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WEEDY RICE-AN EMERGING THREAT TO PADDY PRODUCTION

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Abstract

Weedy rice are complex of Oryza morphotypes widely distributed in the commercial rice fields in more than 50 countries of Asia, Africa and America where farmers have switched to direct seeding due to labour shortage and high cost. Heavy infestation of weedy rice in rice fields during recent years had 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 and a management programme aimed at local eradication at the field level followed by integrated management strategies. Integrated management strategies like use of clean seeds, stale seed bed, preplant 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 the build-up of soil seed bank are viable technologies for managing the difficult to control weed in rice.

Keywords- weedy rice, rice production, direct seeded rice, yield loss, weed management

I. INTRODUCTION

Rice is the principal source of food for more than half of the world population. It is grown on approximately 153 Mha globally, of which 90% of the area is in Asia. Rice is traditionally grown in Asia by manual transplanting of seedlings into puddled soil (Chauhan, 2013). In the recent years, there have been concerns of labour and water shortages in many areas along with the problem of uncertainty in rainfall in the scenario of climate change. Rural labour is migrating to the cities and labour costs have thus increased rapidly. It is also hard to find labour at the time of rice transplanting (Mahajan *et al*., 2013). By 2025, a significant amount of rice area may suffer from 'physical' and 'economic' water scarcity (Tuong and Bouman, 2003). All these factors pulled the farmers to shift from transplanting to direct seeded rice (DSR) system. Although there are several advantages of direct seeded rice, weeds are the major constraints in direct-seeded rice 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 (Chauhan and Johnson, 2010). Among these weeds, weedy rice is the most problematic one which is difficult to manage causing huge yield loss to rice producers. Varshney and Tiwari (2008) reported weedy rice as one of the most problematic weed in 21st century which affect rice yields seriously.

II. WEEDY RICE (*Oryza sativa* f. *spontanea)*

Weedy rice is an unwanted plant of the genus *Oryza* that infest and compete with rice and other crops and produces grains with a distinctly red or rough pericarp (Suh, 2008). It was first documented in USA in 1846 (Londo and Schaal, 2007). But its infestation was first reported in Malaysia in 1988, in Philippines in 1990, and in Vietnam in 1994 (Mortimer *et al*., 2000). In India, infestation was first reported in 1994, but in kerala infestation became serious from 2005. It is known by different names like *Padi Angina* in Malaysia, *Khoanok* in Thailand, *Valvi* in Sri Lanka, *Junglidhan* in India and *Varinellu/Meesha* in Kerala. Until recently, India had no problem of weedy rice due to the fact that transplanting was the main planting method. Reduced labour and decreased availability of irrigation water compelled farmers to shift from transplanting to DSR as a result weedy rice problem started in India (Varshney and Tiwari, 2008).

Rice fields in Kerala were found to have weedy rice as a major problem (Rathore *et al*., 2013). Heavy infestation in the fields of Kerala during recent years has caused a reduction in yield by 30–60% (Abraham *et al*., 2012).

2.1. Why weedy rice a notorious weed?

Since weedy rice and cultivated rice have similar physiological and morphological traits, it cannot be identified at the critical stages of weeding. The population of weedy rice increases in exponential progression and selective herbicides to control weedy rice in conventional rice systems are not available. Other characters of weedy rice that makes weedy rice problematic are:

2.1.1 Origin

The cultivated rice (*O. sativa*) hybridizes in nature with the annual as well as with the perennial wild rice. The hybrids back-cross both ways and produce morphological inter-grades (Sampath and Rao, 1951). These are known as *O. sativa* f. *spontanea* after Roschevicz (1931) and after Sampath and Govindaswami (1958). *Oryza sativa* f. *spontanea* invades the cultivated fields and poses a great problem as weedy rice. The weedy rice resemble the cultivated types but they were differentiated by their shattering nature. Mutation is also responsible for developing weedy rice and there is possibility of evolution of weedy rice during development and production of hybrid rice (Rathore *et al*., 2013).

2.1.2. Characters of weedy rice

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 (Jose *et al*., 2013). Seed possess awns. Length of awn varies with ecotype.

Weedy rice shows hull induced seed dormancy. The seeds in a panicle had variable dormancy ranging from two months to one year or more when exposed to germination in petridish. Weedy rice seeds remained dormant under flooded condition and germinated under moist condition even from 4 cm of soil depth (Jose *et al*., 2013). Dormancy varies with ecotype and storage conditions and can range from a few months to a few years (Suh, 2008). Loss of dormancy in weedy rice was rapid at 6-14% moisture content and very low at moisture content <5% and >18% (Leopold *et al*., 1998).

Longevity of weedy rice increases with increase in burial depth (Noldin *et al*., 2006). Deep ploughing / tillage enhances the longevity of weedy rice seeds in the soil (Singh *et al*., 2013).

Heavy and early seed shattering is a major reason for the dispersal and distribution of weedy rice. Seed shattering behaviour is biotype specific and varies from a few days to a few weeks (Azmi and Karim, 2008). A study from Vietnam reported that seed shattering time and percentage are not correlated and seed shattering in weedy rice varies from 20% to 95% in different seasons and biotypes (Chin *et al*., 2000).

Weedy rice spreads rapidly from infested fields to new non-infested areas. Knowledge of the sources responsible for the dispersal of weedy rice can help in preventing its spread to non-infested areas. The use of contaminated weedy rice seeds is the most important source of its spread to new areas. The use of weedy rice–contaminated agricultural equipment/machinery also plays a vital role in its dispersal. It is therefore important to use weedy rice–free certified seeds and machinery should be cleaned before moving it to new areas to prevent weedy rice spread. In addition, weedy rice can be dispersed from one field to another through irrigation channels or irrigation water, heavy winds or storms, and flooding.

Weedy rice shows profuse tillering. Tillering in weedy rice and cultivated rice begins at the same time. Tillering reduces with increase in height of the weedy rice plant and varies depending upon the environmental conditions.

Weedy rice is taller than cultivated rice. Most of the weedy rice are having a height of 130-145cm where the height of cultivated rice ranges from 90-110cm. Some of the weedy rice cultivars show anthocyanin colouration in its nodes also. These characters can be used as identifying characters and management can be done easy.

Flowering period of weedy rice ranges from 8-93 days is usually longer than that of cultivated rice (7-22 days) and floret opening is also longer by 1 hour, which leads to cross-pollination in some weedy rice biotypes. Floret opening begins in the top florets of the panicle and proceeds downwards to the lowest florets. (Longevin *et al*., 1990)

Weedy rice emerges faster than cultivated rice and develops vigorous root systems; thus, it is highly competitive with cultivated rice for nutrients, light, water, and other plant growth resources (Singh *et al*., 2013). The weedy rice leaves had more micro hairs and epicuticular wax on the adaxial surface compared to the abaxial surface, which can reduce transpiration, reflect away excessive heat and enhance water use efficiency (Hamid *et al*., 2007). Greater nitrogen-use efficiency for weedy rice has also been reported by Chauhan and Johnson (2011).

2.1.3. Problems caused by weedy rice

Rice yield losses is the major problem due to weedy rice which varies depending on the amount of infestation. By infesting rice fields, weedy rice increases production costs and reduces farmers' income by decreasing yield. Its infestations reduce the value of the harvested crop by staining the rice grain with undesirable pericarp colour.

2.2. Management practices

Hand weeding cannot be practiced because the weedy rice can't be identified at the critical stage of weeding i.e. at 20-30 days after sowing or planting. It could only be identified at the time of panicle emergence and need additional weeding to remove this weed. Also hand weeding is laborious and incomplete. Other management practices are:

2.2.1. Preventive Measures

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

2.2.2. Cultural Practices

a) Stale seed bed technique:
Most effective cultural practice. It is nothing but removing the germinated weedy seeds mechanically or using non selective herbicides before planting. In stale seed bed technique, infested fields were subjected to a sequence of operations including burning of stubbles followed by germination of weed seeds from the moist soil by providing conditions for seed germination for 12-15 days. Depending on the availability of time and intensity of infestation, the seedlings emerged from the soil seed bank were destroyed by dry ploughing followed by wet ploughing (to expose soil seed bank), or by applying broad spectrum herbicide (glyphosate @ 0.8 kg ai ha-1) after germination. Ten days after glyphosate application the plots were flooded for 10-15 days. It was found that in severely infested areas it is better to skip one crop and repeat SSB operations twice to prepare a weed free field, giving maximum time for exhausting soil seed bank. Weed control efficiency (WCE) and cost benefit ratio on partial budgeting was also higher in skipped crop with intensive ploughing and repeated germination (Jose *et al*., 2013).

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

c) 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-colored 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 (Chauhan, 2013).

d) 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(Abraham *et al.*, 2010). In a study from Italy, maximum emergence of weedy rice was from 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 soil below 4cm depth (Vidotto and Ferroro, 2000).

e) 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. In rice-rice or rice-rice-rice cropping systems, one rice crop (preferably in the dry season) could be rotated with an upland crop such as pulses or sesame.

f) Soil solarization

Studies at KAU revealed that effectiveness of soil solarization by using 100 micron transparent polyethylene sheets for 30-45 days during the summer months for getting more than 90 per cent control of weedy rice. This will be useful for the rice nurseries to produce seedlings free of weedy rice seedlings.

2.2.3. Establishment Methods

The rotating crop establishment method from wet-seeded rice to transplanted rice may help reduce weedy rice infestation. In most rice areas the spread of weedy rice became significant mainly after the shift from rice transplanting to direct seeding, and has started to become very severe over the last few years (Varshney and Tiwari, 2008). It is better to adopt transplanting method for growing rice in weedy rice infested areas and where water and labourers are plenty. It is because transplanting can reduce weedy rice infestation by 95-98%. Seedling broadcasting is another method which can reduce weedy rice infestation by 71-87 % (Chauhan *et al.*, 2014). By sowing seeds in rows also weedy rice infestation can be reduced since the weedy rice seedlings emerging between the rows can be easily distinguished and manual and mechanical weeding is much easier to perform. Water seeding (pre-germinated rice seeds are broadcast in standing water) also reduces weedy rice infestation.

2.2.4. Mechanical Methods

a) Inter cultivation using mechanical weeders

Mechanical weeding is possible in row-seeded rice. Mechanical weeders such as cono-weeder and inter-cultivation implements (tractor-drawn, bullock-drawn, or manual) 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.

b) 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. In many countries, weedy rice panicles are cut with the help of a machete or a special knife attached to a stick. In developed countries, a combine harvester cutting device is mounted on the front of the tractor and used to cut the weedy rice panicles.

2.2.5. 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.

a) Use of herbicides before sowing:
In Bangladesh, growers apply Pretilachlor (with a safener) before or after tillage operations under standing water to reduce weedy rice infestation (Chauhan, 2013). Surface application of oxyflourfen in 2 inches standing water after land preparation and three days before sowing effectively controls weedy rice in the initial critical period of 12–15 days (Abraham *et al*., 2012).

b) Use of seed protectants:
Studies conducted in Kerala by Nair and coworkers during 1984-86 have reported coating of dry seeds with 20% calcium peroxide using 4% PVA solution, and broadcasting them in field with 10-15 cm standing water for 10 days can control weedy rice. Later, this technology was found not practicable due to increased water fowl attack on coated seeds and lankiness of the crop plants due to continuous submergence.

c) Use of herbicide during the crop season:
Post emergence management of weedy rice by direct contact application of herbicide (DCA) was experimented by utilizing a specially designed wick applicator for selective drying of ear heads of weedy rice which flowers earlier than rice and emerge above the canopy of rice at 60 to 75DAS. Jose et al., (2013) proved that better WCE can be obtained by selective killing of weed panicles by DCA using wick applicator at 60-65 DAS, with broad spectrum herbicides glufosinate ammonium, or glyphosate @ 15-20%, taking advantage of 15-20 cm height difference between rice and weedy rice plants. Quick drying of weedy rice panicles was observed on using ammonium glufosinate. This method of weed management has the advantage of being ecofriendly as the herbicide is not coming in contact with soil or the crop.

2.2.6. 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 2cm 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. (Jose *et al*., 2013)

2.2.7. Biotechnological approach using herbicide resistant rice

Until now, three herbicide-resistant systems have been developed in rice. They are Imidazolinone-resistant cultivars, glufosinate-resistant cultivars 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. Clearfield (CL) rice is a mutated rice that is resistant to imidazolinone herbicides, which are acetolactate synthase (ALS) inhibitors. It is largely used in USA and Malaysia to overcome the problem of weedy rice. The use of herbicide-resistant rice may benefit rice farmers by improving weedy rice control and reducing weed control costs in the short term. But there is disadvantages like

- The control of volunteer rice seedlings,
- The impact of changing patterns of herbicide use,

- The risk of damaging a neighbours' crop by herbicide drift
- The continuous use of a single herbicide may hasten the development of herbicide resistance in other weeds.
- Imidazolinone residue in soil may affect the emergence of nontolerant rotational crops.

As a result, some countries have withdrawn herbicide-resistant rice cultivars from the market because of severe infestation of resistant weedy rice populations in their rice fields.

2.3. Future aspects of weedy rice

Compared with cultivated rice, weedy rice responded more strongly to rising CO_2 level with greater competitive ability, suggesting that weedy rice may become a more problematic weed in the future (Ziska *et al*., 2010).

2.4. Beneficial effects of weedy rice

Even though weedy rice is a weed, it is medicinally important due to the presence of antioxidants, vitamins and minerals. Even diabetic patients can consume weedy rice.

III. CONCLUSION

Heavy infestation of weedy rice in rice fields during recent years had 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.

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