SATSA Mukhapatra - Annual Technical Issue ***27*** *: 2023* ISSN 0971-975X ***Invited Paper***

Weed Management Technology for Rice

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(Received : November 22, 2022; Revised : December 15, 2022; Accepted : January 13, 2023)

ABSTRACT

Weeds are one of the biggest biotic constraints for the production of rice throughout the world. If weeds are not effectively controlled, they can inhibit rice growth through competition for nutrients, water, light, and space. For effective management of these weeds, the different weed floras are to be identified from rice fields. Accordingly weed management practices under different rice establishments namely wet and dry directed seeded rice and puddle transplanted rice are to be adopted in order to reduce weed pressure as well as to keep weed thrust under control in subsequent seasons. A comprehensive strategy that combines variety, agronomic management and integrated weed control measures can effectively control weed as well as improves overall rice productivity and sustainability.

Key words : Weed Flora, Weedy Rice, Dry and Wet seed rice, Puddle transplanted rice, Management practices

Introduction :

When compared to insect-pests (26%) and diseases (20%), weeds are unquestionably the biggest biotic constraint on the production of rice in the majority of rice-growing regions of the world (Debangshi and Ghosh, 2022). If weeds are not effectively controlled during the growing seasons of crops, they can inhibit rice growth by competing with it for nutrients, water, light, and space while also providing a haven for diseases, nematodes, and other insects (Heinrichs and Rangaswamy Muniappan, 2017). Due to changes in rice establishment techniques, such as switching from traditional transplanting to various forms of direct seeding with restricted water in response to the decreased supply of labour and water, the issues related to weeds in rice have become significantly worse in recent years. These modifications make the marijuana scenario considerably more intricate. Depending on the current agro-climatic conditions, soil types, water management, crop establishment practices, weed seed bank in the soil, and cropping system adopted in different rice ecologies, a mixed population of grasses, sedges, along with broadleaved and aquatic weeds are dominating rice fields (Rodenburg and Johnson, 2009). In direct seeded rice, in example, multiple flushes of weeds can appear because soil-borne seeds can germinate whenever conditions are favourable (Rao *et al.* 2017). In rainfed uplands where the crop is developed by direct planting in an aerobic environment, the greatest weed pressure and

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competitiveness occur (Balasubramanian, and Hill, 2002). The competition is least in transplanted rice, which is grown in puddled circumstances with standing water, where it is possible to keep at least 2-3 cm of standing water in rice fields at early vegetative stages (Tabbal *et al.*, 2002). It decreases in rainfed lowlands and irrigated environment.

Weed flora prevails in Indian rice field :

According to soil moisture and local weather patterns, grasses are the most aggressive weed flora. They typically sprout early and coexist with rice crops for a long length of time. Important grasses that are commonly found in Indian rice fields include Crowfoot grass (*Dactyloctenium aegyptium*), Large crab grass (*Digitaria sanguinalis*), Torpedo grass (*Panicum repens*), Bermuda grass (*Cynodon dactylon*), Para grass, and Jungle rice (*Echinochloa colona*). Barnyard grass (*Echinochloa crus-galli*), Cockspur grass (*Echinochloa glabrescens*), Para grass (*Brachiaria mutica*), weedy rice (*Oryza sativa* f. spontanea), etc.

Sedges emerge simultaneously or at later vegetative stages of rice crop depending upon the rice environments. Some important sedges that prevails in rice fields are Purple nut sedge (*Cyperus rotundus),* Small flower Umbrella sedge *(Cyperus difformis),* Rice flat sedge (*Cyperus iria),* Forked fringerush (*Fimbristylis mileacea)*; Bulrush (*Schoenoplectus articulates)* etc.

In addition to these, many kinds of broadleaved weeds have also been found in rice fields. In various rice ecologies, some of them grow in situations that are comparatively less moist while others do. When lowland rice fields receive enough water, some aquatic weeds begin to grow. Compared to grasses and sedges, these weed species compete less fiercely. Important broadleaved weeds occur in rice fields are Sessile joy weed (*Alternanthera sessilis),* Goat weed (*Ageratum conyzoides),* Willow primrose (*Ludwigia octovalvis),* Goose weed (*Sphenoclea zeylanica),* Wild mustard (*Cleome viscosa),* Alligator weed (*Alternanthera philoxeroides)*, Tropical spiderwort (*Commelina benghalensis*), Black pig weed (*Trianthema portulacastrum*) etc. and aquatic weeds viz., Four leaf clover (*Marsilea quadrifolia),* Oval-leaved pond weed (*Monochoria vaginalis),* Water lettuce (*Pistia stratiotes),* Stonewort (*Chara zeylanica),* Water Spinach (*Ipomoea* aquatic), Giant duck weed (*Spirodela polyrbiza*), Duck lettuce (*Otellia alismoides),* Arrow head (*Sagittaria sagittifolia),* etc.

A holistic approach involving some preventive measures along with adoption of improved agronomic practices not only reduce weed pressure during the current rice growing season but also help to keep weed thrust under control in subsequent seasons. Integration of direct weed control measures either by safest herbicides and/ or by machines can bring about substantial yield improvement of the crop. This bulletin highlights the integrated approaches for suppressing weed pressure in rice fields and sustaining rice productivity.

Preventive measures :

- Use of certified seeds or clean seeds from a known source free from admixture of weed seeds.
- Cleaning seeds by dipping in 2% brine solution helps in separation of floating weed seeds.

- Avoid application of un-decomposed farm yard manure/composts as it contains viable weed seeds.
- Off-season ploughing after rice harvest reduces weed seed replenishment.
- Deep summer ploughing once in three years during summer months of April-May helps to expose vegetative propagules of certain weeds and also to bury the weed seeds at a depth that prevents germination and decays the buried seeds.
- Proper crop rotation with pulses, oilseeds and other cover crops like jute, cowpea, or with green manuring crops like *Sesbania* as per the recommendation of a particular region

Prevention of weedy rice :

Weedy rice, an introgressed form of wild and cultivated rice, seems to have inherited the high reproductive capacity from modern rice varieties, and seed shattering and dormancy from wild rice, which contribute towards build up and persistence of its seed bank in the soil (Saha *et al.*, 2014).Its infestation is prevalent in the areas where direct seeding has been practiced in rainfed lowlands since a long time of eastern Uttar Pradesh, Bihar, Odisha, West Bengal, Assam, Manipur, and other hilly tracts of the northeast. But, the threat recently spreads in many other States in irrigated rice, particularly where direct seeding is being adopted by farmers on a large scale in view of the current challenges of hike in cultivation cost along with labour and water shortages. Selective herbicides to control weedy rice in conventional rice cultivation are not available and therefore, managing weedy rice is a challenging and increasing problem (Chauhan, 2013). Some of the proven agronomic management practices are cited below to reduce weedy rice infestation.

- Use of certified seeds or clean seeds from a known source that is free from weedy rice grains
- The canals, irrigation channels etc. should be cleared from infestations of wild/weedy rice.
- Use of clean machinery is another important aspect. The machine used for land preparation, sowing, intercultural operations, harvesting and threshing should be cleaned.
- Adopt 'Stale seed bed technique' to deplete the soil seed bank of wild/ weedy rice.
- 'Water seeding' or 'wet seeding' can be adopted in places where water is available.
- In heavily infested areas, puddling the field combined with presence of a thin layer of water over the well-levelled fields prevents weedy plants from becoming established.
- Green manuring by *Sesbania sp* in rainfed lowlands helps in smothering weedy rice.
- Removal of weedy rice panicles by hand picking at heading/flowering stage helps to reduce the seed bank in soil.
- Proper crop rotation by growing soybean, groundnut, maize, wheat, sunflower, sorghum, greengram, cowpea etc. would help to suppress weedy rice in subsequent rice crops.

- Winter flooding also helps in controlling weedy rice infestation by promoting seed decay.

To enable farmers and other rice cultivation stakeholders to discern between off-type and weedy rice accessions and take the appropriate preventive actions, there is a need to raise awareness among farmers and other stakeholders about the detrimental effects of weedy rice.

Weed management practices under different rice establishments :

A. *Dry direct seed rice (D-DSR)* :

As labour and water become scarcer and cultivation costs rise, D-DSR has become a more economically viable alternative to puddled transplanted rice (Adhikari, 2021). The trade-off in weed management, however, severely restricts the widespread implementation of D-DSR. Therefore, the success and widespread adoption of D-DSR depend on the availability of efficient weed control solutions. The following list includes both direct control methods and some agronomic management choices.

I. *Agronomic management practices* :

- ❖ Plough the field by rotavator or cultivator to get a fine tilth.
- ❖ Remove the weeds and crop stubbles before proper levelling for uniform germination and crop stand.
- ❖ In heavily weed infested areas, adopt stale seed bed technique by allowing weed seeds to emerge and then kill either by shallow tillage or by spraying non-selective herbicides like glyphosate, paraquat etc. at least 10 days before sowing.
- ❖ Sow by seed drill at 15-20 cm apart rows with a relatively moderate seed rate of 35-40 kg ha^{-1} to ensure better crop stand and canopy coverage. In case of mechanical weed control by motorized weeder, sowing should be done at 25 cm apart rows.
- ❖ Avoid basal N application as it stimulates weed growth. Apply the recommended nitrogen fertilizer in 3-4 equal splits depending upon the duration of rice varieties, starting from 15-20 days after emergence (DAE) i.e., after initial weed control measures, and rest at 15-20 days interval.

II. *Recommended direct control measures* :

- ❖ Spray bispyribac-sodium (25-30 g ha^{-1}) at 10-12 days after emergence (DAE) i.e., at 2-3 leaf stage of weeds to suppress early emergent grasses and sedges.
- ❖ Sometimes, efficacy of herbicides is reduced either due to continuous rain or long dry spell prevails following their application or in highly infested fields. Under such situations, sequential application of herbicides is found effective viz., spray fenoxaprop-p-ethyl (60 g ha^{-1}) against subsequent flashes of grasses and ethoxysulfuron (15 g ha^{-1}) against new flashes of sedges and broadleaved weeds at 25-30 DAE in sequence with bispyribac-sodium.
- ❖ In shallow lowlands or irrigated areas, tank-mix application of fenoxaprop-p-ethyl + ethoxysulfuron

(50+15 g ha^{-1}) at 15-18 DAE (2-4 leaf stage of weeds) is found effective against mixed population of grasses, sedges and broadleaved weeds.

- Integration of chemical weed control by spraying bispyribac-sodium at early stage followed by mechanical weed control by operating power weeder at 30-35 DAE is found very effective in shallow lowlands/ irrigated areas. Under this management option, crop should be established at 25 cm apart rows. The mechanical weeder also increases soil aeration and consequently tiller production.
- Based on our recent studies, pre-mix application of florpyrauxifen-benzyl + cyhalofop-butyl (25+125 g/ ha) and pre-mix application of trifamone + ethoxysulfuron (45+22.5 g/ha) followed by one light manual weeding at 40 DAE results effective control of broad-spectrum of weeds in heavily infested areas.

B. *Wet direct seeded rice (W-DSR)* :

In irrigated locations, particularly during the dry season, sowing sprouted (pre-germinated) seeds in moist saturated puddled soils offers an excellent alternate way of crop establishment (Farooq *et al.*, 2013). This W-DSR approach not only aids in faster and simpler crop establishment but also lowers labour costs and drudgery while also bringing in 7–10 days earlier crop maturity. However, in order to control troublesome weeds during the early vegetative stage (the first 3–4 weeks after planting) of the rice crop, proper agronomic techniques and effective weed control strategies are required. The following list includes both direct control methods and some agronomic management choices.

I. Agronomic management practices

- Dry tillage one month before final land preparation for removal of perennial weeds followed by pudding twice at 7-10 days interval and proper land levelling to ensure uniform crop stand.
- Keep 3-5 cm standing water in the field between two puddling for easy decomposition of weeds and crop stubbles.
- Sow by drum seeder at 20 x 15 cm spacing (15 x15 cm during dry season) on moist saturated soil with 35-40 kg seeds ha^{-1} to ensure better crop stand and canopy coverage. In case of mechanical weed control by motorized weeder, row spacing should be adjusted to 25 cm.
- Keep the field under saturated moist condition for initial 7-10 days of sowing (DAS) to facilitate better root and seedling establishment and then keep a thin film of water (1-2 cm depending upon the seedling length) up to 21 DAS.
- Apply the recommended dose of 'N' in 3-4 equal split at 15-20 days interval escaping the basal dose as it encourages early weed competition.

II. *Recommended direct control measures* :

- Spray bispyribac-sodium (25-30 g ha^{-1}) at 12-15 days after sowing (DAS) i.e., at 2-3 leaf stage of weeds to suppress early emergent grasses and sedges.

- ❖ Sequential application of bispyribac-sodium (30 g ha^{-1}) at 10-12 DAS followed by ethoxysulfuron (15 g ha^{-1}) at 25-30 DAS shows effective control of weeds in areas where second flashes of weeds particularly sedges and broadleaved weeds appear under controlled water condition
- ❖ Spray with herbicide mixtures viz., fenoxaprop-p-ethyl + ethoxysulfuron (50+15 g ha^{-1}), penoxulam + cyhalofop-butyl (25+100 g ha^{-1}), florpyrauxifen-benzyl + cyhalofop-butyl (25+125 g/ha) and trifamone + ethoxysulfuraon (45+22.5 g/ha) spray at 15-18 DAS are showed broad spectrum of weed control in fields with mixed population of weeds
- ❖ Spraying bispyribac-sodium at 10-12 DAS followed by mechanical weed control by operating power weeder at 30-35 DAS is an alternative option for effective control of weeds under W-DSR. Under this management option, crop should be established at 25 cm apart rows.

C. *Puddled transplanted rice (PTR)* :

Typically, seedlings are transplanted into puddles of soil to cultivate rice (PTR). By lowering water percolation losses, eliminating weeds, making seedling establishment simple, and fostering anaerobic conditions that increase nutrient availability, puddling is beneficial for rice. But frequent puddling damages soil aggregates, lowers permeability in subsurface layers, and creates hard pans at shallow depths, all of which have a negative impact on the next non-rice crops in the rotation (Sharma *et al.*, 2003). Rice production is becoming less viable since puddling and transplanting need a lot of water and labour, both of which are become more expensive and scarce. Another major worry is the laborious nature of transplantation. All of these elements call for a significant switch from puddled-transplanted rice to direct planting in favourable rainfed lowland areas that are irrigated. Due to puddling and maintaining standing water in crop fields from the outset of rice establishment, the weed problem is significantly less severe in rice that has been transplanted. The following list includes both direct control methods and some agronomic management choices.

I. *Agronomic management practices* :

- ❖ Land preparation is same as W-DSR.
- ❖ Plant 12-15 days old seedlings by transplanter in well levelled saturated soil without any standing water. In case of manual transplanting, plant 25-30 days old seedlings at spacing of 20 x15 cm or 15 x15 cm with 2-3 seedlings per hill depending on crop duration and growing season. In case of mechanical weed control by motorized weeder, row spacing should be adjusted to 25 cm during planting.
- ❖ Keeps the field under saturated moist condition for first 7-10 days in case of machine transplanting to facilitate root and seedling establishment and then keep a thin film of water (1-2 cm depending upon the seedling length) up to 21 days.
- ❖ Apply the recommended dose of 'N' in 3-4 equal split at 15-20 days

interval escaping the basal dose as it encourages early weed competition.

II. *Recommended direct control measures* :

- Spray Pyrazosulfuron-ethyl (20 g ha^{-1}) within 2-3 days of sowing for suppressing weeds in nursery bed.
- Spray bispyribac-sodium (25-30 g ha^{-1}) at 12-15 days after transplanting (DAT) i.e., at 2-3 leaf stage in areas where weed infestation is relatively less to suppress early emergent grasses and sedges.
- In relatively moderate to high weed infestation, spray herbicide mixtures viz., fenoxaprop-p-ethyl + ethoxysulfuron (50+15 g ha^{-1}), penoxulam + cyhalofop-butyl (25+100 g ha^{-1}), florpyrauxifen-benzyl + cyhalofop-butyl (25+125 g ha^{-1}) and trifamone + ethoxysulfuraon (45+22.5 g ha^{-1})at 15-18 DAT or bensulfuron-methyl + pretilachlor (60+600 g ha^{-1}) at 3-7 DAT for broad spectrum of weed control in fields with mixed population of weeds
- Spray bispyribac-sodium at 10-12 DAS followed by mechanical weed control by operating power weeder at 30-35 DAS is an alternative option for effective control of weeds under PTR. Under this management option, crop should be established at 25 cm apart rows.

Recommended herbicides for rice :

One of the most crucial factors for efficient weed management in rice fields is the choice of herbicide/herbicide mixture and its optimal timing and treatment rate. The list below includes a detailed protocol for certain significant herbicides and ready mix/tank mix herbicide combos.

Sl. No	Name	Target weeds	Time of Application	Dose (g a.i. ha^{-1})
A. D-DSR Grasses and sedges are prevalent at early stages. Sometimes, due to relatively aerobic soil conditions, several flashes of weeds generally appear during critical period of crop weed competition.				
1.	Bispyribac-Sodium (Nominee gold)	Early emergent grasses and sedges	10-12 days after emergence (DAE) / OR at 2-3 leaf stage of weeds	25-30
2.	Fenoxaprop-p-ethyl Rice star)	Late emergent grasses	25 DAE / OR at 3-5 leaf stage of weeds	60
3.	Ethoxysulfuron (Sunrise)	Sedges and broadleaved weeds	15 DAE / OR at 2-4 leaf stage of weeds	20
4.	Fenoxaprop-p-ethyl+ Ethoxysulfuron (Tank-mix)	Mixed weed population	15-18 DAE / OR 3-4 leaf stage of weeds	50+15
5.	Florpyrauxifen-benzyl + Cyhalofop-butyl (Pre-mix-Novlect)	Mixed weed population	15-18 DAE / OR 3-4 leaf stage of weeds	25+125

Sl. No	Name	Target weeds	Time of Application	Dose (g a.i. ha^{-1})
B. W-DSR Grasses and sedges are prevalent at early stage and mixed weed population appears at late vegetative stage however their dominance depends on water level in rice fields				
1.	Bispyribac-Sodium	Early emergent grassy weeds and few sedges	10 DAS / OR at 2-3 leaf stage of weeds	25-30
2.	Ethoxysulfuron	Late emergent sedges and broadleaved weeds	18-22 DAS / OR at 2-4 leaf stage of weeds	15-20
3.	Fenoxaprop-p-ethyl + ethoxysulfuron (Tank-mix)	Mixed population of weeds	15-18 DAS / OR at 3-4 leaf stage of weeds	50+15
4.	Penoxulam + Cyhalofop-butyl (Pre-mix Vivaya)	Mixed population of weeds	15-18 DAS / OR at 3-4 leaf stage of weeds	25+100
5.	Florpyrauxifen-benzyl + Cyhalofop-butyl	Mixed population of weeds	15-18 DAS / OR at 3-4 leaf stage of weeds	25+125
6.	Trifamone + Ethoxysulfuraon (Pre-mix Council Activ)	Mixed population of weeds	15-18 DAS / OR at 3-4 leaf stage of weeds	45+22.5
7.	Bensulfuron-methyl + Pretilachlor (Pre-mix Eraze-Strong)	Mixed population of weeds	5-7 DAS	60+600
C. PTR Mixed weed population occurs with dominance of grasses and sedges at early vegetative stage; however the dominance depends on water level in rice fields				
1.	Pyrazosulfuron-ethyl (Saathi)	Nursery beds	1-3 DAS	20
2.	Bispyribac-Sodium	Only early emergent grasses weeds and few sedges	10 DAT / OR at 2-3 leaf stage of weeds	25-30
3.	Ethoxysulfuron	Only sedges and broadleaved weeds	15-18 DAT / OR at 2-4 leaf stage of weeds	15-20
4.	Trifamone + Ethoxysulfuraon	Mixed population weeds	15-18 DAT / OR at 3-4 leaf stage of weeds	45+22.5

Sl. No	Name	Target weeds	Time of Application	Dose (g a.i. ha^{-1})
5.	Florpyrauxifen-benzyl + Cyhalofop-butyl	Mixed population of of weeds	15-18 DAT / OR at 3-4 leaf stage of weeds	25+125
6.	Penoxulam + Cyhalofop-butyl	Mixed population of weeds	15-18 DAT / OR at 3-4 leaf stage of weeds	25+100
7.	Bensulfuron methyl + Pretilachlor	Mixed population of weeds	7 DAT	60+600
8.	Penoxulam (Granite)	Broadleaved and aquatic weeds with few sedges	15-20 DAT OR at 3-5 leaf stage of weeds	25

How to calculate application dose from commercial product/herbicide :

The dose of commercial formulation of the herbicide required for application on field can be calculated by the following formula :

Application does

= (Recommended dose x Area x 100)

÷ Active ingradient (as mentioned in label)

Example :

Herbicide A

Active ingredient=10%; Recommended dose= 30g a.i. ha^{-1}, Area= 2 ha

Application dose = (30 x 2 x 100) ÷ 10 = 600*g*

Spray machine and its maintenance :

The lever-operated knapsack sprayer with a flood jet or flat fan nozzle is the most suitable piece of equipment for applying herbicides. The nozzle tip directs the spray pattern while also assisting in controlling the rate, consistency, and completeness of herbicide application. The equipment needs to be well maintained, especially during the humid-wet season. Even if the same chemical is used again the following day, it still needs to be carefully cleaned after each day's work and allowed to dry in the sun. For greater effectiveness, the machine needs to be fully and frequently greased. Before spraying, the nozzle should be examined, and if necessary, it should be well cleaned. Before spraying, the spraying apparatus and its accessories should be examined. Setting the spraying speed and nozzle swath by adjusting the spray height and nozzle spacing is necessary for machine calibration.

Conclusion :

One of the main biological obstacles to rice cultivation, weeds can cause yield losses of up to 70% or even more in various rice environments. A comprehensive strategy that combines various preventive measures with the right rice variety selection, appropriate agronomic management techniques, followed by efficient direct weed control measures, either by applying herbicide alone, in sequence, or in mixtures (herbicide-based weed control), or by integrating chemical and mechanical weed control measures,

improves overall rice productivity and sustainability.

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