

# Protocol for Herbicide-based Weed Control in Rice

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*Apply post-emergent herbicides  
at 2 -3 leaf stage of weeds*

Herbicides can provide effective and economic control of weeds in rice field. It saves labour cost up to 40% and reduces drudgery. It also plays important role in facilitating the adoption of direct-sown rice (DSR) technology. However, over reliance on one type of herbicide or faulty way of application can lead to herbicide resistance development in weeds and adversely affect environment as well as human health. Herbicides, if not properly applied, may also cause problems of phyto-toxicity to young rice plants. So, correct use of herbicide is essential to ensure that chemical residues on crops and soils do not exceed the limits. Recommended doses of herbicides do not generally injure people, livestock, or crops if used properly and all precautions are taken care. However, most of the herbicides are potentially dangerous if not properly handled or applied.

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Weeds are undoubtedly a major biotic constraints to rice production in most rice growing areas of the world, causing about 33% of total yield losses in comparison to insects (26%) and diseases (20%). Problems associated with weeds in rice are mounting dramatically due to changes in rice establishment methods in response to the declining availability of labour and water. Direct seeding is being used increasingly to reduce dependence on labour. These changes make the weed scenario more complex. A mixed population of grassy weeds, sedges along with broad-leaved and aquatic weeds are dominating rice fields depending on prevailing agro-climatic conditions; soil types; crop establishment, nutrient and water management practices; weed seed bank in soil; and cropping system adopted in different rice ecologies. Manual weeding 2-3 times in a season by engaging more than 80 person days per hectare involves huge cost in weed control. Therefore, herbicides are considered as alternative/supplement to manual-weeding and most economic way to control weeds in rice fields.

A number of herbicides like butachlor, pretilachlor, pendimethalin, oxadiazon, anilofos, oxadiargyl etc. have been recommended as pre-emergence application to control early flashes of weeds. These herbicides are usually useful in direct-sown rice fields to suppress the early flashes of weeds. All these herbicides have differential effects on weeds and have narrow spectrum of controlling annual grasses and some sedges. Their efficacy depends on soil moisture. Adequate soil moisture is necessary to activate most pre-emergent herbicides before and after application.



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Soil saturation (wet top 2 cm layer) is important to reduce degradation and volatilization. On light soils, heavy rains may leach the herbicide in the soil to the germinating crop seeds and cause severe injury. Many pre-emergent herbicides also show severe phytotoxic effects to rice crop emergence causing 50-90% mortality if heavy rain occurs immediately after herbicide application. The subsequent flushes of weed which appear 3-4 weeks after rice establishment, particularly, in direct-sown rice fields, can't be controlled by early application of herbicide. The application rate of pre-emergent herbicides is very high and most of them show detrimental effect not only to rice crop but also to the beneficial microorganisms extant in soil. It was also observed that the flowering time and total duration of rice crop extends up to 2 weeks due to application of pre-emergence herbicides.

In recent times, some new post-emergent herbicides with low dosages viz., bispyribac sodium, cyhalofop butyl, fenoxaprop-p ethyl, ethoxysulfuron, penoxulam, azimsulfuron, flucetosulfuron, etc. and herbicide mixtures like azimsulfuron + bispyribac sodium, fenoxaprop-p ethyl + ethoxysulfuron, bensulfuron methyl + pretilachlor, cyhalofop butyl + penoxulam, metsulfuron methyl + chlormuron ethyl etc. are showing promise for controlling weeds. The rate and time of application of these new generation herbicides/ herbicide mixtures were standardized in such a way that it may keep the weeds under control during first 5-6 weeks of rice crop establishment. These low-dosage, high-efficacy post-emergent herbicides/ herbicide mixtures having broad spectrum of weed control are expected to be an intervention to suppress the weeds during critical period of crop-weed competition up to 35-40 days of weed emergence.

It is very much essential for the herbicide users to identify the key weeds correctly and select the chemical accordingly. It is important to know different types of herbicides, specific herbicides to control different types of weed species, their doses and time of application, and safe handling and accurate application technologies for effective and environmentally safe weed control. Correct use of herbicides is also essential to ensure that chemical residues on crops do not exceed the limits. Recommended herbicides do not generally injure people, livestock, or rice crops if used properly and if recommended precautions are followed. However, the herbicides are potentially dangerous if improperly handled or used. Most of the herbicides are available in liquid form and the spray-solutions are made with water. Few granular formulations are also available and these are generally applied in rice field as sand-mix. For best weed control, instructions are given in the package that should be carefully read and followed. The label on the package provides information regarding herbicide rate/doses, adjuvant, combinations and other requirements of the product. Attempt have been made in this bulletin to highlight the strategies to be taken for effective and most economic way of controlling weeds in rice fields by using herbicides.

### Advantages of herbicide use

- Require less labour (1 person-day per hectare per application) and less drudgery.
- Very cost-effective, if proper schedule of application is practiced.
- Easy to suppress weeds at critical period and no need to wait for weeds to grow up as in the case of manual weeding
- The herbicides are selective in nature which help to control weeds at early stage, as many grassy weeds are morphologically similar to rice plants and cannot distinguished visually by farmers during manual weeding.

- Ensures weed control at early/ critical stages of crop-weed competition to minimize yield penalty.

### Use of Herbicides in Combinations and sequences

Correct information about weed flora and mode of application of herbicides are needed to use them safely and efficiently. Proper selection of herbicides either alone, in combinations/sequences to provide adequate weed control. Herbicide rotation especially the sulfonyl urea herbicides not only helps for controlling the weeds effectively but also reduces the chance of weed flora shift and herbicide resistance. A complete spectrum of weed control is possible by combining/mixing and/or matching the herbicides.

Tank-mix or ready-mix product can reduce the cost of application further and often reduce the dose of one or more herbicides. It also reduces the chance of herbicide resistance. The main purpose of herbicide combinations is to broaden the spectrum of weed control so that each herbicide in the mixer can control the weeds that missed by the other. It is always important to follow the instruction on label of each herbicide with regard to tank mixes. Herbicide sequence is another option to achieve broad-spectrum weed control, particularly in direct-sown rice where weeds come up in several flushes during critical period of crop-weed competition. The most important aspect of sequential application is to protect against the buildup of weed resistance by using herbicides of different modes of action. For example, sequential application of bispyribac sodium followed by fenoxaprop-p-ethyl shows effective control of both the early and late emergent weeds besides the left over grassy weeds in direct-sown rice fields.

### Protocol for Application of Herbicides

1. Apply post-emergent herbicides on moist soil at 2-5 leaf stage of weeds based on the recommendation.
2. Ensure selection of correct herbicide suited for the type and stage of weeds to be controlled as new generation herbicides are often weed-specific.
3. Always read and follow the instructions cited on the product label to understand the toxicity and safety measures.
4. Use clean, fresh and recommended rate/dilution of water
5. Ensure field conditions are suitable for application. Spray on saturated soil with thin film of water only on sunny days. Avoid irrigation for next 24 hours.
6. Use knapsack sprayer having flat fan nozzle with spray volume of 300 litres ha<sup>-1</sup>. Ensure nozzles are functioning well and providing uniform output.
7. Do not use cone type nozzle for herbicide spraying. Use multiple-nozzle boom fitted with flat-fan nozzle.
8. Apply granular herbicides by mixing with little wet sand at 10-12 kg ha<sup>-1</sup>.
9. Identify the type of weeds and extent of damage and choose the recommended herbicide accordingly.
10. Fill the tank half with water; add herbicide before complete filling of the tank. Add surfactant for enhancing efficacy and stir well for proper mixing of herbicide before spray.



- Spray uniformly across the field after mixing the chemical. Maintain steady pressure, steady walking speed and uniform application rate with swath overlap.
- Set spraying speed and nozzle swath by adjusting the spray height and nozzle spacing.
- Spray from a height of around 50 cm above the target weeds. Spray perpendicular to the wind, so that product is blown away from the applicator.
- Avoid application during strong winds and rainy/cloudy day
- Check the spraying equipment and accessories before spraying, mainly the nozzle, in case of repeated spray with in a day.
- Reduce drift loss by minimizing application in non-target areas.
- Rotate the herbicides based on recommendation to reduce chances of herbicide resistance

### Safety measures during application

- Apply herbicides only at a recommended dose and do not mix herbicides unless recommended.
- Use appropriate cover for head, eyes, nose, mouth and hands. Wear long sleeved shirts and pants with covered footwear.
- Always clean the blocked nozzles by non-abrasive implement. Never clean nozzles by blowing on them with the mouth.
- Wear protective clothing during mixing the product.
- Never eat, drink, or smoke while applying herbicides. Avoid spilling spray materials on skin or clothing. If such an accident occurs, wash immediately with soap and water.
- Wash the spray machine properly before and after each application
- Bathe after applying herbicides and change into freshly laundered clothing.
- Wash contaminated clothes separately from other household clothes.
- Unused herbicides in the spray tank should be disposed at safe place either in pits or in the waste land
- Destroy the herbicide bottles/container after use.



Apply herbicide on saturated soil with thin film of water



Use low dose high efficacy post emergent herbicides

### How to calculate application dose from commercial product/herbicide

Application dose =  
 $(\text{Recommended dose} \times \text{Area} \times 100) \div$   
 active ingredient (as mentioned in label)

#### Example:

Herbicide A  
 Active ingredient=10%; Recommended

dose= 30g a.i. ha<sup>-1</sup>, Area= 2 ha

Application dose =  $(30 \times 2 \times 100) \div 10 = 600\text{g}$

### Spray machine and its maintenance

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 sprayer should be well maintained particularly during wet-humid conditions. It should be washed properly after each day's work and dried 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.



Use Knapsack sprayer for herbicide application

### Major weeds in rice field

Major grassy weeds in rice fields viz., 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*), weedy rice (*Oryza sativa f. spontanea*) etc. are the most competitive weed-flora that emerges early and grows simultaneously with the rice crop for a considerable time period depending on soil saturation/moisture condition.

Sedges viz., Purple nut sedge (*Cyperus rotundus*), Small flower Umbrella sedge (*Cyperus difformis*), Rice flat sedge (*Cyperus iria*), Forked fringerush (*Fimbristylis mileacea*); Bulrush (*Schoenoplectus articulatus*) etc. and broad-leaved weeds Sessile joyweed (*Alternanthera sessilis*), Goat weed (*Ageratum conyzoides*), Willow primrose (*Ludwigia octovalvis*), Goose weed (*Sphenoclea zeylanica*), Wild mustard (*Cleome viscosa*), Alligator weed (*Alternanthera philoxeroides*) etc. and aquatic weeds viz., Fourleaf clover (*Marsilea quadrifolia*), Oval-leaved pond weed (*Monochoria vaginalis*), Water lettuce (*Pistia stratiotes*); Tropical spiderwort (*Commelina benghalensis*), Stonewort (*Chara zeylanica*), Duck lettuce (*Otella alismoides*), Arrow head (*Sagittaria sagittifolia* etc.) emerge subsequently at later stages of rice growth. Sometimes several flushes of weeds come up as seeds present in soil germinate as and when conditions are favourable. Aquatic weeds emerge when sufficient water accumulates in lowland rice fields.

## Important weed flora which compete with rice plant at critical period of crop-weed competition



*Echinochloa colona*



*Cyperus difformis*



*Sphenoclea zeylanica*



*Leptocloa chinensis*



*Fimbristylis mileacea*



*Ludwigia octovalvis*

## Recommended herbicides for rice

The selection of herbicide depends on the type and stage of crops and weed status in field. A number of herbicides or their ready-mix/tank-mix combinations are recommended for effective weed control in rice. The details are cited below:

### A. Dry direct-sown rice (Rainfed uplands & lowlands)

Grassy weeds and sedges are prevalent in alluvial/sandy loam to clay loam soil; while few grassy weeds along with sedges and broad-leaved weeds are prevalent in lateritic soil, mostly in uplands.

Sl. No.	Name	Target weeds	Time of Application	Dose (g a.i. ha <sup>-1</sup> )
1.	Bispyribac Sodium (Nominee gold)	Early emergent grassy weeds and few sedges	8-10 days after sowing (DAS) / OR at 2-3 leaf stage of weeds	30
2.	Fenoxaprop-p-ethyl (Rice star)	Late emergent grassy weeds	15-20 DAS / OR at 3-5 leaf stage of weeds	60
3.	Cyhalofop-butyl (Clincher)	Grassy weeds	12-15 DAS / OR 2-4 leaf stage of weeds	100
4.	Ethoxysulfuron (Sunrise)	Sedges and broadleaved weeds	15 DAS / OR at 2-4 leaf stage of weeds	20
5.	Fenoxaprop-p-ethyl + Ethoxysulfuron (Tank-mix)	Mixed weed population	15-20 DAS / OR 3-4 leaf stage of weeds	50+15

### B. Wet direct-sown rice (Rainfed shallow lowlands & irrigated)

Grassy weeds and sedges are prevalent at early stage; mixed weed populations occur at late vegetative stage; the weed dominance depends on water level in rice fields

Sl. No.	Name	Target weeds	Time of Application	Dose (g a.i. ha <sup>-1</sup> )
1.	Bispyribac Sodium	Early emergent grassy weeds and few sedges	10 DAS / OR at 2-3 leaf stage of weeds	30
2.	Bensulfuron methyl + Pretilachlor (Ready-mix - Eraze-Strong/Londax power)	Mixed population of weeds	7 DAS	10 kg ha <sup>-1</sup>
3.	Ethoxysulfuron	Sedges and broad-leaved weeds	15 DAS / OR at 2-4 leaf stage of weeds	20
4.	Metsulfuron methyl + chlormuron ethyl (Ready-mix-Almix)	Sedges and broad-leaved weeds	15-18 DAS / OR at 3-4 leaf stage of weeds	4

### C. Transplanted rice (Rainfed shallow lowlands & irrigated)

Mixed weed populations occur with little dominance of grassy weeds and sedges at early vegetative stage; however the dominance depends on water level in rice fields

Sl. No.	Name	Target weeds	Time of Application	Dose (g a.i. ha <sup>-1</sup> )
1.	Pyrazosulfuron ethyl (Saathi)	Nursery beds	1-3 DAS	20
2.	Bensulfuron methyl + Pretilachlor	Mixed weed populations in shallow lowlands-saturated fields.	7 days after transplanting (DAT)	10 kg ha <sup>-1</sup>
3.	Penoxulam (Granite)	Broad-leaved and aquatic weeds with few sedges	15 DAS OR at 3-4 leaf stage of weeds	25
4.	Penoxulam + Cyhalofop-butyl (Ready-mix Vivaya)	Mixed weed populations	15-20 DAT OR at 3-4 leaf stage of weeds	135