3) and un weeded control (W_4) replicated thrice. Weed flora of the experimental field comprised *Cyperus rotundus, Digitaria marginata, Dactyloctenium aegyptium, Chloris barbata, Cynodon dactylon. Echinochloa colona* (among grasses); *Euphorbia hirta, Parthenium hysterophorus, Mollugo cerviana, commulina bengalensis, Croton bonplandium* and *Celosia argentia* among broadleaf weeds. The grain yield of MAS 868 (3283 and 3591 kg/ha) and MAS 946-1 (3190 and 3446 kg/ha) was significantly higher over MAS 26 (2867 and 3066 kg/ha) and MAS 109 (2701 and 3033 kg/ha) during 2008 and 2009, respectively. The water use efficiency (WUE) of MAS 868 was 27.3 and 24.6 kg/ha during 2008 and 2009, respectively which was at par with MAS 946-1 (26.5 and 23.5 kg/ha). Significantly higher yield was observed with hand weeding at 30 and 45 DAS (3940 and 4367 kg/ha), which was at par with pre-emergence application of pyrazosulfuron @ 25 g/ha with hand weeding at 30 DAS and inter cultivation at 45 DAS (3921 and 4327 kg/ha) and significantly superior over inter cultivation at 30 and 45 DAS (3310 and 3537 kg/ha) and un weeded control (871 and 905 kg/ha) during 2008 and 2009. The WUE was significantly higher with hand weeding at 30 and 45 DAS (32.7 and 30.8 kg/ha/cm) which was at par with pre emergence application of pyrazosulfuron @ 25 g/ha with hand weeding at 30 DAS and inter cultivation at 45 DAS (32.6 and 29.6 kg/ha/cm). Significantly lower weed biomass was observed with hand weeding at 30 and 45 DAS which was significantly superior over rest of the treatments at different growth stages. The higher weed control efficiency and lower weed index was observed with MAS 26 and MAS 109 compared to MAS 868 and MAS 946-1.

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DETERMINING SUITABLE WEED MANAGEMENT PRACTICE FOR THE SELECTED GENOTYPES OF AEROBIC RICE

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A field experiments was conducted during *kharif* 2009 selecting two weed competitive genotypes MAS 868 and MAS 946-1 of rice to standardize the weed management practices for improving yield potential. The experiment was laid out in factorial RBD design with two selected weed competitive genotypes MAS 868 (G_1) and MAS 946-1 (G_2) and an integrated weed management practices such as inter cultivation at 30 and 45 DAS (W_1), pre-emergence application of pyrazosulfuron-ethyl 25 g/ha + inter-cultivation at 30 and 45 DAS (W_2), pyrazosulfuron at 25 g/ha +inter-cultivation at 30 DAS + hand weeding at 45 DAS (W_3), pyrazosulfuron at 25 g/ha + 2, 4 –DEE (38 EC) @ 1.0 kg/ha + inter -cultivation at 45 DAS (W_4), weed free check (W_5) and un-weeded control (W_6) replicated thrice. Weed flora of the experimental field comprised *Cyperus rotundus, Digitaria marginata, Dactyloctenium aegyptium, Chloris barbata, Cynodon dactylon. Echinochloa colona* (grasses); *Euphorbia hirta, Parthenium hysterophorus, Mollugo cerviana, commulina bengalensis, Croton bonplandium* and *Celosia argentia* (BLW). The higher grain yield of MAS 868 (3739 kg/ha) which was significantly higher over MAS 946-1 (3566 kg/ha). Significantly higher straw yield and harvest index was observed with MAS 868 when compared to MAS 946-1. Grain yield was significantly higher with weed free check (W_5) (4765 kg/ha) which was at par with pyrazosulfuron 25 g/ha + 2, 4 –DEE (38 EC) @ 1.0 kg/ha + inter-cultivation at 45 DAS (W_4) (4520 kg/ha) and significantly superior over pyrazosulfuron 25 g/ha +inter cultivation at 30 DAS + hand weeding at 45 DAS (W_3) (4056 kg/ha), pyrazosulfuron 25 g/ha + inter cultivation at 30 and 45 DAS (W_2) (3942 kg/ha), inter cultivation at 30 and 45 DAS (W_1) (3720 kg/ha) and un weeded control 915 kg/ha). Significantly higher net returns, B:C ratio was observed with pyrazosulfuron 25 g/ha + 2, 4 –DEE (38 EC) @ 1.0 kg/ha + inter cultivation at 45 DAS which was significantly superior over weed free check (2.20) and pyrazosulfuron 25 g/ha with inter cultivation at 30 and 45 DAS (2.24). Higher weed control efficiency and lower weed index was observed with MAS 868 compared MAS 946-1 and with weed free check and pyrazosulfuron 25 g/ha + 2, 4 –DEE (38 EC) @ 1.0 kg/ha + inter cultivation at 45 DAS.

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PERFORMANCE OF DIRECT SEEDED RICE (*ORYZA SATIVA* L.) UNDER DIFFERENT PLANTING DENSITIES

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A field experiment was conducted during *kharif* 2009 at Research Farm, Department of Agronomy, PAU, Ludhiana to assess the performance of direct seeded rice using different seed rates i.e. 20, 30, 40 and 50 kg/ha with different row to row spacing i.e. 15, 20, 25 and 30 cm. The plant height, effective tillers per square metre, panicle length, seed weight per panicle and seed yield did not differ significantly under different seed rates and row spacing. There was increase in number of effective tillers and paddy yield with the

successive increase in seed rate but decrease in seed weight per panicle though the differences were non-significant. Plant height at 90 DAS was significantly higher under closer row spacing (15 cm) as compared to wider row spacing of 25 to 30 cm, but it was at par with that obtained under 20 cm row spacing. At 140 DAS, plant height did not differ significantly under the influence of different row spacing. The highest grain yield (58.68 q/ha) was observed under closer row spacing but the differences among different row spacing were non-significant.

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EFFECT OF FERTILIZER AND MANURE ON WEED INCIDENCE, DEPLETION OF NUTRIENTS BY WEEDS AND YIELD OF SOYBEAN

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A field experiment was conducted during the rainy season of 2008 to study the effect of fertilizer and manure on weed incidence and depletion of nutrients by weeds in soybean. The dominant weed flora was broad leaved 33.63%, *Commelina commnunis* 14.68 %, *Echinochloa colona* 11.97 %, *Cyperus rotundus* 10.14 %, *Cynodon dactylon* 6.70 % and other weeds 22.86 %. Among the different fertility levels, 100 % NPK + 15 t FYM /ha gave significantly lowest weed biomass, highest (61.51%) WCE, zero percent weed index, significantly highest grain yield (8.13 q/ha), highest NPKS nutrient contents in weeds and lowest depletion of NPKS nutrient by weeds.

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EFFECT OF WEED MANAGEMENT PRACTICES ON YIELD AND ECONOMICS OF FENUGREEK (*TRIGONELLA FOENUM-GRAECUM* L)

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A field study was conducted during 2007-08 and 2008-09 on the effect of weed management practices on fenugreek under sandy loam soil at NRCSS, Ajmer. The experiment was laid out in a randomised block design with three replications. The study revealed that besides weed free treatment, significantly higher plant height, number of branches/plant, number of nodules/plant, dry weight of nodules/plant and dry matter accumulation/plant (60 and 90 DAS and at harvest) was recorded with the pre-emergence (PRE)application of oxadiargyl 75 g /ha + one hand weeding at 45 days after sowing (DAS) which being at par with PRE application of pendimethalin 1.0 kg/ha + one hand weeding at 45 DAS. Number of pods/ plant, length of pod, pod weight, number of seed/pod and test weight as well as highest seed and straw yield of fenugreek was recorded with PRE application of oxadiargyl 75 g /ha + one hand weeding at 45 DAS which was at par with PRE application of pendimethalin 1.0 kg/ha + one hand weeding at 45 DAS, except weed free treatment. Besides weed free treatment, lowest weed dry weight at harvest and weed index with highest weed control

efficiency was obtained under PRE application of oxadiargyl 75 g/ha + one hand weeding at 45 DAS. The Highest gross returns and net returns/ha was obtained in weed free treatment followed by effective control of weed with PRE application of oxadiargyl 75 g/ha + one hand weeding at 45 DAS, but highest B: C ratio (4.38) was recorded with PRE application of oxadiargyl 75 g/ha +one hand weeding at 45 DAS.

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CHEMICAL WEED CONTROL IN SOYBEAN (*Glycine max.* L. Merril.)

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Cultivation of soybean in India was first started in Punjab in 1969, but farmers did not take interest in its cultivation as the productivity level was low due to its poor emergence on pre shower monsoon and management problems. Yield of soybean in India still lags behind from its major producers in the world; however, Indian soybean is considered the best in quality due to its Non GMO nature and high protein content. Soybean oil in its crude form is the most traded oil in international market after palm oil. Soybean accounts for more than 50% of the world oilseeds production and around 35% of the beans production is traded in world market. Successful weed control is one of the most important practices for economical soybean production. Losses in seed yield due to weeds have been one of the major limiting factors in soybean production. Weeds compete with soybean for light, moisture, and nutrients with early-season competition being the most critical. Most of the yield reduction due to weed competition occurs during the first six weeks after planting; therefore, major emphasis on control should be given during this period. To access the effect of herbicide and hand weeding on weed dynamics and seed yield of soybean a field study was conducted at the Practical Crop Production Area, Department of Agronomy during *Kharif* 2008 on loamy sand soil. The soybean seed yield in Pursuit (imazethapyr) one litre/ha applied as post emergence 30 days after sowing in treated plot was 21.6 q/ha which was 6.9% more than two hand weeding (3 and 6 weeks after sowing) and 45.0 % more than control. Similarly, stover yield was 62.5 q/ha in Imazethapyr treated plots followed by 62.0 q/ha in two hand weedings and 57.5 q/ha in control. The test weight also favoured herbicidal treatment which was 112.0 g in imazethapyr treated plot > two hand weedings (111.0 g) > Control (94.0 g). The lowest weed dry matter 4.0 q/ha was recorded at maturity in herbicidal treatment (imazethapyr) which was 20.0 and 145.0% lower than two hand weedings and control, respectively.

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CHEMICAL WEED CONTROL IN KHARIF GROUNDNUT (*Arachis hypogea* L.)

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Weed menace directly affects the yields of field crops up to 78%. Negative impact of weeds is more on crop like groundnut which requires more nutrients to get higher yields. The *khandesh* tract of Maharashtra has assured rainfall pattern. If rains are regular, weeds competes with crop combined with paucity of agricultural labourers. Therefore, in the recent years this crop being ignored for cultivation by farmers. This situation leads to chemical weed control in field crops. Maharashtra has substantial area (5.83 lakh ha.) under groundnut which is grown in kharif and summer seasons. The various weeds observed in groundnut field during kharif season viz., *Amaranthus viridis, Parthenium hysterophorus, Acalypha indica , Cyperus rotundus , Cynodon dactylon, Phyllanthus niruri, Commelina species, Eragrostis minor, Eragrostic major, Celosia argentea and Euphorbia species. Commelina benghalensis, Celosia argentia, Eragrostis minor, Eragrostic major* etc. and in sedges *Cyperus rotundus* was predominant. Considering the above facts an experiment was conducted at Oilseeds Research Station, Jalgaon during 2007 to 2009 in order to control weeds in kharif groundnut. A set of seven treatments of pre and post emergence herbicides comprising weedy and weed free check replicated three in Randomized Block Design (RBD) on medium clay loam soils with pH 8.2. Among the different herbicide pre-mergence application of pendimethalin @ 1.0 kg/ha + post-emergence application of imazethapyr@ 50 g/ha at 20 DAS recorded maximum weed control efficiency (74%) minimum weed population (42.67/m^2) and weed dry matter (185g/m^2) . This treatment recorded significantly higher dry pod yield (1997 kg/ha), gross returns (46,445 Rs/ha) net returns (28,705 Rs/ha) and B: C ratio 1: 2.44. The pre-emergence application of pendimethalin @ 1.0 kg/ha + post-emergence application of imazethapyr @ 50 g/ha was the most profitable way to control the weeds found in groundnut crop during early growth stage of groundnut in kharif season.

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WEED MANAGEMENT PRACTICES IN HELICONIUM (*HELICONIA* SP.) CV. GOLDEN TORCH

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Heliconium is a tropical cut flower gaining momentum nowadays in the floriculture industry due to its attractive foliage and brilliant flower spikes. The experiment was carried out in the floriculture unit, Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during–2008, to study weed management practices in *Helicoium* system under different shading condition. The experimental results revealed that the pre-emergence application of pendimethalin at 1.0 kg/ha with one hand weeding at 40 DAP was found to be superior to suppress the weed growth in *Heliconium*. Weed density and weed dry

matters were significantly lower with the two hand weeding at 20 and 40 DAP. The maximum weed control efficiency (94.3%) was recorded at 50 DAP with the pre emergence application of pendimethalin at 1.0 kg/ha + one hand weeding at 40 DAP followed by alachlor at 1.0 kg/ha + one hand weeding at 40 DAP (91.8%). Higher growth and yield performance were obtained by maintaining weed free condition throughout the crop growth period which, was followed by pendimethalin at 1.0 kg/ha with one hand weeding at 40 DAP. Combination of one herbicide with one hand weeding provided better growth and flowering performance resulted in higher flower yield.

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INTEGRATED WEED MANAGEMENT IN AEROBIC RICE (*Oryza sativa*)

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A field experiment on integrated weed management in aerobic rice was conducted during *Kharif* 2009 at Zonal Agricultural research station, V. C. Farm, Mandya, Karnataka. The experimental site was uniform in topography with red sandy loam in soil texture. The soil pH was neutral in reaction and medium in available nitrogen, phosphorus and potassium. The experiment consisted of 12 treatments laid out in a randomized complete block design with three replications consisting of four pre-emergence herbicides integrated with one intercultivation at 40 days after sowing (DAS), hand weeding twice at 20 and 40 DAS, intercultivation thrice at 20, 40 and 60 DAS compared with weed free and unweeded check. The predominant weed flora observed in the experimental field was, *Echinochloa colona*, *Digitaria marginata, Ageratum conyzoides, Spilanthus acmella, Commelina benghalensis, Celosia argentia, Cyperus iria* and *Cyperus rotundus*. The results revealed that pre-emergence application of bensulfuron-methyl + pretilachlor (6.6 GR) @ 0.06 + 0.60 kg/ha + one intercultivation at 40 DAS recorded significantly higher grain yield and straw yield (4425 and 5020 kg/ha, respectively), lower weed population and their dry weight (68 g/m^2 and 9.98 g/m^2, respectively). The plant growth and yield components *viz.* plant height (79.10 cm), leaf area (2175.41 cm^2 $hill^{-1}$), total dry matter production (69.30 g/hill), number of productive tillers/hill (25.9), weight of panicle (3.80 g), filled spikelets per panicle (128.60) and 1000 grain weight (23.70 g) were significantly higher with the same treatment. Further the nutrient uptake by the crop (103.99, 19.28 and 77.71 Kg NPK/ha) was maximum and the net returns and B:C Ratio was also high with the pre-emergence application of bensulfuron + pretilachlor followed by one intercultivation at 40 DAS.

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SOIL ENZYME ACTIVITY AS INFLUENCED BY INTEGRATED WEED MANAGEMENT PRACTICES IN *KHARIF* SUNFLOWER

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When herbicides are applied to soils, they generally disturb the natural eco-system through their effects on soil microbial and enzymatic activities. Application of herbicides is known to have side effects on soil enzymes. Intensive use of herbicides without adequate knowledge on its effects on soil enzymes may have adverse impact on soil-bio-chemical processes and nutrient cycling affecting the below ground processes. Keeping these issues in view, the present experiment was conducted to assess the effects of different herbicides on soil enzymatic activity and corresponding seed yield. The soil samples were collected from the field experiments that were conducted during *kharif* season of 2006-07 to 2007-08 for two consecutive years on medium Vertisols at Hyderabad, Andhra Pradesh. The experimental site was clay soil with a soil pH, organic carbon, available N, P and K of 7.7, 0.51%, 228 kg/ha, 15 kg/ha and 772 kg/ha, respectively. Sunflower (KBSH-1) was grown in randomized block design with three replications of 8 treatments. The experimental site was fertilized with 60: 60: 30 kg NPK through urea, single super phosphate and muriate of potash respectively. Sunflower was hand dibbled with spacing of 60 cm x 30 cm on ridges and furrows. The eight treatments comprised of pre-emergence application of pendimethalin (Stomp 30 EC) 1.5 kg/ha; imazethapyr (Pursuit 10 WP) 0.20 kg/ha as post-emergence at 15-20 days after sowing (DAS); pendimethalin 1.0 kg /ha follwed by (fb) imazethapyr 0.15 kg/ha at 21-25 DAS; pendimethalin 1.0 kg/ha *fb* one intercultivation at 21-25 DAS; pendimethalin 1.0 kg/ha fb intercultiivation at 21-25 DAS + hand weeding, farmers' practice compared with weed free check and unweeded control treatment. The soil samples were collected at 60 DAS synchronizing with maximum enzymatic activity for estimation of urease, dehydrogenase and phosphatase by following standard procedures. In the present investigation, there was marked inhibition of three soil enzymes (urease, phosphatase and dehydrogenase) with the application of pre and post-emergence herbicides *viz.*, pendimethalin and imazethapyr at higher doses alone and in combination, compared to control. Application of lower doses of pendimethalin 1.0 kg.ha followed either by intercultivation at 20-25 DAS and hand weeding maintained favorably higher activity of soil enzymes similar to that of weed free situation. A lower dose of pre-emergence application of herbicides followed by soil working was found to enhance the porosity of soils leading to improved aeration and higher microbial activity and higher yield of sunflower.

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HERBICIDE SPRAY PATTERN OF PUNJAB FARMERS

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A survey was conducted during 2008-09 and 2009-10 in all the districts of Punjab regarding the herbicide use pattern by the farmers for the control of *Phalaris minor* in wheat. One hundred eighty three (183) farmers were surveyed during first year and 69 during second years. The survey report indicated that 87.0 % of the farmers used recommended herbicides and 13 % used unrecommended herbicides during 2009-10 as compared to 80.9 and 19.1 % during 2008-09, respectively. About 88.4 % farmers used recommended dose of herbicides during both the years. The survey report also indicated that 17.4%, 51.5 % and 31.1% farmers used flat fan, flood jet and cone type nozzle during 2008-09 as compared to 71.0, 14.5 and 14.5 % during 2009-10, respectively. During 2008-09, 81.4 % and during 2009-10 66.7 % of the farmers obtained more than 75 % control of *P. minor* and were satisfied with the performance of herbicides. During first year, 3.8 %, 11.5% and 84.7% of the farmers got 25-50 % and 50-75 % and > 75% control of *P. minor* as compared to 5.8%, 11.6%, and 82.6% during 2009-10, respectively. Most of farmers i.e. 67.2 % used clodinafop group of herbicides which was followed by sulfosulfuron (24.6 %). They also used other groups i.e. fenoxaprop-P-ethyl, isoproturon, sulfosulfuron + metsulfuron, mesosulfuron + iodosulfuron, metribuzin etc.

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RESIDUAL EFFECT OF SULFONYLUREA HERBICIDES APPLIED TO WHEAT ON THE FOLLOWING *KHARIF* CROPS AS AFFECTED BY SOIL pH

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An experiment was conducted during 2003-04 and 2004-05 to study the residual effect of sulfonylurea herbicides applied to wheat on different *kharif* crops as affected by normal soil pH of 7.4 and high pH of 8.9. No significant difference in *Phalaris minor* and wheat crop height was recorded due to different pH of soils. At all the growth stages, *P. minor* height was significantly more in unsprayed control than rest of the herbicidal treatments. The plant height was at par where sulfosulfuron was applied at 25 g and 37.5 g/ha at different growth stages of wheat during both the years. The grain and straw yield of wheat did not differ significantly in different pH soils during both the years while significantly lower yield was obtained in unsprayed crop when compared with all other treatments which were though at par with each other during Ist year. On an average of two years, the per cent increase in grain yield was to the extent of 11.2, 14.6, 11.0 and 4.5 in sulfosulfuron at 25 g and 37.5 g/ha and in mesosulfuron + iodosulfuron at 12 g and 18 g/ha, respectively over unsprayed control. During *kharif* season, the fresh weight of summer and *kharif* moong was not affected significantly in both pH soils in both the years, though significant differences were recorded in case of herbicidal treatments during 2nd year in both the crops. No significant difference in the fresh weight of

maize was recorded in two different pH soils and herbicide treatments during Ist year. During 2nd year, fresh weight was significantly more in normal pH (7.4) soil than high pH (8.9) soil, which indicated that herbicides persist longer in high pH soil indicating that there might be risks of residue carry over in alkaline soils. The fresh weight of rice and cotton was non significant with respect to all herbicidal treatments and different pH soils during both the years.

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EVALUATION OF DIFFERENT HERBICIDES ON MAIZE UNDER NORTHERN TRANSITIONAL ZONE OF KARNATAKA

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In recent years maize has replaced many traditional crops and its area is increasing very fast in Northern Transitional Zone of Karnataka because of ease of cultivation, free from pest and diseases, high yield and better market price. But, still there is a lot of scope to increase the present maize yields by avoiding crop-weed competition. Among the different agronomic manipulations, the management of weeds is considered to be an important factor for achieving higher productivity as weed problem is more severe during continuous rains in early stages of maize growth which cannot be controlled by cultural practices due to much wetness. By keeping above information in a view, a field experiment was conducted under rainfed conditions during kharif 2007 at Agricultural Research Station, Devihosur, Haveri District, University of Agricultural Sciences, Dharwad. The experiment consisted 12 treatments involving four pre-emergence herbicides *viz.*, atrazine, butachlor, pendimethalin and alachlor @ 1.0 kg/ha both as spray and sand broadcasting in conjunction with one intercultivation at 30 days after sowing (DAS), maize+ fodder cowpea (1:1) intercropping and incorporation of fodder cowpea at 45 DAS, farmers practice (one hand weeding at 30DAS + two intercultivation at 30 and 45 DAS), weedy check and weed free check. The experiment was laid out in a randomized complete block design with three replications. Pre emergence application @ 1.0 kg/ha + one intercultivation at 30 DAS of atrazine as spray or sand broadcasting or butachlor as spray recorded significantly lower weed population, weed dry weight and higher weed control efficiency. Among the weed control treatments, significantly higher maize grain (5554 kg/ha) and Stover yield (8886 kg/ha) was recorded with atrazine @ 1.0 kg/ha as spray+ one intercultivation at 30 DAS, which was at par with atrazine sand broad casting, butachlor or alachlor as spray or sand broadcasting and farmers practice. Similar trend was followed with growth and yield parameters of maize.

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EFFECT OF CHEMICAL WEED MANAGEMENT IN AEROBIC RICE

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Aerobic rice is a new way of cultivating rice that requires less water than lowland rice. It entails the growing of rice in aerobic soil, with the use of external inputs such as supplementary irrigation and fertilizers aiming at high yields. The main driving force behind aerobic rice is the increasing water scarcity, which threatens the sustainability of lowland rice production. With this method about 60 to 70% of irrigation water is observed to be saved. However, the major constraint under aerobic soil condition to achieve higher yields is the problem of weed infestation. Field experiment was conducted at Agriculture College, Mandya during kharif 2005 to evolve suitable herbicide and its dose on aerobic rice on sandy loam soil. The treatments consisted of butachlor @ 0.75, 1.0 and 1.25 kg/ha, pyrazosulfuron-ethyl @ 20, 25 and 30 g/ha and clomozone + 2,4-DEE @ 0.75, 1.0 and 1.25 kg/ha along with two hand weeding at 20 and 45 DAS and Weedy Check in RCBD with three replications. The results of the experiment revealed that weeds in aerobic rice reduced grain yield to the extent of 82.84 and 82.60 % as compared to the HW at 20 & 45 DAS and pyrazosulfuron 30 g/ha, respectively. Among the weed control treatments, maximum grain yield was recorded with HW at 20 & 45 DAS (5.07 t/ha) and was on far with pyrazosulfuron 30 g/ha (5.00 t/ha). This was attributed to their higher weed control efficiency during early growth stage of the crop and this in turn positively influenced the grain yield by improving yield components *viz.*, number of effective tillers per hill (20 and 19.3, respectively), total grains per panicle (138.47 and 138.60, respectively) and 1000 grain weight (24.93 and 24.83, respectively).

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HERBICIDE TANK-MIXES *VERSUS* SEQUENTIAL APPLICATION FOR WEED MANAGEMENT AND SOYBEAN YIELD

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A field experiment was undertaken at the Division of Agronomy, Indian Agricultural Research Institute, New Delhi during the rainy-seasons (*kharif*) of 2008 and 2009 to evaluate the efficacy of herbicide tank-mixes *versus* sequential applications for weed management in soybean. The treatments comprising of GA_3 (400 ppm) + pendimethalin (1.0 kg/ha) pre-emergence (PRE) followed by imazethapyr (100 g/ha post-emergence (POST) at 20 DAS), GA_3 (400 ppm) + tank-mix of pendimethalin (0.75 kg/ha) and imazethapyr (100 g/ha) PRE, KNO_3 (6%) + pendimethalin (1.0 kg/ha) PRE followed by imazethapyr (100 g/ha POST at 20 DAS), KNO_3 (6%) + tank-mix of pendimethalin (0.75 kg/ha) and imazethapyr (100 g/ha) PRE, GA_3 (400 ppm) + one hand weeding at 30 DAS, KNO_3 (6%) + one hand weeding at 30 DAS, unweeded control and weed-free check were laid out in a randomized block design with three replications. Heavy infestation of weeds comprising of grass, sedge and broad-leaved weeds was observed under unweeded control during 2008 and 2009. All tank-mixes and sequential applications of pendimethalin and imazethapyr completely

controlled all broad-leaved weeds during both the years. The control of *Cyperus rotundus* was more in the tank-mixes of pendimethalin (0.75 kg/ha) and imazethapyr (0.1 kg/ha) PE with GA_3 (400 ppm), and KNO_3 (6%) compared to their respective sequential applications. Thus, these two tank-mixes in terms of total weed control or weed control efficiency were superior to others. However, all herbicide treatments irrespective of tank-mixes and sequential applications were comparable with weed-free check and recorded significantly higher soybean seed yield than that in unweeded control.

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PERSISTENCE OF ALS INHIBITOR HERBICIDES

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For any sound and viable herbicidal recommendation for effective weed management in a crop, it is very important to study the residual impact of that herbicide on succeeding crops in rotation. Metsulfuron-methyl at 2, 4 and 8 g/ha was applied in wheat as sub-plots at 35 days after sowing (DAS) along with 2, 4 and 6 irrigation levels (main-plot treatments). The experiment was conducted in split-plot design with four replications during 2005-06. After 150 days of its application, succeeding maize crop was sown keeping the original layout undisturbed. The growth parameters like plant height and dry matter accumulation of wheat at 30, 60, 90, 120 DAS and at harvest were significantly higher under weed free situation as compared to various doses of metsulfuron. Similarly, various yield attributes (*viz.* effective tillers, length of earhead, number of grains per earhead and 1000-grain weight), yields (grain and straw yield) and harvest index of wheat were also significantly higher under weed free conditions as compared to metsulfuron treated plots. However, various doses of metsulfuron were at par in respect of these parameters. Increasing soil moisture increased growth and yield of wheat with significantly lower growth and yield parameters under 2-irrigations as compared to 4 and 6 irrigations which were at par. Different levels of metsulfuron-methyl and irrigation applied in wheat did not have any residual harmful effects on succeeding maize crop. Metsulfuron-methyl at 2, 4 and 8 g/ha incubated for 150 days at 15, 25 and 35°C to see the persistence of metsulfuron-methyl on maize crop (pot bioassay). Metsulfuron at 2, 4 and 8 g/ha incubated for 150 days at 15, 25 and 35°C had no significant phytotoxic effect on maize crop at 35°C even at 8 g/ha. At 25°C, the maize crop was affected only at 8 g/ha, where as at 15°C, the maize crop was adversely affected by metsulfuron-methyl even at 2 g/ha.

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EVALUATION OF DIFFERENT HERBICIDES FOR WEED CONTROL IN WHEAT + SUGARCANE INTERCROPPING SYSTEM

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Phalaris minor is a very serious weed in wheat + sugarcane intercropping system, which has attained resistance against the only recommended herbicide i.e. isoproturon, so there is urgent need to evaluate alternate herbicides which can control this weed without adversely effecting the sugarcane growth and yield. An on farm trial was conducted during 2008-09 at farmer's field to assess the effect of different herbicides to control weeds in wheat intercropped with sugarcane and to evaluate their phytotoxicity on sugarcane plants. The trail was carried out in randomized block design with thirteen treatments replicated thrice at S. Harmeet Singh's Farm, Mustfabad village, locating at Gurdaspur district in Punjab. The treatments comprised four doses of metribuzin (132 g, 175 g, 220 g, and 263 g/ha), two doses of isoproturon (938 g and 1406 g/ha), sulfosulfuron 25 g/ha, mesosulfuron+iodosulfuron 14.5 g/ha, sulfosulfuron + metsulfuron 30 g/ha, clodinafop 60 g/ha and unweeded control. Sugarcane (Co J 85) was planted on 25th Oct 2008, whereas wheat (PBW 343) was intercropped on 15th Nov 2008. Application of meso+iodosulfuron 14.5 g a/ha and sulfo+metsulfuron 30 g/ha resulted in effective control of weeds in wheat and recorded highest wheat (28.38 and 28.00 q/ha) and cane yield (700.0 and 712.5 q/ha), respectively, with maximum B:C ratio of 1.72 each, whereas clodinafop 60 g/ha recorded lowest cane yield (650 q/ha) and B:C ratio (1.42). Isoproturon even at higher rate did not control *Phalaris minor*. Sulfonylurea group of herbicides like sulfosulfuron, meso+iodosulfuron, sulfo+metsulfuron proved to be very effective for controlling *P. minor* as well as broadleaf weeds in wheat in wheat + sugarcane cropping system. However, clodinafob caused phtotoxicity to sugarcane crop. Although, all the tested herbicides except clodinafob proved safe to sugarcane, but these herbicides need further evaluated at their higher doses as sometimes farmers can spray at higher rates or with wrong method of spray and at times overlapping can result into higher concentration on sugarcane plant causing crop phytotoxicity.

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STUDIES ON HARVEST TIME RESIDUE OF HERBICIDE IN SOIL, GRAIN AND STRAW OF MAIZE (*Zea mays* L.)

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Atrazine (6-chloro-*N*-ethyl-*N*'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) residue was evaluated at Research Farm, Punjab Agricultural University, Ludhiana on loamy sand soils. Atrazine was applied in maize as pre-emergence @ 1.0 kg/ha, band application and post-emergence @ 1.0 kg/ha was analyzed in soil, maize grain and maize straw at the time of harvest. The soil samples were collected from 0-15 cm depth. Grain and straw samples for each treatment were taken at the time of harvest and a single step extraction and clean up technique for extraction of atrazine was followed. Absorbance was measured at 225, 240 and

255 nm by UV Spectrophotometric method. The minimum detectable limit for atrazine is 0.003 ppm. The results revealed that the quantity of atrazine in soil, maize grain and maize plant samples were below the detectable limit in all treatments. This further showed that atrazine application posed no problem in maize straw used for fodder and maize grain for industrial products.

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BEHAVIOUR OF ISOPROTURON RESISTANT BIOTYPES OF *PHALARIS MINOR* TO ALTERNATE HERBICIDES UNDER CONTROL CONDITIONS

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The seed of 22 Isoproturon resistant biotypes of *Phalaris minor* were collected from different fields of wheat crop exposed to various herbicides for controlling *P. minor* from various districts of Punjab. Uniform number of seed were sown in pots and after emergence, 10 plants/pot were kept. Ten herbicidal treatments were kept in main plots and 22 biotypes of *P. minor* in sub plot. Pre-emergence application of Treflan (trifluralin) at 1.2 kg/ha was made immediately after sowing seed of *P. minor*. Post-emergence application of Atlantis 3.6 WDG (mesosulfuron+ iodosulfuron) at 12 g/ha, Total 75 WG (sulfosulfuron + metsulfuron) at 30 g/ha, Leader 75 WG (sulfosulfuron) at 25 g/ha, Topik 15 WP (clodinafop-propargyl) at 60 g/ha, Axial 5 EC (pinoxadin) at 50 g/ha, Puma power (fenoxaprop-P-ethyl) at 100 g/ha, sulfosulfuron + carfentrazone at 45 g/ha and AEF 04-6360-8% + DIC 1468 – 14 %-22% at 0.30 kg/ha was done 35-40 days after sowing (DAS) the seeds of *P. minor* biotypes. All the tried herbicides except sulfosulfuron + carfentrazone provided 100% control of all the tested biotypes of *P. minor* as there was no dry matter accumulation under these treatments. The different biotypes showed variable response to different herbicides. Minimum dry matter accumulation was recorded in biotypes B2, B4, B22, B1 and B13, respectively and dry matter accumulation was significantly less in these biotypes as compared to other tried biotypes.

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PERFORMANCE OF NEW HERBICIDE (AEF 04-6340-8% + DIC 1468-14%-22% EC) FOR THE CONTROL OF GRASSY AND BROADLEAF WEEDS IN WHEAT

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An experiment was conducted for three years at the Research Farm of Department of Agronomy, Punjab Agricultural University, Ludhiana during rabi season of 2007-08 to 2009-10. The experimental field was heavily infested with *Phalaris minor* and other broadleaf weeds. A new herbicide i.e. AEF 04-6340-8 % + DIC 1468-14 % - 22 % EC (fenoxaprop-P-ethyl + metribuzin) was applied at 0.75, 1.0, 1.25, 1.5 and 2.5 litre/ha of the commercial product as post emergence (30-35 DAS). The results of three years revealed that application of this herbicide at 1.25 and 1.5 litre/ha of the commercial product provided effective control of *P. minor* and broadleaf weeds from wheat crop and were found statistically at par with the standard treatment i.e. Atlantis 3.6 WDG 400 g/ha of commercial product with respect to dry matter accumulation by *P. minor* and broadleaf weeds. On an average of three years, post emergence application of AEF 04-6340-8 % + DIC 1468-14 % - 22 % EC at 1.25 and 1.5 litre/ha as well as Atlantis 3.6 WDG increased wheat grain yield by 59.8, 64.2 and 67.3 % as compared to unweeded control treatment, respectively.

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WEED MANAGEMENT IN DSR (*Oryza sativa*) BY APPLYING PRE AND POST EMERGENCE HERBICIDES

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Field experiment was conducted during *Kharif* season of 2007 and 2008 at research farm of the department of Agronomy, PAU, Ludhiana to evolve suitable combination of pre and post-emergence herbicides for effective weed management in direct seeded rice under unpuddled conditions. The experimental field had mixture of all typical paddy and non paddy weeds during both years of study. Results indicated that during 2007, integration of post emergence application (30 DAS) of bispyribac (25 and 30 g/ha) or azimsulfuron (20 g/ha) with pre-emergence application of pendimethalin 0.75 kg/ha, pretilachlor 0.5 kg/ha and thiobencarb 1.25 kg/ha provided effective controlled weeds and produced significantly higher yields than unweeded control. During 2008, integration of pre-emergence application of pendimethalin 0.75 kg/ha or oxadiargyl 0.90 g/ha with post-emergence application of bispyribac 25 kg/ha, azimsulfuron 20 g/ha and 2, 4-D 0.5 kg/ha resulted in significant reduction in dry matter accumulation by weeds and all these treatments significantly increased seed yield as compared to alone application of pendimethalin 0.75 kg/ha. Pre-emergence application of flufenacet 80 g/ha and early post-emergence application of pinoxsulam 30 and 35/g ha were found ineffective for controlling weeds in direct seeded rice.

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BIO EFFICACY OF IMAZETHAPYR FORMULATIONS AGAINST WEEDS IN KHARIF GROUNDNUT (*ARACHIS HYPOGEA L.*)

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Groundnut is one of the important *kharif* crops of Western Maharashtra. Due to continuous intermittent rains, heavy infestation of weeds is a serious problem in increasing sustained productivity of groundnut. Groundnut yield losses due to weeds have been estimated as high as 24 to 70%. Various methods are documented for weed control in groundnut, but due to labour shortage, short period to curtail weed competition necessitate an effective herbicide with no crop phytotoxicity and satisfactory weed control. A field experiment was conducted at research farm of integrated farming system research project, MPKV, Rahuri during kharif 2008-09 and 2009-10 to evaluate bio-efficacy and phytotoxicity of imazethapyr (10 IPR) and productivity of groundnut (cv. TAG–24). The treatments comprising four doses of imazethapyr (10 IPR) at 500, 1000, 1500 and 2000 ml/ha were compared with the two rates of Pursuit (imazethapyr 10 SL) at 1000 and 1500 ml/ha, hand weeding at 15 and 30 DAS and weedy check. The observation on weed population m^{-2}, weed control efficacy and phototoxicity was recorded for various grasses, sedges and broad leaved weeds (BLW's). Application of Pursuit 1500 ml/ha was most effective and produced significantly higher pod yield (12.65 q/ha) and was at par with imazethapyr (10 IPR grade) @ 1500 ml/ha (11.90 q/ha) and @ 2000 ml/ha (11.60 q/ha) dry pod yield. The study revealed that the lowest weed population (2.77 and 1.77 weeds/m^2) 30 and 45 DAT) and highest weed control efficiency (92 and 95 %), respectively for grassy weeds with imazethapyr (10 IPR) 2000 ml/ha followed by Pursuit 1500 ml/ha was significantly superior over rest of the treatments. The application of imazethapyr formulations for the control of broad leaves weeds (viz. *Euphorbia geniculata, Euphorbia hirta, Commelina spp. Digera arvensis and Cynotis axiallaris*) had lowest weed population with Imazethapyr (10 IPR) 2000 ml/ha at 30 and 50 DAT (1.11 and 0.18 BLW's population/m^2) and weed control efficiency of (97 and 99.5%) followed by Pursuit at 1500 ml/ha and statistically significant over hand weeding at 15 and 30 DAS. Highest dry pod yield (12.65 q/ha) was recorded with Pursuit 1500 ml/ha which was at par with imazethapyr (10 IPR) 1500 ml/ha (11.90 q/ha) yielding about 69.6 and 59.5 % higher over control.

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DECREASING BIO-EFFICACY OF ALTERNATE HERBICIDES IN WHEAT

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After the development of resistance in *Phalaris minor* against isoproturon in early nineties alternate herbicides were recommended for the control of resistant biotypes of little canary grass. Three types of herbicides *viz.* clodinafop-propargyl, sulfosulfuron and phenoxprop-P-ehtyl satisfactorily controlled the grassy weeds and *P. minor* in particular. The farmers following rice-wheat cropping system especially in Punjab and Haryana are using these three types of herbicides in wheat continuously without making the rotation of alternate herbicide. It is evident from the survey reports that adoption pattern of types of herbicides, time of application, type of nozzle and volume of spray may be responsible for poor efficacy of herbicides. Fenoxaprop has been phased out five years back and sulfosulfuron has become the second choice after clodinafop as observed for the last three years. Therefore, most of the farmers are still inclined on usage of clodinafop while switching towards sulfosulfurn+metsulforon (ready mix) and mesosulforon+iodosulfuron (ready mix) at very low rate due to rider of residual effect on sorghum, maize and pulse crops. The awareness among farmers regarding low or poor efficacy of herbicides in wheat resulted in registering complaints against the source of procuring the herbicides. During the redressal of the complaints it has been observed that the farmers who were applying the same category of herbicides since a decade faced the more ineffectiveness of herbicides irrespective of spraying techniques coupled with foggy weather during the stage of applying herbicides. There were recordable instances when the farmers repeated the same herbicide to manage the robust type of *P. minor* and even with altered formulations. Such cases increased during the year 2009-10 reporting poor bio-efficacy of alternate herbicides in wheat in potential rice-wheat crop rotation zone.

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GERMINATION, EMERGENCE AND GROWTH BEHAVIOR OF *MEDICAGO DENTICULATA, VICIA SATIVA, CONVOLVULUS ARVENSIS* AND *LATHYRUS APHACA*

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Laboratory and screen house experiments were conducted at CCS HAU Hisar to evaluate the effect of temperature, salinity, osmotic potential, light/dark periods, seeding depth and flooding on germination and emergence of *Medicago denticulata, Vicia sativa, Convolvulus arvensis* and *Lathyrus aphaca.* Maximum germination of *M. denticulata* (61%), *C. arvensis* (41%) and *L. aphaca* (91%) was recorded at 20°C whereas, *V. sativa* (78%) germination was maximum at 15°C. Root length and shoot length was maximum at 15°C for *M. denticulata, V. sativa,* and *L. aphaca* whereas, maximum root and shoot length for *C. arvensis*

was recorded at 20 and 15°C, respectively. With any decrease or increase from optimum temperature germination decreased and growth was affected adversely at high or low temperatures. Germination in all the four weed species was maximum with distilled water. *M. denticulata* germinated (15%) up to 100 mM NaCl conc., whereas, *V. sativa* (5%), *C. arvensis* (20%) and *L. aphaca* (55%) germinated even at 200 mM NaCl conc. Significant reduction in germination, root, and shoot growth was observed at 200 mM NaCl in all the four weed species. The effect of osmotic potential on germination was declining in nature, as the osmotic potential was lowered from 0 to -0.8 MPa the germination decreased drastically. The osmotic potential of -0.8 MPa reduced the germination of *M. denticulata, V. sativa* and *C. arvensis* to zero while *L. aphaca* germination reduced to 3%. Light was not prerequisite for the germination of any of the four weed species. Optimum depth for the germination of *M. denticulata, V. sativa, C. arvensis* and *L. aphaca* was 2.0, 2.0, 1.0 and 1.0 cm, respectively where corresponding germination was 61, 69, 40 and 79%. Reduction in germination and growth was recorded with increase and decrease from optimum depth. *V. sativa* and *L. aphaca* germinated even from a depth of 8.0 cm. *M. denticulata* was very sensitive to flooding; even a flooding of 5 days completely restricted its germination. *V. sativa* and *C. arvensis* tolerated 20 days of flooding, whereas *L. aphaca* germinated (17%) even after 40 days of flooding and 2% after 80 days of flooding.

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SIGNIFICANCE OF WEEDS IN PLANT QUARANTINE IN INDIA

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The introduction of invasive weeds is one of the major threats to plant diversity as well agriculture by means of its negative impacts. In the past many alien invasive weeds have been invaded into our agricultural and non-agricultural ecosystems and are threatening the survival and productivity of the systems. Many introduced weeds are posing serious ecological and social implications. Consequent to the implementation of the World Trade Organization-Sanitary and Phyto-Sanitary Agreement (WTO-SPS), the international agricultural trade has been increased in many folds. However, there is high Phyto-sanitary risk associated with the import of agricultural commodities in international trade. Thus, the international trade in agricultural commodities is coming under increasing Plant Quarantine scrutiny in India. Plant Quarantine is adopting risk assessment procedures to justify the exclusion of commodities contaminated with weed seeds. The challenge for the Plant Quarantine Organization in India is to prevent the entry of exotic weeds in to the country. To fulfill this, the Plant Quarantine (Regulation of Import in to India) Order 2003, (PQ Order, 2003) came into force. This order includes the restriction on import commodities contaminated with exotic weed seeds contamination. As of now, 31 number of quarantine weeds have been regulated under Schedule VIII of PQ Order, 2003. To meet the requirements specified in PQ Order, 2003, standard sampling procedures, inspection and detection methods are being effectively followed at all the Plant Quarantine Stations at the port of entry with an objective to prevent any inadvertent entry of exotic weeds.

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STATUS OF HERBICIDE RESIDUES IN INDIA

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In modern agriculture, chemical weed control through herbicide is the most effective method as it requires less labour and efficient control of weeds. Due to rapid rate of urbanization labour problem for agriculture sector is growing and in order to meet the needs of agricultural production this protection technology has to play a crucial role. From a meager amount of 2000 MT per year during fifties, the production of pesticides and allied chemicals in India touched a level of 85030 MT during 1994-95 and 85338 MT in 2008-09. These figures have a major share of insecticides, as in India percent use of insecticides is much more than herbicides. Total number of pesticides registered for use in India is 221, out of which 38 are herbicides. Out of 41 pesticides produced in India only 8 are herbicides. Total herbicide production amounted to 5918 MT out of 85338 MT of total pesticides in 2008-09. Consumption of 12 herbicides in India amounts to 6032MT (14.3%) out of 42378MT of total pesticides in 2008-09. (Source: Department of Chemicals and Petrochemicals). Various field studies conducted under Indian agro-climatic conditions indicates that herbicide residues are still not a serious problem. In most of the cases herbicide residues in harvested produce are below detectable limits (mostly cereal crops) except in few cases where repeated applications are given to combat weeds. These results indicate towards the safety of this plant protection group. Second matrix for pesticide residues is soil. Actually soil is a sink for all type of such chemicals. In case of insecticides/fungicides, they are applied in the latter stage of crop growth (fruiting time) when crop canopy is high and a small amount of these pesticide falls to reach soil, while herbicide are applied at early crop growth stages, the chances of falling on soil are more. Moreover, many herbicides are soil applied; therefore, the residues of herbicides in soil have their own importance as they can affect the next crop in rotation. But the literature regarding residues in soil shows that most of the recent herbicides are short lived, hence leaves no residues. Only few examples of sulfonylureas have shown phyto-toxic effects to sensitive rotational crops. In post emergence application also, most of the time it is early stage of crop growth, therefore the time span between the herbicide application and crop harvest is quite long leaving behind no detectable residues. On the contrary most of the insecticides are applied at 50% fruit formation stage with a short duration (few days) between pesticide application and fruit harvest. A longer duration between herbicide application and next crop sowing also give enough time to recover the soil itself through soil microbial population.

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EFFECT OF FLY ASH ON SORPTION BEHAVIOUR OF METRIBUZIN IN AGRICULTURAL SOILS

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Soil amendments can play a crucial role in the management of run off and leaching losses of pesticides. Any amendment to soil changes its physico-chemical properties, which in turn, affect the sorption behaviour of soil-applied pesticides. Fly ash has been recommended in agricultural soils as soil conditioners as it improves soil porosity, enhances water retention capacity, improves soil nutrient status and increases crop productivity. The use of fly ash in agriculture may provide a feasible alternative for its safer disposal, as in the present scenario only 32% of the total fly ash produced in India (110 mt in 2004) finds its use in the manufacture of cements, concretes and bricks and only 1% of it was used in agriculture. Fly ash has also shown significant adsorption capacity for organic pollutant, therefore its application to soil may have implications in reducing the downward mobility of soil-applied pesticides, especially herbicides.

Metribuzin (4-amino-6-*tert*-butyl-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one) is a broad spectrum herbicide. Metribuzin is weakly sorbed in soils and has potential for downward movement in soils and has been detected in water samples. Reports suggested that leaching of metribuzin to lower soil profiles is mainly responsible for loss of its activity. Therefore, we studied the effect of two fly ashes collected from thermal power stations at Kota, Rajasthan and Inderprastha (IP), Delhi on sorption behaviour of metribuzin in three Indian soils at 0.5, 1, 2 and 5% levels. Compared to Kota fly ash IP fly ash was highly effective in increasing the sorption of metribuzin in the soils. The adsorption isotherms fitted very well to the Freundlich equation. Fly ash amendment to soils created soil heterogeneity and resulted in nonlinear isotherms and in general, slope (1/n) values less then unity were observed. Both the fly ashes significantly decreased the metribuzin desorption, but IP fly ash was comparatively more effective in retaining metribuzin in the soil. Metribuzin sorption and desorption in IP fly ash amended soils showed strong correlation with the fly ash content and compared to K_f/K_d values KFA values (sorption normalized to fly ash content) showed lesser variation. Metribuzin sorption/ desorption did not correlate to the organic carbon content of the soil-fly ash mixture suggesting that residual carbon in fly ash was not responsible for the increased metribuzin sorption. The study demonstrates that all coal fly ashes may not be effective in sorbing metribuzin in soils.