Crop Protection 100 (2017) 106–110

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Impact of burial and flooding depths on Indian weedy rice

Dibakar Ghosh [a, b, *], Meenal Rathore [b, c], Koushik Brahmachari [a], Raghwendra Singh [b, d], Bhumesh Kumar [b]

[a] Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, 741252, India
[b] ICAR-Directorate of Weed Research, Jabalpur, Madhya Pradesh, 482004, India
[c] ICAR-Indian Institute of Pulse Research, Kanpur, Uttar Pradesh, 208024, India
[d] ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, 221305, India

ARTICLE INFO

Article history:
Received 1 December 2016
Received in revised form
6 June 2017
Accepted 16 June 2017

Keywords:
Weedy rice
Tillage
Flooding
Seedling emergence

ABSTRACT

Increased labour costs and water scarcity have compelled Indian farmers to shift from transplanting to direct-seeded rice (DSR). Weedy rice is a serious problem in DSR and non-availability of a selective herbicide to control it has worsened the scenario. Cultural weed management approaches are suitable for managing this pest weed, and hence a study was conducted to assess the potential of eight Indian weedy rice accessions, collected from different geographical regions, to emerge from different burial (0-, 2-, 4-, 6-, 8- and 10- cm) and flooding (0-, 2-, 4-, 6-, 8- and 10- cm) depths. Seedling emergence gradually decreased with increased burial depth, with minimal emergence from a depth of 10 cm. Flooding depth had more impact than seeding depth on seedling emergence. Accessions from Jharkhand, Kerala, Bihar, and Madhya Pradesh had the highest germination under anaerobic situations. A flooding depth of 2 cm or more reduced the seedling emergence, but the results differed between the weedy rice accessions (varying between 28 and 84%). The results of this study suggest that weedy rice emergence can be suppressed by deep tillage, burying the seeds below the maximum depth of emergence, and by flooding fields to create anaerobic conditions.

1. Introduction

Rice is grown across diverse agro-ecological zones of India. However, it is mainly grown by manual transplanting of 3–6 weeks old seedlings into puddled soil (wet tillage) with continuous submergence (Ghosh et al., 2016). Puddled transplanted rice requires huge labour, water, and energy (Mahajan et al., 2012) leading to increased labour wages due to limited availability of labours during peak period of rice transplanting and hence, an increase in production cost (Mahajan et al., 2017). Greater dependence on ground water for rice cultivation has already led to a decrease in the water table by up to 1 m year^{-1}, resulting in water scarcity and increased cost for pumping water (Rodell et al., 2009).

Farmers in India and many other Asian countries have already begun to transition from transplanting to direct-seeded rice (Jabran et al., 2012, 2015a, 2015b). With this shift, weedy rice (*Oryza sativa* f. *spontanea*) has emerged as a problem weed, and is a major threat to rice production in countries like Malaysia, Sri Lanka, Thailand, Vietnam, and China, where DSR is the dominant establishment method. In Malaysia, weedy rice infestations were reported to cause yield losses in rice by up to 74% (Azmi et al., 1994). In India, weedy rice has become prevalent in many rice producing areas, including eastern Uttar Pradesh, Madhya Pradesh, Jharkhand, Chhattisgarh, Bihar, and Kerala (Rathore et al., 2013, 2016; Singh et al., 2013). Rice production in India may be seriously affected if weedy rice is not controlled properly and in a timely manner (Thomas, 2009). Therefore, effective management strategies are essential to counter this weedy rice threat.

The conspecific weedy rice causes escalated production costs and high yield losses in rice. Because weedy rice usually grows taller and faster, and tillers more profusely than cultivated rice, it competes with the crop for nutrients, water, light, and space (Rathore et al., 2013). Early flowering, and easy grain shattering, enables weedy rice to rapidly increase its soil seed bank (Rathore et al., 2013). Higher nitrogen use efficiency for biomass production is also reported in weedy rice (Chauhan and Johnson, 2011). The majority of weedy rice phenotypes have a coloured pericarp,

---

* Corresponding author. Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, 741252, India.
E-mail addresses: dibakar.ghosh@icar.gov.in, dghoshagro@gmail.com (D. Ghosh).

http://dx.doi.org/10.1016/j.cropro.2017.06.011
0261-2194/© 2017 Elsevier Ltd. All rights reserved.

and hence contaminate the final rice product, reducing the market value and also increasing milling costs (Martin and Tanzo, 2015). As no selective herbicide is available for weedy rice control in conventional rice cultivars, cultural weed management approaches like tillage and flooding remain suitable options for managing it. Gealy et al. (2000) studied the performance of weedy rice accessions collected from Arkansas, Louisiana, and Mississippi, USA and Chauhan (2012) worked on four Asian weedy rice accessions, collected from four different countries, and studied their performance under various seed burial and flooding depths. However, such information on the impact of seed burial and flooding depths on seedling emergence of weedy rice accessions from India is scarce. The current study was carried out with the objective of determining the effect of seed burial and flooding depths on emergence of eight Indian weedy rice accessions, collected from different geographic regions.

2. Materials and methods

2.1. Plant material

Experiments were carried out at the Indian Council of Agricultural Research (ICAR)–Directorate of Weed Research (DWR), Jabalpur, Madhya Pradesh, India. Eight accessions of weedy rice were collected from different geographical zones viz. Jabalpur– Madhya Pradesh (JMP), Gwalior– Madhya Pradesh (GMP), Jharkhand (JK), Chhattisgarh (CG), Bihar (BR), Varanasi– Uttar Pradesh (VUP), Ghazipur– Uttar Pradesh (GUP), and Kerala (KL) (Table 1). These accessions were grown in a field at the research farm of ICAR– DWR, with no previous history of weedy rice. The emerged panicles were individually bagged to maintain seed purity. Seeds were harvested and stored at 25 °C for one year before conducting further experiments.

2.2. Soil preparation

The soil used in the experiment was collected from rice fields of the research farm, sterilized, and sieved through a 3 mm sieve before use. The soil was clay loam containing 26, 25, and 49% sand, silt, and clay, respectively.

2.3. Effect of seed burial depth on seedling emergence

The experiment was conducted twice (started on September 2 and 28, 2013), in a randomized complete block design with eight weedy rice accessions. Twenty seeds of each accession were placed in a single row of 40 cm on the soil surface of plastic trays (dimension: 50 cm × 40 cm × 40 cm), with 5 cm row spacing between each accession. Seeds were then covered with the same soil to achieve burial depths of 0, 2, 4, 6, 8, and 10 cm. Adequate soil moisture for proper germination was maintained by timely irrigation. Seedlings were considered ‘emerged’ when the coleoptiles could easily be recognized. The experiment was terminated 21 days after sowing.

Table 1
Detailed about weedy rice morphotype.

Morphotype	Location	State	Latitude	Longitude
JMP	Jabalpur	Madhya Pradesh	23°13′49.16″N	79°58′27.8″E
GMP	Gwalior	Madhya Pradesh	26°31′07.27″N	78°00′10.49″E
JK	Ranchi	Jharkhand	23°14′51.6″N	85°16′53.68″E
CG	Utai	Chhattisgarh	21°13′32.63″N	81°4101.81″E
BR	Patna	Bihar	25°59′03.99″N	85°39′32.57″E
VUP	Varanasi	Uttar Pradesh	25°10′21.40″N	83°17′35.39″E
GUP	Ghazipur	Uttar Pradesh	25°51′43.70″N	83°34′05.64″E
KL	Thrissur	Kerala	10°45′52.8″N	76°40′23.85″E

2.4. Effect of flooding depth on seedling emergence

Twenty seeds of each weedy rice accession were sown at 1 cm soil depth in plastic trays (dimension: 50 cm × 40 cm × 40 cm), on two different dates *viz.* August 1 and September 26, 2013. After sowing, the trays were subjected to 0, 2, 4, 6, 8, and 10 cm flooding depths above the soil surface using a fixed measuring scale. The tray size, sowing pattern, and soil used were similar to those in the seed burial experiment. The number of seedlings emerged were counted 21 days after sowing.

2.5. Statistical analyses

Both the experiments were conducted independently, repeated twice within an interval of 25 days. There was non-significant trial effect and interaction between treatments and trials. Therefore, the data were combined and subjected to analysis of variance (ANOVA). The statistical analysis was done using SAS Windows Version 9.3. Each weedy rice accession was analysed separately for seed burial and flooding depth. Treatment means were separated with the use of Tukey's Honest Significant Difference test at a 5% level of significance.

3. Results

Seed burial depth significantly affected the seedling emergence of all weedy rice accessions (Fig. 1a). Maximum seedling emergence (96%) in the JMP accession was observed in seeds sown at 2 cm soil depth (Fig. 1a). No significant difference in germination/seedling emergence was observed for seeds buried at 0, 2, 4, and 6 cm soil depths. However, with an increase in soil depth to 8 and 10 cm as compared to surface seeding, seedling emergence was reduced by 25 and 43%, respectively. Relative to seed burial depth, depth of flooding had a more pronounced impact on seedling emergence of the weedy rice accessions. A flooding depth of 2 cm reduced the seedling emergence of the JMP accession by 78%. But beyond this, an increase in flooding depth had no significant effect on seedling emergence.

Similarly, no significant difference was recorded in seedling emergence of the GMP accession from soil depths of 0–6 cm (Fig. 1b). A significant decrease was recorded at 8 cm soil depth, which had similar seedling emergence to that observed at 10 cm depth. An increase in flooding depth consistently reduced seedling emergence of this accession. An increase of flooding depth to 2 cm reduced seedling emergence by up to 42%. Thereafter, there was no significant reduction in seedling emergence with increased flooding depth.

No significant differences were observed when the JK accession was sown at soil burial depths ranging from 0 to 8 cm (Fig. 1c). But, with a further increase in seed burial depth (from 8 cm to 10 cm), seedling emergence declined by 47%. Observations on the effect of increasing flooding depth on seedling emergence suggest an initial significant decrease only (by 28% at the flooding depth of 2 cm). With further increases in flooding depth, no significant difference was recorded. Increasing the flooding depth from 2 cm to 10 cm reduced seedling emergence only by 9%.

Increasing seed burial depth had no significant effect on seedling emergence of the CG accession (Fig. 1d). The maximum decline (12%) in seedling emergence was observed for seeds sown at a burial depth of 10 cm, but this too was statistically non-significant. Flooding had a significant effect on seedling emergence of this weedy rice accession. Standing water of 2 cm depth reduced