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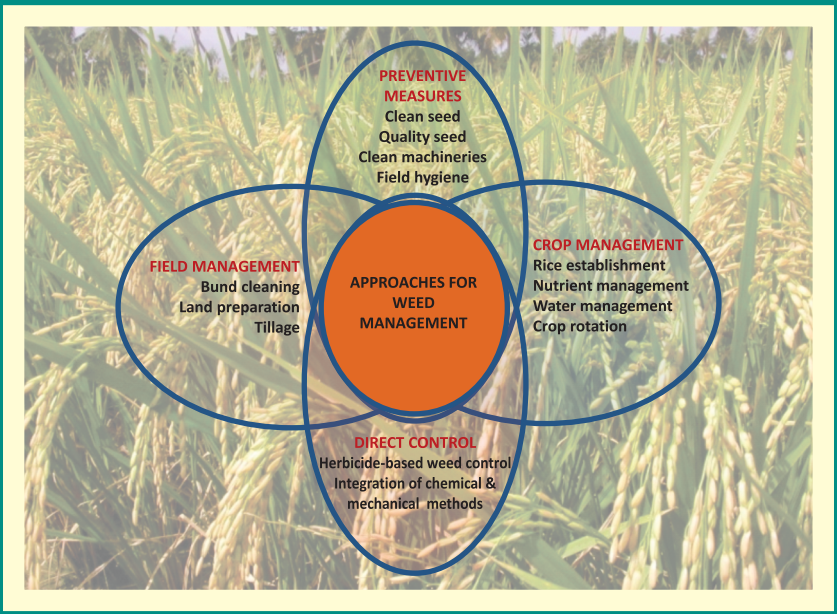
WEED MANAGEMENT TECHNOLOGY FOR RICE



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Weeds are undoubtedly a major biotic constraint to rice production in most rice growing areas of the world, causing about 33% of total yield losses in comparison to insect-pests (26%) and diseases (20%). Weeds interfere with rice growth by competing for light, nutrients, water and space and simultaneously create habitat for various 'insect-pests' nematodes and pathogens, if not managed properly during crop growing seasons. In recent years, the problems associated with weeds in rice are aggravated dramatically due to changes in rice establishment methods from traditional transplanting to different ways of direct seeding with limited water in response to the declining

availability of labour and water. These changes make the weed scenario much more complex. A mixed population of grasses, sedges along with broadleaved and aquatic weeds are dominating rice fields depending on prevailing agro-climatic conditions, soil types, water management, crop establishment practices, weed seed bank in soil and cropping system adopted in different rice ecologies. Sometimes several flushes of weeds come up particularly in direct-seeded rice as seeds present in soil germinate as and when conditions are favourable. The greatest weed pressure and competition occurs in rainfed uplands where the crop is established by direct seeding under aerobic environment. It reduces under rainfed lowlands and irrigated ecology where it is possible to maintain at least 2-3 cm standing water in rice fields at early vegetative stages and the competition is least in transplanted rice where the crop is established under puddled conditions with standing water.

Weed flora prevails in Indian rice field

Grasses are the most competitive weed flora that generally emerges early and grows simultaneously with the rice crop for a considerable time period depending on soil moisture and prevailing weather conditions. Some of the important grasses generally occurs in Indian rice fields are Jungle rice (*Echinochloa colona),* Barnyard grass *(Echinochloa crus-galli),* Cockspur grass (*Echinochloa glabrescens),* Chinese sprangletop (*Leptochloa chinensis),* Crowfoot grass (*Dactyloctenium aegyptium)*, Large crab grass (*Digitaria sanguinalis)*, Torpedo grass (*Panicum repens),* Bermuda grass (*Cynodon dactylon)*, 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.

Besides these, different types of broadleaved weeds are also appeared in rice fields. Some of them grow under relatively less moist environments while others grow under moist conditions in different rice ecologies. Some aquatic weeds emerge when sufficient water accumulates in lowland rice fields.These weed species are relatively less competitive in comparison to grasses and sedges. Important broadleaved weeds occur in rice fields are Sessile joyweed (*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., Fourleaf clover (*Marsilea quadrifolia),* Oval-leaved pond weed (*Monochoria vaginalis),* Water lettuce (*Pistia stratiotes),* Stonewort (*Chara zeylanica),* Water Spinach (*Ipomoea* aquatica), Giant duck weed (*Spirodela polyrbiza*),Duck lettuce (*Otellia alismoides),* Arrow head (*Sagittaria sagittifolia),* etc.

***Echinochloa colona*, the most dominant weed flora in rice field**

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 contain 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.

Scientist demonstrating the use of brine solution for seed cleaning

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.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.

(a) Panicle of weedy rice with awned seeds and (b) rice field infested with weedy rice

Selective herbicides to control weedy rice in conventional rice cultivation are not available and therefore, managing weedy rice is a challenging and increasing problem. 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 'State 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.

There is a need to increase awareness among the farmers and other stakeholders associated with rice cultivation about the negative impact of weedy rice so that they are able to distinguish off type and weedy rice accessions from cultivated rice and adopt necessary preventive measures.

Weed management practices under different rice establishments

A. Dry direct-seeded rice (D-DSR)

D-DSR has emerged as an economically viable alternative to puddled transplanted rice to address emerging constraints of labour and water scarcity and the rising cost of cultivation. However, wide adoption of D-

DSR is seriously constrained by weed management trade-off. Therefore, the availability of effective weed control options is critical for the success and wide-scale adoption of D-DSR. Some of the agronomic management options along with direct control measures are cited below.

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 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, at 10-12 DAE.
- 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^{-1}) and pre-mix application of trifamone + ethoxysulfuron (45+22.5 g ha^{-1}) 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)

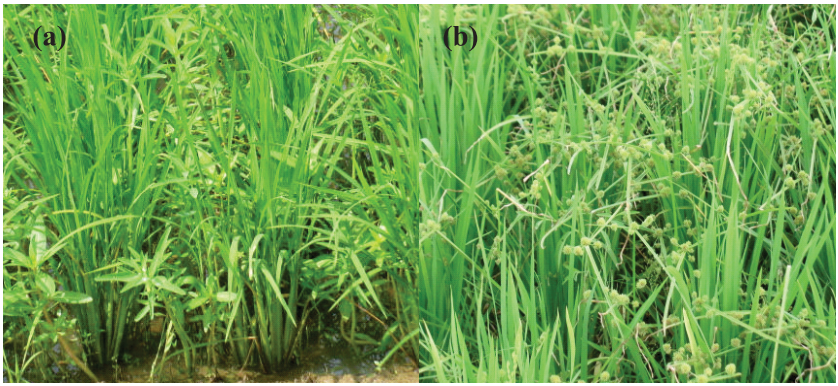
Sowing sprouted (pre-germinated) seeds in wet saturated puddled soils offers a good alternative method of crop establishment in irrigated areas particularly during dry season. This practice of W-DSR not only helps for earlier and easier crop establishment but also reduces labour cost and drudgery along with earlier crop maturity by 7-10 days. However, proper agronomic practices and appropriate weed control strategies are needed for control of problem weeds at early vegetative stage (first 3-4 weeks of sowing) of rice crop. Some of the agronomic management options along with direct control measures are cited below.

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 power 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 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



Rice field infested with (a) *Sphenoclea zeylanica* and (b) *Cyperus difformis*

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^{-1}) and trifamone + ethoxysulfuraon (45+22.5 g ha^{-1}) 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)

Rice is commonly grown by transplanting seedlings into puddled soil. Puddling benefits rice by reducing water percolation losses, controlling weeds, facilitating easy seedling establishment, and creating anaerobic conditions to enhance nutrient availability. But, repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in subsurface layers, and forming hard-pans at shallow depths, all of which negatively affect tthe succeeding non-rice crops in rotation. Puddling and transplanting require large amount of water and labour, both of which are becoming increasingly scarce and expensive, making rice production less profitable. The drudgery involved in transplanting is also of serious concern. All these factors demand a major shift from puddled-transplanted rice to direct seeding in irrigated and favourable rainfed lowland areas. The weed problem is relatively less in transplanted rice due to pudling and keeping standing water in crop fields from beginning of rice establishment. Some of the

agronomic management options along with direct control measures are cited below.

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 power weeder, row spacing should be adjusted to 25 cm during planting.
- Keep the field under saturated moist condition for first 7-10 days in case of machine transplanting to facilitate root and seedling establishmentand 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.

Mechanical weed control by power weeder

II. Recommended direct control measures

- Spray Pyrazosulfuron-ethyl (20 g ha^{-1}) within 2-3 days of sowing for supressing 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 lessto 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.

- Spray bispyribac-sodium at 10-12 DAS followed by mechanical weed control by operating power weeder at 30-35 DAT 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

The selection of herbicide/herbicide mixture and its correct time of application with proper application rate is one of the most important criteria for effective weed control in rice field. Some important herbicides and ready mix/ or tank mix combinations of herbicides are listed below with details protocol.

Sl. No.	Name	Target weeds	Time of Application	Dose (g a.i. ha^{-}
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
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

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 of weeds	15-18 DAT / OR at 3-4 leaf stage of weeds	45+22.5
5.	Florpyrauxifen-benzyl + Cyhalofop-butyl	Mixed population 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 dose

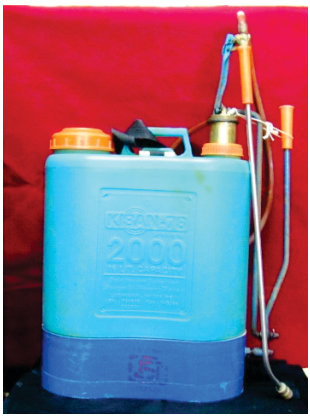
= (Recommended dose x *Area* x *100)*

÷ 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



Knapsack sprayer fitted with flat fan nozzle

The most ideal machine for herbicide spray is lever operated knapsack sprayer with flood jet or flat fan nozzle. The nozzle helps to control the rate, consistency and thoroughness of herbicide application and the nozzle tip guides the spray pattern. The machine should be maintained well particularly during the wet-humid season. It should be washed properly after each day's work and dry in open sun; even if the same chemical is being used in the next day. The machine should be lubricated thoroughly and regularly for better efficiency. The nozzle should be checked before spraying, and if required, it should be cleaned properly. The spray machine and accessories should be checked before spraying. The machine should be calibrated by setting the spraying speed and nozzle swath by adjusting the spray height and nozzle spacing.

Conclusion

Weeds undoubtedly a major biotic constraints to rice cultivation that leads up to 70% or even more yield losses under different rice environments. A holistic approach by combining different preventive measures along with selection of proper rice varieties with appropriate agronomic management practices followed by effective direct weed control practices either by applying herbicide alone and/or in sequence/mixtures (herbicide-based weed control) or integration of chemical and mechanical weed control measures, that not only helps for successful weed management but also improves overall rice productivity and sustainability.

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