

Weedy rice invasion in fields of India

and management options

Nimmy Jose¹, C. T. Abraham² and Meenal Rathore³

Kerala Agricultural University, Thrissur (Kerala) 680 656

Rice experiences severe competition from weeds. Losses due to weeds range from 30 to 100% under moderate to severe infestations. Of late, weedy rice infestation is a serious threat in traditional rice belts of the country as it affects crop production, harvest quality and farmers income. Weedy rice is a complex of Oryza morphotypes widely distributed in commercial rice fields, especially in areas where farmers have switched to direct seeding due to labour shortage and high wages. India has the earliest history of rice cultivation and introgression between perennial wild rice and annual cultivated rice has given rise to highly variable population of weedy/wild rice forms, including annuals and perennials. Indian weedy rice was reported to be Oryza sativa f. spontanea, belonging to the indica group. Being a conspecific weed, weedy rice is morphologically and biochemically similar to cultivated and wild counterpart species; complete control of weedy rice by hand-weeding or herbicides is impractical. Heavy infestation of weedy rice and subsequent reduction in rice crop yields in India during recent years has forced farmers to abandon rice cultivation in many areas. Management of weedy rice infestation is complex because of its morphological similarity to cultivated rice and non-availability of selective herbicides. Extensive research showed several facts about Indian weedy rice biology and ecology and also standardized package of practices for the management of weedy rice in direct seeded puddled rice.

Key words: Fields, Management, Invasion, Rice, Weedy

CULTIVATED RICE is included in the genus *Oryza* of the grass family (Poaceae). This genus includes two cultivated species (Asian rice - *Oryza sativa*, and African rice *Oryza 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. 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 sexually compatible with cultivated rice. There are several hypothesis for the origin of weedy rice and they vary from place to place. With diverse biotypes, weedy rice infested pendamically more than 50 countries of Asia, Africa and Latin America. In India, weedy rice infestations was in

West Bengal, Andhra Pradesh, Asom, Bihar, Karnataka, Madhya Pradesh, Odisha, Tamil Nadu and Uttar Pradesh. Wild and weedy forms are problematic in eastern India (Eastern Uttar Pradesh, Bihar, Odisha, Manipur, and West Bengal) and Southern India (Kerala). Weedy rice plants are adapted to a wide range of environmental conditions. They spread as contaminants with seed material are distributed through irrigation water, machinery and animals, and efficient replenishment to the soil seed bank also adds to the severity of infestation and invasion to newer areas.

Characters of weedy rice

A weedy rice plant showed wide variability in anatomical, biological and physiological features. It is difficult to distinguish weedy rice at



Fig. 1. Variants of weedy rice in paddy fields

seedling stage as they mimic the rice crop, but distinguishing is possible after tillering due to many morphological differences e.g. numerous, longer and more slender tillers, leaves are often hispid on both surfaces, taller plants, pigmentation of several plant parts, grains with awns and red pericarp and shattering of seeds. Grains of weedy rice mature earlier and asynchronously in

comparison to cultivated rice and are easily shattered. Some morphotypes have anthocyanin pigmentation in the apiculous, first internode, ligule, margins of the first leaf and auricles (Fig. 1).

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 possess variable degree of dormancy and tendency for the seeds to shatter as soon as they mature. Seeds mature within a short period and became viable at about nine days from the beginning of flowering with 20% germinability, reaching about 85% at 12 days after flowering. Despite years of research on seed dormancy, mechanisms for the regulation of germinability are basically unknown. Seed longevity in the soil was found to be ecotype dependent and is also affected by burial depth, soil type and moisture, cultivation practices, fecundity and dormancy. Emergence of weedy rice is greatly influenced by soil texture, presence of water in the field and depth of seed burial, which in turn is strictly related to the cultural practices adopted for seedbed preparation. 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 germinate only when they are brought to the surface in subsequent ploughing operations.

Competitive ability

Weedy rice usually coexists with cultivated rice and is highly competitive in rice fields. 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 60% yield loss and under serious infestation, 74% yield loss was also observed in direct seeded rice. Short varieties are usually more susceptible and interference duration is a yield deciding factor. Studies on crop weed interference under elevated CO₂ concentration were found to enhance competition and reduce crop

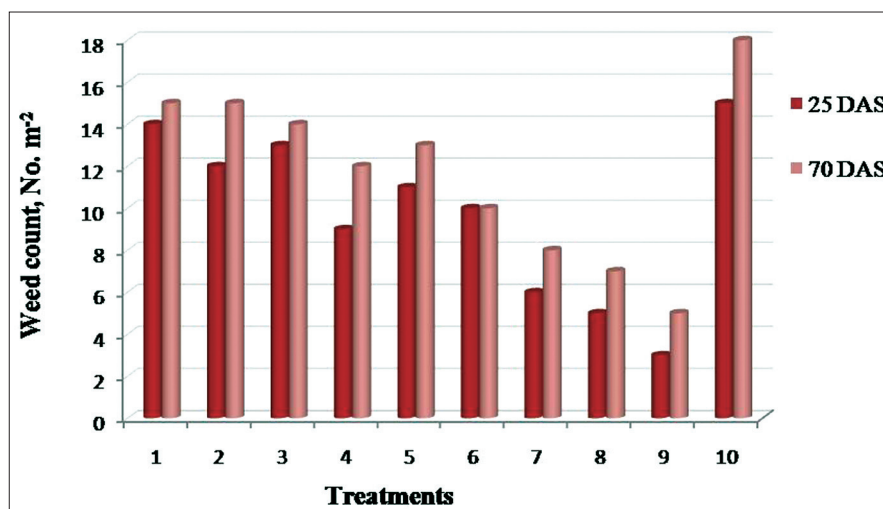


Fig. 2. Effect of pre sowing application of herbicides on weedy rice infestation

yield.

Control of weedy rice

Weedy rice infestation in rice fields reduces grain yield and quality. Several methods are available for control of wild and weedy rice, but none are highly effective individually. Therefore, effective control of weedy rice populations becomes very important for sustainable production of rice crop in all growing regions world wide.

Prevention: It is the basic means of reducing weedy rice infestation and can be achieved mainly by sowing clean rice seeds. Another effective preventive measure is cleaning of equipments used for rice harvesting to avoid spread of weedy rice to uninfected fields.

Cultural methods: In the absence of effective selective post-emergence chemical control, techniques to minimize weedy rice infestations should focus on lowering the chance of emergence of weedy rice seedlings at crop establishment; and preventing subsequent seed return to the soil from surviving plants at maturity. The former include repeated (wet and dry) tillage to provide clean seed beds, rotation of crop establishment methods (transplanting, water seeding, wet direct seeding), and cultivar selection to enable water management during crop establishment. Studies conducted revealed reduction in weedy rice population in transplanting (95-98%) compared to direct seeding. Cultural strategy also included 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. The best control of weedy rice could be obtained with crop rotation with crops like soybean, maize, sunflower, sorghum etc.

Stale seed bed technique: Stale seed bed, also named as false seeding technique, is a cultural method commonly applied in rice monoculture for weed management. After seed bed 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 reduces the weed infestation in the same season and gradually decreasing its seed bank.

Enhanced seed rate and row seeding: Enhanced crop seeding rates of 110–120 kg ha⁻¹ in infested fields suppresses weedy rice infestations. Row seeding was observed as a better and easy method to differentiate cultivated rice plants in rows and weedy rice between rows and can be controlled by mechanical weeders.

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 weedy rice. Excessive drainage will expose the soil to air and increased oxygen concentration in the soil, thus stimulating weedy rice germination.

Table 1. Effect of stale seed bed technique in managing weedy rice

Treatment	Plant density at 45 DAS (No./m ²)		Grain yield (kg/ha)	WCE (%) (%)
	Weedy rice	Rice		
One SSB*	6	75	5688	49.8
Two SSB	3	75	6562	75.2
SSB with skip crop	1	74	7500	89.6
Control	12	73	2420	0
CD (0.05)	2	NS	587	-

* SSB - Stale Seed Bed

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.

Hand weeding: It 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 showed poor results, so as to avoid grain dispersal and also in seed production plots.

Mechanical control of weedy rice: 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. The experience revealed that at least 90% 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 of weedy rice: Herbicide-based weed management is very difficult because of anatomical and physiological similarity of weedy rice to the crop. However, with modification in the time and method of herbicide application, chemical control can be successful in managing weedy rice. Use of antigerminative herbicides thiobencarb at 2.1 kg/ha, oxadiazon at 0.24 kg/ha and pre-plant incorporation of thiocarbamate herbicides, seed protectants like oxabetrinil at 1.5 g/kg and flurazone at 2.5 g/kg are also effective in controlling weedy rice. Weedy rice that had grown taller than rice could be treated with herbicides using wick/wiper applicators for drying of

weedy rice panicles.

Genetic and biotechnological approach for weedy rice control: A new approach to chemical control of wild and weedy rice is the use of herbicide tolerant crop cultivars. A non-transgenic rice variety 'Clearfield' tolerant to herbicide imazethapyr was in use in red rice infested fields of United States of America from 2002 onwards. However, possibility of out crossing of resistant variety with wild rice is suspected to taint the advantage of this technology.

Research activities under AICRP on Weed Control, Kerala Centre showed pioneer work on management of weedy rice. Infestation became serious from 2005 when farmers started relying more on chemical weeding and mechanized harvesting. Heavy infestation of weedy rice in rice fields of Kerala during recent years forced the farmers to abandon the crop due to huge reduction in crop yield (around 30-60%) depending on the severity of infestation (15-20 mature weedy rice plants/m²). Acute labour shortage and high wages added to the severity of the problem. Survey undertaken in the major rice growing tracts of Kerala during 2010-15 identified the infestation of weedy rice to the tune of 15-30 or even plants/m² in infested areas. Infested polders were

Table 2. Effect of direct contact application of herbicides on the control of weedy rice panicles

Herbicide	Formulation, %	Panicles, No./m ²		Panicles dried % dried
		Before	Not sweeping	
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
CD (P=0.05)		NS	8.4	16.0

**Fig. 3.** Dried panicles on using KAU Weed Wiper at 70 days after sowing

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 morphotypes of Kerala. Major reason for the spread was the difficulty to recognise weedy rice biotypes or hybrids in the crop field during the early stage of infestation due to its close similarity to the cultivated rice, with short awns and straw coloured grains, gradually turning black or deep brown on maturity. At seedling stage, it is difficult to distinguish weedy plants as it mimics the crop, while it was possible after tillering with many morphological differences with the rice varieties i.e., numerous, longer and more slender tillers, leaves which were often hispid on both surfaces, light green, tall plants, pigmentation of several plant parts, grains with awns and red pericarp and shattering of seeds. 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 coloured



Fig. 4. KAU Weed Wiper

are noticed in Kerala. The seeds have parallel rows of trichomes which help in dispersal of seeds and leaves have more micro-hairs and epicuticular wax which can reduce transpiration and enhance water use efficiency.

It was observed that the variable dormancy and staggered germination in weedy rice favored the survival and spread in cultivated fields. Lab studies confirmed hull induced dormancy in weedy rice of Kerala which can be broken by subjecting seeds to low temperature of 22°C for 48 hr, scraping of seed hull and soaking in 0.6% nitric acid for six hours. These treatments can be effectively opted alone or in combination under different field situations during stale seed bed preparation for weedy rice management.

Studies in severely infested rice fields of Kerala revealed that stale seed bed 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 seed bed 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, farmers do not get ample time for doing the staling operations twice. Participatory technology demonstrations 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).

Kerala Agricultural University studies revealed the effectiveness of soil solarisation by using 100 μ transparent polyethylene sheets for 30 to 45 days during the summer 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. Pre-sowing surface application of oxyfluorfen @ 0.2 to 0.3 kg ha⁻¹ in 2.0 cm water three days before sowing effectively controlled weeds (84% reduction in weedy rice dry weight) during (Fig.2) the initial critical period.

- T 1 Butachlor @ 2.0 kg/ha
- T 6 Oxyfluorfen @0.2 kg/ha
- T 2 Butachlor @ 2.5 kg/ha
- T 7 Oxyfluorfen @ 0.3 kg/ha
- T 3 Pretilachlor @ 1.5 kg/ha
- T8 Oxyfluorfen @ 0.4 kg/ha
- T 4 Pretilachlor @ 2.0 kg/ha
- T 9 H.W. 20 and 40 days after sowing
- T 5 Oxyfluorfen @ 0.1 kg/ha
- T 10 Unweeded control

The research activities undertaken at Kerala Agricultural University have standardized a new prototype of 'KAU Weed Wiper' for selective drying of weedy rice earheads for which patent is awaited. The specially designed wiper applicator favours selective drying of weedy rice panicles by direct contact application of glufosinate ammonium or glyphosate or paraquat @ 15 to 20% concentration at 60-65 days after sowing, taking advantage of 15-20 cm height difference between rice and weedy rice plants and earliness in flowering (Table 2 and Fig. 3).

The technology transfer of machine was done and now it is marketed as 'KAU Weed Wiper' (Fig. 4).

Integrated management of weedy rice

The trend towards increased herbicide use, likely environmental concerns and health consequences always call for integrated weedy rice management. 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 ecobiology of the weed. Integrated management strategies like stale seed bed 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 integrating other management options like higher seed rate, use of pigmented rice varieties, appropriate tillage practices, adoption of mechanized transplanting or dibbling, scientific water management, and hand weeding.

SUMMARY

Weedy rice has emerged as a dominant weed species and major threat to rice production in traditional rice belts of the country. It emerges faster than cultivated rice and develops vigorous root systems and competes with rice for nutrients, light, water, and other plant growth resources. Weedy rice causes 34 to 75% reduction in direct seeded rice depending upon its intensity. Integration of different management options like higher seed rate, use of pigmented rice varieties, appropriate tillage practices, adoption of mechanized transplanting or dibbling, scientific water management, and hand weeding are the effective management options for management of weedy rice.

^{1,2}Scientist, AICRP-Weed Management, Kerala Agricultural University, Thrissur 680 656;

³Scientist (Plant Biotechnology), Indian Institute of Pulses Research, Kanpur (Uttar Pradesh). Corresponding author's e mail: nimmy.jose@kau.in