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Weedy rice invasion and its management

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ABSTRACT

Weedy rice (*Oryza sativa* f. *spontanea*) is the complex of morphotypes of *Oryza* species, evolved largely by natural hybridization between wild and cultivated rice. With diverse biotypes, weedy rice has already infested large rice growing areas across the globe. It has also become a threat in major rice tracts of eastern and southern India. The weed has distributed in the commercial rice fields especially in areas where farmers have switched to direct-seeding due to labour shortage and high cost. Weedy rice has competitive advantage over cultivated rice as it grows taller and faster, tillers profusely and competes with cultivated rice for nutrients, light and space. It flowers much earlier than cultivated rice and produces grain that shatter easily thus enhancing the weed seed bank. Survey conducted has revealed the presence of weedy rice variants with respect to morphological characters like number of tillers per plant, height of plant, length of ligule, panicle characters, colour of grains, and length and colour of awns. Management of weedy rice infestation is complex mainly because of its morphological similarities to cultivated rice and lack of herbicides for selective control of weedy rice in cropped fields. Management options found effective for the control of weedy rice in direct seeded puddled rice include pre sowing surface application of oxyfluorfen 0.3 kg/ha, three DBS in thin film of water and selective drying of weedy rice panicles by direct contact application of glufosinate-ammonium or glyphosate or paraquat 15- 20% concentration at 60-65 DAS using specially designed wick applicator. Stale seedbed technique with dry and wet ploughing followed by the application of a broad spectrum herbicide and flooding proved to be effective in exhausting soil seed bank. Integrated management strategies are to be adopted for effective control of weedy rice.

Key words: Dormancy, Oxyfluorfen, Pre-sowing application, Stale seedbed, Weedy rice, Wick applicator

Rice, being a short statured crop grown during the warm climate in moist and flooded soil condition, experience very severe competition from weeds. Losses due to weeds range from 30-100% under very severe competition. Of late, weedy rice infestation has become a serious threat in the traditional rice belts of the country. Weedy rice (*Oryza sativa* f. *spontanea*) evolved largely by natural hybridization between wild and cultivated rice, is an emerging threat to rice cultivation as it affects crop production, harvest, quality and income. As the conspecific weed, weedy rice is morphologically and biochemically similar to cultivated and wild counterpart species. Control of weedy rice by hand weeding or herbicides is almost incomplete and impractical. Heavy infestation of weedy rice and subsequent reduction in crop yield in rice fields of India during recent years have forced farmers to abandon rice cultivation mostly in the traditional rice belts.

Origin and spread of weedy rice

Cultivated rice is included in the genus O*ryza* of the grass family (Poaceae). This genus includes two cultivated species (Asian rice - *Oryza sativa*, and African rice - *O. glaberrima*) and more than 20 wild species with ten different genome types, *i.e.* AA, BB, CC, BBCC, CCDD, EE, FF, GG, JJHH, and JJKK. The wild relatives of rice with different genome types usually have significant reproductive isolation, making them unlikely to hybridize under natural conditions. The AA genome weedy and wild relatives are highly compatible sexually with cultivated rice. Their interspecific F_1 hybrids could form complete chromosome pairing in meiosis and have relatively high pollen and seed fertility to produce viable offspring (Lu and Snow 2005). It is widely hypothesized that weedy rice has a variety of origins.

With diverse biotypes, weedy rice has already infested more than 50 countries of Asia, Africa and Latin America. In India, weedy rice infestations are seen in West Bengal, Andhra Pradesh, Assam, Bihar, Karnataka, Madhya Pradesh, Orissa, Tamil Nadu and Uttar Pradesh. Wild and weedy forms are problematic in Eastern India (Eastern U.P., Bihar, Odisha, Manipur and West Bengal) and Southern India (Kerala). Weedy rice plants are adapted to a wide range of environmental conditions. The spread of weedy rice

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as contaminants with seed material, its distribution through irrigation water, machinery and animals, and efficient replenishment to the soil seed bank also add to the severity of infestation and invasion to newer areas (Chauhan 2013a).

Characters of weedy rice

Weedy rice plants showed wide variability of anatomical, biological and physiological features (Vaughan *et al.* 2001). At seedling stage, it is difficult to distinguish weedy rice as they mimic the crop, while it is possible after tillering, due to many morphological differences with the rice varieties *i.e.*, more numerous, longer and more slender tillers, leaves are often hispid on both surfaces, tall plants, pigmentation of several plant parts, grains with awns and red pericarp and shattering of seeds (Kwon *et al.* 1992, Suh *et al.* 1997). The grains of weedy rice ripen earlier and less regularly than those of cultivated rice and are extremely prone to shattering. The stem of weedy rice is comparatively more brittle and round in cross section than that of cultivated rice; the surface of the leaf sheath of weedy rice is softer and spongier than that of cultivated rice. Certain weedy morphotypes have anthocyanin pigmentation in the apiculous, first internode, ligule, margins of the first leaf and auricles (Espinoza *et al.* 2005, Chauhan 2013a).

Undesirable traits of weedy rice

Like the rice crop, weedy rice seeds are unable to germinate in saturated soil. Unlike cultivated varieties, weedy rice seeds showed variable degree of dormancy and tendency for the seeds to shatter as soon as they mature (Perreto *et al*. 1993). Seeds mature within a short period and shatter immediately facilitating the buildup of weed seed bank before the farmer gets a chance to remove the seeds. Early seed shattering is a specific characteristic of weedy rice, controlled by the gene Sh which shows the shattering character in conditions of dominant homozygosys (Sh Sh) or heterozygosys (sh Sh) (Sastry and Seetharaman 1973). Ferrero and Vidotto (1998) found that seed shattering in weedy rice started nine days after flowering and increased gradually for 30 days (65% of the total grains). Ferrero (2010) reported that shattered and non-shattered seeds became viable at about nine days from the beginning of flowering, with a germinability of about 20 percent, reaching about 85% at 12 days after flowering. Many researchers emphasized the influence of environmental factors during seed development, storage, and germination on the trait (Nair *et al*. 1965, Rao 1994, Gu *et al*. 2006).

The breaking of weedy rice dormancy, obtained with substances such as sodium nitrite, propionic acid, propionate-methyl, cytokinin, n-propanol, resulted to be usually accompanied by a pH reduction of the embryo tissues (Footitt and Cohn 1992). In a study conducted in Italy, the viability of weedy rice seeds taken at a depth by ploughing in loamy soil decreased to six per cent after one year and five per cent after two years of burial (Ferrero and Vidotto 1998). The non-viable seeds appeared empty, without embryos, and reserve matter. Despite years of research on seed dormancy, mechanisms for the regulation of germinability are basically unknown (Foley 2001, Koornneef *et al*. 2002). It was observed by Veasey *et al*. (2004) that the seeds of the dry region developed longer periods of seed dormancy, waiting for the wet period when environmental conditions again became favourable for germination and seedling survival. Seed longevity in the soil was found to be ecotype dependent and also affected by burial depth, soil type and moisture, cultivation practices, the magnitude of seed production and dormancy intensity (Noldin 1995). Emergence of weedy rice is greatly influenced by the soil texture, presence of water in the field and the depth of seed burial, which in turn is strictly related to the tillage adopted for seedbed preparation (Ferrero and Finassi 1995). The minimum temperature for weedy rice germination is considered to be 10°C, same as that of cultivated rice. Seeds which remain on the surface over a depth of 4 cm have the maximum germination. Seeds buried by ploughing will germinate only when they are brought to the surface in subsequent ploughing operations.

Competitive ability and yield in crop

Yield losses largely depend on season, weed species, weed density, rice cultivar, growth rate and density of weeds and rice. Weedy rice at 35% infestation caused about a 60% yield loss and, under serious infestation, yield loss of 74% was recorded in direct seeded rice (Watanabe *et al*. 1996). Yield of weedy rice infested plots at the rate of 10, 100, and 1,000 weedy seeds/m^2 were 4.05, 2.75, and 0.43 t/ha, respectively, compared to check yield (Chin *et al.* 2000). Short varieties were usually more susceptible to weedy rice competition than tall ones and interference duration was also a yield deciding factor (Kwon *et al.* 1991). Weedy rice usually coexists with cultivated rice and is highly competitive in rice fields of China (Xia *et al*. 2011). In the context of climate change, the problem is bound to aggravate as rising CO_2 concentration may enhance the competition in rice production systems.

Control of weedy rice

Controlling weedy rice is difficult as it mimics cultivated rice. Several methods are available for the control of wild and weedy rice, but none are highly effective on their own. Therefore, effective control of weedy rice populations becomes very important for the sustainable production of rice crop in all growing regions worldwide.

Prevention

Prevention is the basic means of reducing weedy rice infestation and can be achieved mainly by sowing clean rice seeds. Another preventative measure found effective is cleaning the equipments used for rice harvesting to avoid spread of weedy rice to uninfested fields (Chauhan 2013b).

Cultural methods

Non-chemical means of weed control in rice should be centered on land preparation, varietal selection, water management and fertilizer management. In the absence of effective selective post-emergence chemical control, techniques to minimize weedy rice infestations should focus on (1) lowering the chance of emergence of weedy rice seedlings at crop establishment and (2) preventing subsequent seed return to the soil from surviving plants at maturity. The former include repeated (wet and dry) tillage to provide clean seedbeds, rotation of crop establishment methods (transplanting, water seeding, wet-direct seeding), and cultivar selection to enable water management during crop establishment. All of these practices reduce the chance of plant survival (as seed or seedling). Minimum tillage systems were used in many areas with severe red rice problems (Menezes *et al.* 1994, Azmi and Johnson 2001, Choudhary and Suri 2014). The practice they adopted was after seedbed preparation, the area was kept fallow to enable red rice and other weeds to grow and to form a good mulching cover. Rice could either be drilled or water seeded after spraying the area with non-selective herbicides (glyphosate or paraquat). The crop should be flooded soon after rice emergence; otherwise, the degree of weed control will decrease. Studies conducted at Srilanka have revealed the reduction in weedy rice seed production in transplanting (96-98%) followed by seedling broadcasting (71-87%) compared to direct-seeding method (farmers practice) of crop establishment (Chauhan 2014). Cultural strategy of weedy rice control also includes the use of weed suppressing varieties and submergence tolerant varieties. Tall and long cycle varieties usually showed a greater competitiveness than modern early and semi dwarf varieties. A new approach to chemical control of wild and red rice is the use of herbicide tolerant crop cultivars, which can be safely treated with non-selective herbicides such as glufosinate (Sankula *et al.* 1997). The best control of weedy rice could be obtained with crop rotation and in temperate climate, crops like soybean, maize, wheat, sunflower, sorghum etc. can be taken up. Introduction of mungbean cropping in Vietnam resulted in a huge decrease of the weedy rice plants and other species (Watanabe *et al.* 1998).

Stale seedbed technique: Stale seedbed, also named as false seeding technique, is a cultural method commonly applied in rice monoculture for weed management. Chen (2001) observed stale seedbed technique as an efficient means to manage weedy rice. After seedbed preparation the area is left idle, to allow weedy rice and other weeds to germinate. Rice can then either be drilled or water seeded after the weeds are destroyed by either mechanical (harrows) or chemical (non-selective herbicides) means. This technique is aimed at reducing the weed infestation in the same season in which it is applied and gradually decreasing its seed bank. Sindhu *et al.* (2011) reported the effectiveness of stale seedbed technique in reducing the weed population and decreasing soil weed seed reserves in rice fields of Kerala. According to Azmi and Johnson (2001) the success of the stale seedbed method depended on the way the soil is prepared, the water management and its duration. Wet tillage after weed germination destroyed weedy rice seedlings and promoted new emergence. Puckridge *et al.* (1988) pointed out that soil flooding during the application of the stale seedbed reduced emergence from the soil in comparison to dry or moist soil, but favoured the evenness of the germination that in turn made the control easier. The duration of this technique in temperate climate conditions should be about 25-30 days.

Enhanced seed rate: Enhanced crop seeding rates of 80–100 kg/ha, above the optimum rate of 60 kg/ha in infested fields, suppress weedy rice infestations (Bakar *et al.* 2000). Azmi and Johnson (2001) reported that seed rate of more than 150 kg/ha could suppress weedy rice in infested areas.

Row seeding: Row seeding was also reported as a better and easy method to differentiate cultivated rice plants in rows and weedy rice between rows (Luat 1997). Weeds emerging in between the rows can be controlled by mechanical weeders, and those in the intra rows by manual weeding.

Soil solarization

Soil solarization was reported as an advanced non-chemical field technology for weed management (Yaduraju 1993, Kumar *et al*. 1993). The process significantly increased the soil temperature to 10-15ºC above the normal temperature. This technique was practiced in the warmest months for duration of 4- 6 weeks using thin transparent polyethylene films of 19-25 micro meter. High initial investment and practical difficulties restrict the adoption of this technology to seed production fields and nurseries.

Water management

Water management can play an important role in weedy rice control. Early flooding 20-30 days before land preparation would help to control red rice (Noldin *et al*. 1997). After seeding of pre-germinated seeds, water management is critical to successfully suppress weedy rice. There are two management strategies for irrigation after seeding: (1) water can be maintained at a depth of 5–10 cm until drainage at harvest (continuous flooding); or (2) drain the field and keep the field saturated for 3–5 days, followed by gradual flooding. Excessive drainage will expose the soil to air and increased oxygen concentration in the soil, thus stimulating weedy rice germination. Azmi and Abdullah (1997) reported that farmers resorting to transplanting rice culture in weedy rice infested areas had minimal or no recurrent problems with weeds. Puddling combined with the presence of a thin layer of water over the well levelled soil maintained the anaerobic conditions in the top soil and prevented weedy plants from becoming established (Fisher 1999). Vidotto and Ferrero (2000) have also found that flooding in well levelled soils limited weedy rice germination.

Manual and mechanical management

The control of weedy rice is sometimes carried out manually, but this practice is. Hand weeding is costly, time consuming and quite impractical up to 30-40 days after crop emergence as it is very difficult to distinguish the cultivated varieties from the weedy rice in the early stages. Hand weeding of weedy rice plants can be carried out for light infestations and frequently it is used together with other means of control (chemical) when the latter has given poor results, so as to avoid grain dispersal and also in seed production plots.

Weedy rice can also be controlled mechanically in line planted rice using tools. This practice is aimed at preventing the spread of the weed and is mainly carried out by cutting tall weed panicles before they set seeds (Ferrero and Vidotto 1999). The European experience showed that at least 94% of the panicles could be cut down using this practice in two phases, the first at the beginning of the flowering and the second 15 days later.

Chemical control

Herbicide based weed management is generally the most popular method for weed control in the direct seeded rice fields (Kaur *et al*. 2015). However, it is very difficult to control weedy rice by the use of selective herbicides because of the close anatomical and physiological similarity of weedy rice to the crop (Chen *et al*. 2004). However, with modification in the time and method of herbicide application, chemical control can be successful in managing weedy rice.

Use of herbicides before sowing: According to Noldin *et al*. (1998), use of anti-germinative herbicides, such as metolachlor 3.5 kg/ha, alachlor 3.5 kg/ ha, applied in soybean as pre-emergence resulted in weedy rice control of about 90%. Ferrero *et al*. (1999) could obtain good control of weedy rice (often higher than 75%) in European rice conditions with pretilachlor and dimethenamid used alone or in combination 1.5 and 0.48 kg/ha, respectively. To avoid any phytotoxicity risks, both herbicides need to be applied at least 25 days before rice planting. Pre-plant incorporation of thiocarbamate herbicides like molinate and butylate also controlled weedy plants (Fisher 1999, Garcia and Rivero 1999). Kuk *et al*. (1997) found that weedy rice was completely controlled by thiobencarb 2.1 kg/ha and oxadiazon 0.24 kg/ha. Molinate (6.5 kg/ha), however, gave 26–67% control when applied six days before rice seeding.Thiobencarb application as a preplant surface treatment 4.4 kg/ha in combination with reflooding within 3 to 5 d after drainage is recommended to control red rice in the United States (Sadohara *et al*. 2000).

Use of seed protectants: The experiments carried out in Central and South America revealed that the best weedy rice control could be achieved by applying molinate 7.2 kg/ha and butylate 4.2 kg/ha with seed protectants such as oxabetrinil 1.5 g/kg and flurazole 2.5 g/kg (Smith 1992).

Use of herbicides during the crop season: Chemical control in crop post planting should only be considered as a salvage operation and it mainly relies on difference in size or growth stage between weedy rice and commercial rice. Weedy rice that had grown taller than rice could be treated with foliar systemic herbicides such as glyphosate or cycloxydim, at 20 and 5% concentrations, respectively, by using wick/ wiper applicators (Stroud and Kempen 1989). The equipment can be mounted on self-moving machines or in front of a tractor. Hand held applicators for direct contact application of the herbicide (DCA) may also be useful.

The plant growth regulator, maleic hydrazide sprayed at the rice milk stage and prior to or during red rice heading stage reduces the production of red rice seed (Dunand 1996, Andres and Menezes 1997). Rice cultivars must be earlier and head at least 10–15 days before red rice. It was noticed that maleic hydrazide reduced seed viability and so it should not be used on rice seed production fields.

Genetic and biotechnological approach

The problem of weedy rice could be tackled by the introduction of herbicide tolerant varieties which allows the selective post emergence control (Linscombe *et al.* 1996, Wheeler *et al.* 1997). Glufosinate applied at the 3-4 leaf stage of the weedy rice (red rice) resulted in a better control (91%) than at panicle initiation (74%) or boot stage (77%). Imazethapyr could be selectively applied to imidazolinone resistant varieties (IMI rice) for effective control of weedy rice and other rice weeds (Olofsdotter *et al.* 1999). A non-transgenic rice variety '*Clearfield'* tolerant to herbicide imazethapyr had been in use in red rice infested fields of United States of America from 2002 onwards (Shivrain *et al.* 2009). However, possibility of out crossing of resistant variety with wild rice is suspected to taint the advantage of this technology.

The transfer of resistance genes to weedy species is likely to occur as the incidence of natural hybridization ranges between 1-52% in early and late flowering varieties (Langevin *et al.* 1990). Such problems have already occurred in Arkansas and Malaysia. Liu *et al.* (2012) made a major finding to prevent the spread of transgenes form GM rice to weedy rice which in due course would taint the advantage of GM herbicide resistant crop. They developed an insect-resistant and glyphosate-herbicide tolerant GM rice line that is sensitive to bentazon, a commonly used herbicide. He reported that weedy rice plants containing transgenes from GM rice through gene flow can be selectively killed by the spray of bentazon when a non GM rice variety is cultivated alternately in a few year intervals. The built in control mechanism in combination of cropping management is likely to mitigate the spread of transgenes into weedy rice populations.

Integrated weedy rice management

The trend towards increased herbicide use and the likely environmental concerns and health consequences always call for integrated weedy rice management. According to Abraham (2012), the only way to avoid the problem associated with weedy rice control is the implementation of improved weed control within the context of integrated weed management, with emphasis on the eco-biology of the species.

Research on the biology and management of weedy rice in Kerala

Heavy infestation of weedy rice in rice fields of Kerala during recent years had forced the farmers to abandon the crop due to huge reduction in crop yield (around 30-60%) depending on the severity of infestation (3-10 mature weedy plants per square meter). Acute labour shortage and high wages added to the severity of the problem. Infestation became serious from 2005 when farmers started relying more on chemical weeding and mechanized harvesting. Survey undertaken in the major rice growing tracts of Kerala during 2009-12 identified the infestation of weedy rice to the tune of 1-15 plants/m^2 in infested areas. Infested polders were categorized as those with mild, moderate and severe occurrence. Variations in plant height, tiller production, pigmentation, length of awn and grain were noticed in the weedy rice types of Kerala. The weedy plants have more brittle culm and are round in cross section than that of cultivated rice. The plants generally have a spreading habit and flower earlier than cultivated rice plants. Weedy morphotypes with and without auricles, either straw or red colour, are noticed in Kerala (Jose 2015).

It was observed that the variable dormancy and staggered germination in weedy rice favoured the survival and spread in cultivated fields. Lab studies have confirmed the hull induced dormancy in weedy rice of Kerala. Among the various treatments evaluated for breaking hull induced seed dormancy of weedy rice, treatments in the descending order of efficiency were:(i) subjecting seeds to low temperature of 22ºC for 48 hours, (ii) scraping of seed hull, (iii) salt water treatment for six hours (EC–5 dS/m and 15 dS/m) and (iv) 0.6% nitric acid soaking for six hours. These treatments can be effectively opted alone or in combination during different seasons in stale seedbed preparation for weedy rice management under different field situations (Jose *et al.* 2013). Scanning electron microscope studies of weedy rice seeds (Jose *et al.*

2013) revealed the presence of indentations on the exterior surface with silica in the mid region. The seed surface had parallel rows of trichomes which help in dispersal of seeds, give better grip for seeds in soil facilitating germination and prevent wash out during heavy rains. Observations confirmed the delayed germinability of matured weedy rice seeds compared to immature ones. The weedy rice leaves had more micro hairs and epicuticular wax which can reduce transpiration and enhance water use efficiency.

Studies in severely infested rice fields of Kerala (Jose *et al.* 2012a) revealed that stale seedbed preparation by ploughing the field in between two germinations at 25-30 days interval prior to sowing provided conditions for germination of majority of weed seeds in the soil seed bank. Ploughing (wet ploughing was more effective than dry ploughing) in between two stale seedbed operations took the buried seeds to the top soil for promoting germination, as weedy rice seeds do not germinate under continuous submergence and emerged only from top 4 cm of soil. In double cropped fields, where farmers do not get ample time for doing the staling operations twice, burning of straw before first stale broke seed dormancy and ensured uniform germination of weeds from the soil surface. Participatory technology demonstration also revealed that in severely infested double cropped areas, it is better to skip one crop season and repeat staling operations twice to prepare a weed free field, giving maximum time for exhausting soil seed bank (Table 1).

Studies at KAU revealed the effectiveness of soil solarization by using 100 micron transparent polyethylene sheets for 30 to 45 days during the summer months for getting more than 90% control of weedy rice. This technique will be useful for the rice nurseries to produce seedlings free of weedy rice seedlings. Surface application of oxyfluorfen 0.2 to 0.3 kg/ha in 2 cm standing water three days before sowing effectively controlled weeds (84% reduction in weedy rice dry weight) during (Fig.1) the initial critical period (Jose *et al.* 2012b).

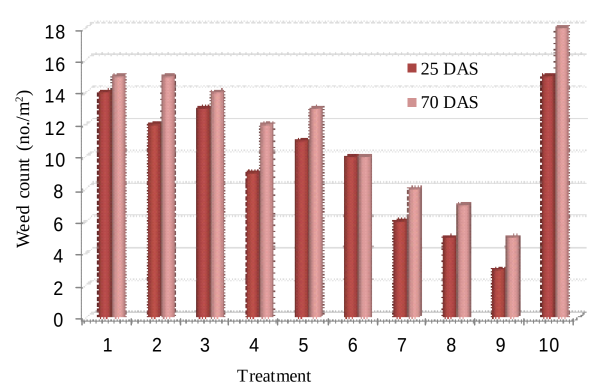
The research activities undertaken at KAU have standardized a new prototype of 'KAU Weed Wiper' for selective drying of weedy rice earheads for which patent is awaited. It was proved that better WCE can be obtained by selective killing of weedy panicles by DCA (Table 2) using a specially designed wiper device at 60-65 DAS, with broad spectrum herbicides *viz.*, glufosinate ammonium, paraquat or glyphosate 15-20% concentration of the formulated product, taking advantage of 15-20 cm height difference between rice and weedy rice plants (Jose 2015).

Integrated management strategies like stale seedbed technique to exhaust soil seed bank, pre-emergence application of herbicides to prevent the early emergence, and use of wiper device to selectively dry the panicles of weedy rice in standing crop to prevent buildup of soil seed bank are viable technologies for managing this difficult to control weed in rice. Effective management of weedy rice is possible by following other management options like higher seed rate, use of pigmented rice varieties, straw burning, appropriate tillage practices, adoption of mechanized transplanting or dibbling, scientific water management, and hand weeding in an integrated approach (Abraham *et al.* 2012). Participatory technology demonstration have confirmed that weedy rice infestation in farmers' fields required a management program aimed at local eradication at the field level followed by integrated management strategies.

Table 1. Effect of stale seedbed technique in managing weedy rice

Treatment	Plant density at 45 DAS (no./m^2)		Grain yield (t/ha)	WCE (%)
	Weedy rice	Rice		
One SSB	6	75	5.69	49.8
Two SSB	3	75	6.56	75.2
SSB with skip crop	1	74	7.50	89.6
Control	12	73	2.42	0
LSD (P=0.05)	2	NS	0.59	-

SSB - Stale seedbed



1	Butachlor 2.0 kg/ha	6	Oxyfluorfen 0.2 kg/ha
2	Butachlor 2.5 kg/ha	7	Oxyfluorfen 0.3 kg/ha
3	Pretilachlor 1.5 kg/ha	8	Oxyfluorfen 0.4 kg/ha
4	Pretilachlor 2.0 kg/ha	9	H.W. 20 & 40 DAS
5	Oxyfluorfen 0.1 kg/ha	10	Un weeded control

Fig. 1. Effect of pre-sowing application of herbicides on weedy rice infestation

Table 2. Effect of direct contact application (DCA) of herbicides on control of weedy rice panicles

Herbicide	Formulation (%)	Panicles (no./m^2)		Panicles dried (%)
		Before sweeping	Not dried	
Paraquat dichloride 24 SC	10	41	15	63
Paraquat dichloride 24 SC	15	44	7	78
Glyphosate 41 SL	10	44	13	71
Glyphosate 41 SL	15	45	12	73
Glufosinate ammonium 15 SL	5	39	19	52
Glufosinate ammonium 15 SL	10	43	15	67
Glufosinate ammonium 15 SL	15	44	9	80
Control		42	42	0

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