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Weed Management in a Novel Water Saving Technology (Direct Seeded Rice) in the Tungabhadra Command Area of Karnataka State

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1. Introduction

Dry seeded rice (DSR) is becoming an attractive option for farmers in the Tungabhadra command area where farmers invariably experience water shortage even in kharif season. This attribute is due to elimination of the labor requirement for nursery preparation and maintenance, pulling out and transport of seedlings, and transplanting. Because the soil is not puddled, DSR also has a lower water requirement for crop establishment. Furthermore, the total crop cycle is shorter by 10−15 days because of the absence of transplanting shock. These features of DSR are of major importance for the Tungabhadra command area, especially the tail end areas the water reaches here late resulting in increasing scarcity of water for irrigation in the area. DSR is readily adopted by some small farmers as well as large farmers in Raichur district, as the required machinery is locally available (e.g., through custom hire). The DSR may be adopted by rest of the farmers of the Raichur district also. Best practice involves using a 2- or 4-wheel tractor-drawn drill to seed in rows in dry or slightly moist soil.

There are two major ricecropping seasons:
Kharif (June to October/November)—rice cropping is dependent on irrigation from canals supplied by the TBP and/or from groundwater, supplemented by rainfall from the southwest monsoon.

Rabi/summer (late December/January to March/April)—rice cropping dependent on the northeast monsoon and supplemental irrigation from the canal. The Rabi crop is the second rice crop following a Kharif crop.

In Rabi/summer, pulses (black and green gram), mustard and gingelly (sesame) are also grown in rice fallows on residual moisture alone or with supplementary irrigation; access to groundwater also allows the cultivation of maize and vegetables.

The time of release of water from TBP Dam determines the rice production in the Raichur district. When the water is released late, the rice transplanting gets delayed resulting in labor shortage, use of overaged rice seedlings, increased pest problems in late transplanted fields and ultimately less rice yields.

The major rice production constraints in the Tungabhadra command area is:

- Continued use of traditional transplanting method of rice establishment along with excessive use of water for irrigation by farmers nearer to project dam
- Uncertainty about the period when water from Tungabhadra Dam will be available for irrigation.
- Labor shortage during the peak periods of planting and harvest.
- Late release of water during the *kharif* season, delaying the *kharif* rice transplanting.
- Use of higher amount of fertilizers than required by rice
- Weed menace during earlier period of rice establishment
- Improper use of pesticides.

Weed management
In direct seeded rice (DSR) cultivation systems, rice and weed seedlings emerge simultaneously and there is no standing water to suppress weed emergence and growth at crop emergence. For this reason, weeds are considered one of the major biological constraints in DSR and cause a substantial rice yield loss. Weeds are mainly controlled using herbicides or manually. However, manual weeding is becoming less effective because of labor crisis at critical times and increased labor costs. Herbicides are replacing manual weeding as they are easy to use but there are concerns about the sole use of herbicides, such as evolution of resistance in weeds, shifts in weed populations, cost of weed management to farmers and concerns about the environment. There is a need to integrate different weed management strategies to achieve effective and sustainable weed control in DSR systems

Weed management is usually the biggest challenge for successful production of DSR. A much larger range of weeds occurs in DSR than in puddled transplanted rice, and, if uncontrolled, the degree of infestation can be great enough to reduce rice yield to zero. There are three broad classes of weeds—grasses, broadleaves, and sedges. Table 1 lists the weeds commonly found in DSR in TBP area,Karnataka.

a. Cultural practices
Stale seedbed technique*:* This technique is highly desirable if the field has a large weed seed bank (i.e., lots of weed seeds in the soil as a result of weed infestation in the past).Weeds are germinated by giving one or two irrigations starting about 1 month prior to sowing, and then killed by either a nonselective herbicide (paraquat or glyphosate) or a shallow tillage. If the soil condition is suitable for sowing, use a nonselective herbicide to kill the weeds and sow the

crop without any tillage (tillage brings more weed seeds near the soil surface and thus promotes their germination).Note that the weeds must be actively growing at the time of herbicide application; so, if the soil is dry, an irrigation will be needed prior to herbicide application. This method has great potential for reducing weeds and volunteer rice in DSR.

b. Chemicals

A wide range of herbicides is available for controlling weeds (Table 2 and 3).

All herbicides need to be mixed with water prior to application. Clean water should be used, as muddy water reduces herbicide efficacy. Spray tanks, booms, and nozzles should be cleaned properly with clean water after use. Chemicals should not be mixed together unless recommended, as this may reduce their effectiveness on weeds and/or be harmful to the rice plants. Chemicals should always be applied at the recommended rate.

Uniform application of the spray across the entire field is needed to avoid "misses" (with costly follow-up hand weeding needed) and over spraying (waste of costly chemicals). The best way of achieving this is with a multinozzle (e.g., three) boom fitted with flat-fan nozzles and slightly overlapping spray patterns at the soil surface. The overlap is achieved by holding the boom at the right height (approximately 50 cm) above the target (for pre emergence, the soil surface is the target; for post emergence, weeds are the target, so the boom should be 50 cm above the top of weeds).

All herbicides and pesticides are dangerous. Proper safety precautions should be followed. These include

- Wearing gloves, a breathing mask, and goggles when handling neat (undiluted) chemicals and when spraying.
- Wearing protective clothing while spraying (e.g., made from washed fertilizer bags).

i) Preplant/knockdown herbicides

These herbicides are used to kill existing vegetation prior to rice sowing under ZT-DSR. Glyphosate (1.0 kg a.i./ha) and paraquat (0.5 kg a.i./ha) are recommended. If fields are infested with perennial weeds, use glyphosate, not paraquat.

c. After crop sowing

The choice of herbicide depends on the types of weeds, and no single herbicide can control all weeds in the rice crop. In many situations, the best method for effective weed control is the application of a pre emergence herbicide (1–3 DAS, before the weeds and rice emerge), followed by a post emergenceapplication at 15–25 DAS. This will typically involve the use of pendimethalin or oxadiargyl as apreemergence herbicide followed by a postemergence application of bispyribac-sodium or azimsulfuron or bispyribac-sodium plus azimsulfuron. However, in cases where the pre emergence herbicide is missed (e.g., due to rain) or fails (e.g., due to management errors, such as soil too dry at the time of spraying), early herbicide application at 15 DAS should be made based on the types of weedspresent.

d. Physical

Physical weed control consists of removing weeds by hand (manual weeding) or by machine (mechanical weeding). It is practically and economically impossible to control weeds solely by hand weeding because of the labor scarcity and rising labor wages. However, one or two spot hand weeding are strongly recommended to remove weeds that escape herbicide application to prevent weed seed production and the accumulation of weed seeds in the soil. Mechanical weeding can be useful in reducing labor use in weeding. Manual or motorized cono weeders and other hand weeders are available in the region and can be included as part of integrated weed management.

e. Surface residue retention

Retention of crop residues on the soil surface in zero-tillage systems also helps to suppress weeds.

Table 1: Common weeds of rice in the Tungabhadra Project Area

Grass		Broadleaf		Sedge	
Botanical name	Local name	Botanical name	Local name	Botanical name	Local name
Cynodondactylon	Garike	*Eclipta prostrata*	Garagadasappu, Garugalu, Kadiggagaraga	*Cyperusiria*	
Echinochloacolona	kaaduhaarakahullu	*Cyanotis axillaris*		*C.rotundus*	
E. crus-galli	Kaaduhaaraka hull	*Commelina benghalensis*		*C.difformis*	
Echinochloaglabrescens		*Ammannia* baccifera		Fimbristylismiliacea	
Echinochloaoryzoides		Ludwigia parviflora		Cyperusesculentus	
Digitariaciliaris		*Centella asiatica*	Brahmi soppu, Elavarigesoppu,	Cyperuspilosus	
Leptochloachinensis		*Marsilea quadrifolia*			
Eleusineindica	Ragi	*Monochoria vaginalis*			
Panicumrepens		*Parthenium hysterophorus*			
Paspalumscrobiculatum		*Ageratum conyzoides*			
		Rotala verticillaris			
		Portulaca oleracea			
		Spilanthus acmella			

Table 2: Major nonselective and preemergence herbicides for weed control in DSR in the Tungabhadra Project Area

Herbicide	Product (trade) name*	Concen-tration (g a.i./ha)	Product dose (g/ha or mL/ha)	Application time (DAS)	Strengths	Weaknesses
Knockdown/nonselective						
Glyphosate	Roundup	1,000	2,500 mL	Before crop planting	Effective control of almost all weeds	Weak on *Ipomoea triloba* and *Commelina*species
Paraquat	Gramoxone	500	2,000 mL	Before crop planting	Effective control of almost all weeds	Weak on perennial weeds
Preemergence						
Pendimethalin	Stomp/Stomp xtra	1,000	3,300 mL 2,580 mL	1−3	Some broadleaves and annual sedges	Sufficient moisture is needed for its activity
Oxadiargyl	Topstar	90	112.5 g	1−3	Good control of most grasses, some broadleaves and annual sedges	Sufficient moisture is needed for its activity
Pyrazosulfuron ethyl	Saathi	20	200 g	1–3	Broad-spectrum weed control of grasses, broadleaves, and annual sedges. Has residual control.	Sufficient moisture is needed for its activity

* *Does not imply endorsement of the product*

Table 3: Major postemergence herbicides for weed control in DSR in the Tungabhadra Project Area

Herbicide (active ingredient, a.i.)	Product (trade) name*	Concen-tration (g a.i./ha)	Product dose (g/ha or mL/ha)	Applica-tion time (DAS)	Strengths	Weaknesses
Postemergence						
Bispyribac-sodium	Nominee Gold/ Macho/ Tata Taarak /Adora Macho	25	250 mL	15–25	Broad-spectrum weed control of grasses, broadleaves, and annual sedges. Good control of *Echinochloa* species.	Poor on grasses other than *Echinochloa* species, including *Leptochloachinensis*, *Dactylocteniumaegyptium*, *Eleusineindica*, and*Eragrostis*species. No residual control.
Azimsulfuron	Segment	17.5−35	35−70 g	15−20	Broad-spectrum control of grasses, broadleaves, and sedges. Good control of sedges,including *Cyperusrotundus.*	Poor on *Echinochloa*species.
2,4-D sodium salt	Fernoxone	1,200	1,500mL	15−25	Controlsbraodleafweeds.	*Effective only on a single group of weeds*
Chlorimuron + metsulfuron	Almix	4 (2 + 2)	20 g	15–25	Effective on broadleaves and annual sedges.	No control of grassy weeds and poor on *C. rotundus.*
Bispyribac-sodium + azimsulfuron		25 + 17.5	250 mL + 35 g	15–25	Broad-spectrum weed control of grasses, broadleaves, and sedges, including *C. rotundus.*	Poor on grasses other than *Echinochloa* species.
Bispyribac-sodium + pyrazosulfuron		25 + 25	250 mL + 250 g	15–20	Broad-spectrum weed control of grasses, broadleaves, and sedges, including *C. rotundus.*	Poor on grasses other than *Echinochloa* species.

* Does not imply endorsement of the product.

2. Conclusion

The land area under DSR systems is expected to increase in the Tungabhadra command area because of labor and water crisis. Weeds are the major constraints to DSR system and its management is a fundamental practice, failure of which may results in severe losses in terms of yield and economic return. Weed is a serious problem in direct seeded rice and weed management has been a huge challenge for the weed researchers and rice farmers as well. Weeds are dynamic in nature and a shift in their abundance and dominance is likely with the changes in management practices. Herbicide is the smartest and most economic tool to fight against weeds. But recurrent use of one herbicide for a long time may result in development of herbicide resistant weed biotypes. Integrated approaches are suggested for sustainable weed control in direct seeded rice, such as the use of clean certified seeds, higher seeding densities, cultivation of competitive variety, seed invigoration, stale seed bed preparation, crop rotation, water and fertilizer management along with rotation of herbicides with different mode of actions followed by manual weeding and rouging after mid stage of rice growth. Moreover, any weed management approach should be aimed at controlling weeds only during critical period of weed competition for a more cost-effective and eco-friendly weed management. A long term changes in weed flora, herbicide efficacy, resistance, residual toxicity and environmental implications of continuous use of herbicides should be properly addressed for sustainability of direct seeded rice culture.

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