

Weedy rice: Threat for sustainability of direct seeded rice production

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Rice is the staple food for the world. Asia accounts for 90% of the world's total rice area and production. It is traditionally grown in Asia by manual transplanting of seedlings into puddled soil. In the recent years, due to the labour and water shortages along with the problem of uncertainty in rainfall in the changing climate, pulled the farmers to shift from transplanting to direct seeded rice (DSR) system. DSR is more rapidly and easily planted, is less labour intensive, consumes less water, matures 7 to 10 day earlier, and has least methane emission. Despite these benefits, one of the major threats associated with the introduction of DSR is the evolution of weedy rice, one of the most difficult-to-control weed species of rice in the world. Add extent of loss due to weed infestation in DSR and transplanted rice both and also from weedy rice alone.

Key words: Herbicide, Infestation, Weedy rice

THERE are too many weed flora in DSR i.e. complex weed flora which cannot be controlled through use of one herbicide. *Echinochloa*, *Cyprus*, *trienthema* and *Ludwigia* spp. Are some of the main weeds found almost in all rice belts and causes severe yield reduction up to 70-80 % yield loss if not controlled in time. Weeds are the major biological constraints in direct seeded rice (DSR) production because of the absence of the suppressive effect of standing water on weed growth at crop emergence and the absence of stage difference between the crop and the weeds. Among these weeds, weedy rice is the most problematic one which is difficult to manage causing huge yield loss to rice producers under DSR. It belongs to the same genus and species as cultivated rice but as light difference in morphology. It grows faster; produces more tillers, panicles and dry matter; earlier seed shatter ring and possesses longer dormancy in the soil. Single management technique can be in effective to control weedy rice. Even to date, no selective

herbicides are available to control weedy rice in conventional rice cultivars and therefore managing weedy rice is a challenging the sustainability of rice production under DSR. Therefore, integrated approach including preventive, cultural, mechanical and chemical control measures are essential.

What is weedy rice?

Weedy rice (*Oryza sativa* f. *spontanea*) evolved largely by natural hybridization between wild and cultivated rice, possess biosimilar AA genome complex and shares traits with both cultivated (high fecundity,

enhanced growth) and wild types (asynchronous maturity, early shattering, dormancy, coloured pericarp) of rice. Most types of weedy rice possess a red pericarp hence called red rice. It is a potential threat to rice cultivation as it affects crop production, harvest, quality and income. Weedy rice is morphologically and biochemically similar to cultivated and wild counterpart species. It was first documented in USA in 1846. The infestation was first reported in Malaysia in 1988, in Philippines in 1990, and in Vietnam in 1994. In India, infestation was first reported in

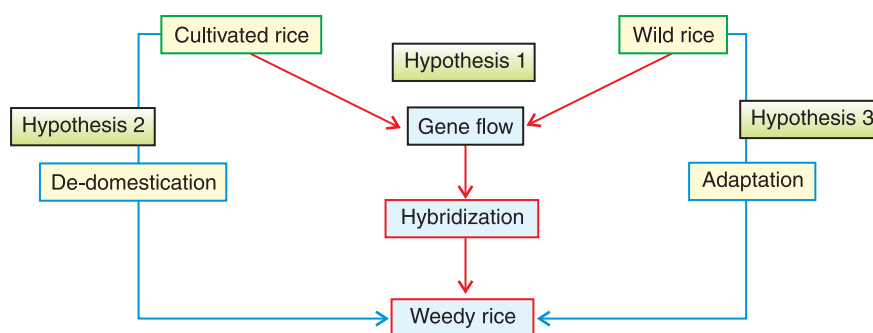


Fig. 1. Hypothesis for the origin of weedy rice

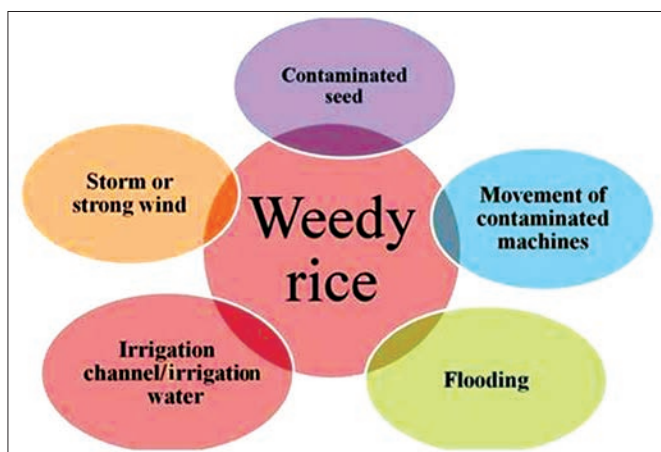


Fig. 2. Weedy rice dispersal from infested areas to new areas.

1994 and spreads in West Bengal, Andhra Pradesh, Asom, Bihar, Karnataka, Madhya Pradesh, Orissa, 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). It infested 5–60% field across different states, with 11.32–44.28% in cultivators' fields. A yield reduction of 30–60% has been documented in rice agricultural fields. In North Western states like Punjab and Haryana, weedy rice is rarely seen due to the absence of wild rice progeny and cultivation of paddy through transplanting method. Heavy infestation of weedy rice in rice fields during the recent years was reported in Kerala, forcing farmers to abandon the crop due to huge reduction in crop yield (around 40–70 %) depending on the severity of infestation.

The literature reveals three major hypotheses of weedy rice origin (Fig. 1). Hypothesis 1: through a continual process of gene flow between cultivated rice and its reproductively compatible wild populations, which leads to natural hybridization. Hypothesis 2: through a process of “de-domestication” of cultivated rice to weedy rice. Hypothesis 3: through direct adaptation of wildrice to continuous habitat disturbance, along with domestication of crop species. The major dispersal mechanisms of weedy rice are presented in Fig. 2.

Characters of weedy rice

Weedy rice showed the wide

variability of anatomical, biological and physiological features.

Emergence: Emergence of weedy rice decreases with increases in seed depth in both moist and flooded soil conditions. The maximum emergence of

weedy rice was 0–5 cm and then it declined with increases in depth and ceased at 10 cm. However, under flooded conditions (water depth 4–5 cm), no emergence was recorded from seeds placed in the soil below 4 cm depth. At seedling stage, it was difficult to distinguish weedy rice as they mimic the crop.

Rapid early growth: Taller canopy; high tillering capacity; spreading growth habit with long, drooping leaves; tendency to lodge because of weak culm; voracious consumption of fertilizer; tolerance to shade (Fig. 3). Most of the weedy rice are having a height of 130–145 cm where the height of cultivated rice ranges from 90–110 cm. Some of the weedy rice cultivars show anthocyanin colouration in its nodes also. These characters can be used as identifying weedy rice and management can be done easily.

Flowering and grain formation: The flowering period range of weedy

rice (8–93 days) is usually longer than that of cultivated rice (7–22 days) and floret opening remain longer by 1 hour, which leads to cross-pollination in some weedy rice biotypes. Cultivated rice cross pollinate rate less than 5%, but in wild rice out crossing rates can go up to 100%. Early flowering and taller plants of weedy rice may lead to a prolonged reproductive phase. Seed surface had parallel rows of trichomes with varying length of awns (Fig. 4) which help in dispersal of seeds, give better grip for seeds in soil facilitating germination and prevent wash out during heavy rains.

Seed shattering: It was observed that the grains of weedy rice ripened earlier and less regularly than those of cultivated rice and were extremely prone for heavy and early seed shattering (Fig. 5), which is a major reason for the dispersal and distribution of weedy rice. Seed shattering varies among different weedy rice biotypes ranges 20% to 95%.

Longevity: Longevity of weedy rice increases with increase in burial depth. Deep ploughing/tillage enhance the longevity of weedy rice seeds in the soil.

Management strategies of weedy rice

Weedy rice cannot be differentiated from cultivated rice in vegetative stages and by the time panicles emerge, the damage is already done. With no specific selective herbicide available for control of weedy rice. An appropriate

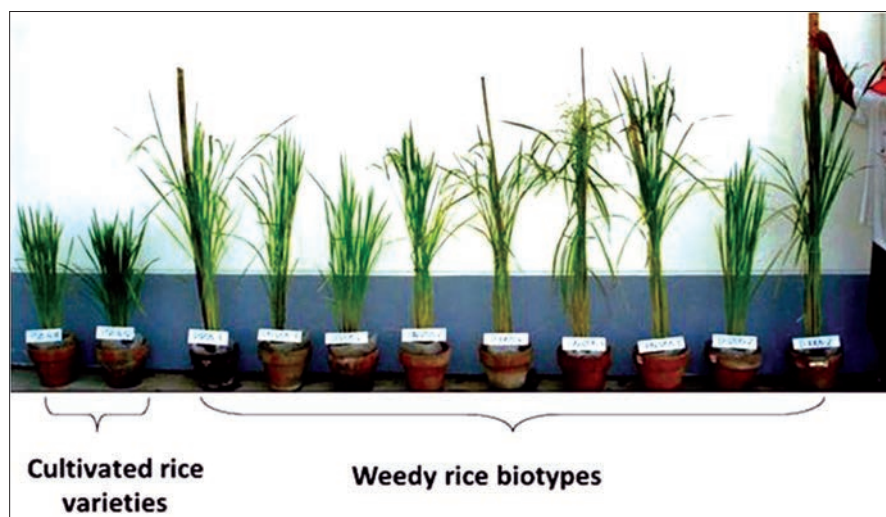


Fig. 3. Growth pattern of weedy rice



Fig. 4. Seeds of weedy rice showing trichomes.

combination of different methods including preventative, cultural, mechanical, chemical and/or genetic practices can reduce the chances of weedy rice infestation.

Preventive methods: Use of clean and certified seeds, use of clean farm implements and regular field inspection by farmers can prevent weedy rice infestation.

Cultural methods: Cultural approaches play significant role to determine the competitiveness of a crop with weeds for aboveground and below ground resources. Different cultural methods of weed control are:

Stale seedbed technique: It is 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.

Soil solarisation: The effectiveness of soil solarization by using 100 micron transparent polyethylene sheets for 30-45 days during the summer months for getting more than 90% control of weedy rice. This

will be useful for the rice nurseries to produce seedlings free of weedy rice seedlings.

Straw and stubble burning: Burning straw and stubble is an effective strategy in reducing weedy rice seed present on the soil surface.

Selection of cultivars: Use of tall cultivars, cultivars with early vigour and quick canopy closure are more competitive with weedy rice. Short-duration cultivars mature earlier than weedy rice. Cultivars with purple coloured leaves help to identify weedy rice early and can be used to reduce the loss due to weedy rice infestation. Shade through weed-competitive cultivars and use of high seeding rate can reduce weedy rice growth.

Water seeding: Rice plants require oxygen, moisture, and optimum temperature for germination and one of these missing may cause a reduction in rice germination. In the water-seeding technique, pre-germinated rice seeds are shown on well-levelled flat soils having minimum residue with clear standing water by the broadcasting method to decrease the weedy rice population.

Line sowing: Line sowing of cultivated rice instead of broadcasting facilitates the identification and removal of weedy rice seedlings that emerge between rows as inter-cultivation operations are easier in

row-seeded crops.

Flooding: Appropriate timing, duration, and depth of flooding are critical in managing weedy rice and other weeds in direct-seeded rice systems. The use of rice cultivars capable of emerging under anaerobic soil conditions will suppress emergence and growth of weedy rice during crop emergence in direct-seeded rice. Many weedy rice seeds decay between long periods of flooded condition.

Crop rotation: Continuous growing of rice with similar management practices allows weedy rice to become dominant in the cropping system. Crops with different management practices, however, may help in disrupting the growth cycle of weedy rice.

Mechanical methods

Inter cultivation using mechanical weeder: Mechanical weeding is possible in row-seeded rice. Mechanical weeders such as cono-weeder and inter-cultivation implements (tractor-drawn, bullock-drawn) or manually, remove weeds from between the rows. Line sowing also reduces seed cost as a lower seed rate is used when seeds are drilled than when seeds are broadcast.

Chopping: This method is applicable for controlling weedy rice plants, which are taller than cultivated rice. The panicles are chopped from the weedy rice plants before seed setting takes place.

Chemical methods: Selective herbicides to control weedy rice in conventional rice systems are not available as weedy rice and cultivated rice belong to the same species. Pre-plant application of effective soil active herbicides may help to suppress weedy rice emergence. Pre-emergence herbicides, such as acetochlor ($1.5 \text{ kg ai ha}^{-1}$), metolachlor ($2.5 \text{ kg ai ha}^{-1}$), alachlor ($2.4 \text{ kg ai ha}^{-1}$), and dimethenamid ($1.4 \text{ kg ai ha}^{-1}$), provided 85-92% control of weedy rice with no phytotoxicity when applied 15 days before cropsowing. Use of pretilachlor at $1.5 \text{ kg ai ha}^{-1}$ provided >75% control of weedy rice but, to avoid rice phytotoxicity, the herbicide had to be applied at least 25 days



Fig. 5. Showing the early seed shattering of weedy rice.

before rice planting.

Biotechnological approach – herbicide-resistant rice: Herbicide-resistant rice cultivars are resistant to a particular herbicide or herbicides that would otherwise damage the rice crop. These particular herbicides are sprayed on the resistant rice cultivar and they will not affect the rice but will instead kill weedy rice and other weeds in the crop. Therefore, in the absence of selective herbicides in conventional rice systems, herbicide-resistant rice cultivars could provide an attractive management solution to problems such as weedy rice and other hard-to-control weed species. Until now, three herbicide-resistant systems have been developed in rice: imidazolinone, glufosinate, and glyphosate resistant cultivars. The imidazolinone resistance is based on chemical mutagenesis (*i.e.* nontransgenic), while glyphosate and

glufosinate resistance is based on transgenic rice. Give names for herbicide-resistant rice cultivars.

Integrated weed management: Depending on the severity of infestation, effective control of weedy rice in direct seeded puddled rice is possible by integrating the management options like stale seed bed, pre sowing surface application of oxyfluorfen @ 0.2 kg/ha three days before sowing in 2 cm of standing water along with selective drying of weedy rice panicles by direct contact application of broad spectrum herbicides at 15 to 20 % concentration using wiper device at 60-65 and/or 70-75 DAS.

Effect of climate change (elevated CO₂) on crop-weedy rice interaction

Higher levels of atmospheric carbon dioxide (CO₂) facilitate the flow of genes between closely related

wild or weedy rice plants and domesticated rice varieties. Increased temperatures due to CO₂ levels lead to double flowering in wild rice varieties. Moreover, the weedy rice may grow taller than domesticated rice. Flowering and plant height are important factors in pollen sharing and impact gene flow. Transfer of wild genetic material to domesticated rice can result in the production of seed with weedy characteristics that would be undesirable in rice production. It suggests that rising CO₂ may enhance the competition from wild weedy rice in rice production and reduce consumable rice production.

Conclusion

With a shift to direct seeding of rice and increasing infestation of weedy rice, the bio similar has emerged as a potential threat to rice cultivation in India as well. That forced the farmers to abandon the crop due to huge reduction in crop yield. Hence weedy rice infestation in the farmer's field required immediate attention. A management programme aimed at local eradication at the field level followed by integrated management strategies should be given prime attention to sustain rice production under DSR.

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