

Weed management in direct seeded rice

Impact of biotic constraint and its sustainable management options

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Direct-seeded rice is an alternative cropping technique that should require less water and labour than the classical method of transplanted-flooded rice. Weed competition is the major biological constraint in this resource-conserving production technique reducing the crop yield by 30–80%. Though manual weeding is considered to be the best, undependable labour availability and escalating labour cost have given impetus to the development and use of new chemicals for weed control. In contrast to this, chemical weed management offers economic and efficient weed control if applied at proper dose and stage. But, intensive use of herbicides may result in the development of resistant weed biotypes, crop phytotoxicity and public health hazard. Amidst these concerns, adoption of any single approach remains both insufficient and ineffective for sustainable weed management in direct seeded rice and the present situation emphasizes integrated weed management practices for direct seeded rice. The study attempts to identify various sustainable options of the weed management economically and effectively to reap the benefits offered by direct-seeded rice.

Keywords: Direct-seeded rice, economics, sustainable options, weed management

RICE (*Oryza sativa* L.) is a primary food crop grown widely over 161 million ha in more than 100 countries of the World and provides income and employment for more than 100 million households in Asia and Africa. Increasing water scarcity, rising production costs and labour shortage are threatening food production in conventional transplanted rice system resulting in a drastic shift to direct-seeding of rice. Direct-seeded rice (DSR) production system is subject to greater weed pressure than conventional rice transplanting systems, in which weeds are suppressed by flooding and transplanted rice seedlings have a “head start” over germinating weed seedlings. Direct-seeded rice (DSR) cultivation needs only 34% of the total labour requirement and saves 29% cost of the transplanted rice. Direct-seeding is practiced in two major ways *viz.* wet-seeding and dry-

seeding. In wet-seeded rice, pre-germinated seeds are broadcast onto the puddled soil. However, in dry direct-seeding of rice (dry-DSR), non-pre-germinated seeds are sown onto dry-ploughed, unpuddled dry or moist soil. Uncontrolled weeds decreased the yield by 96 per cent in dry DSR and 61 per cent in wet DSR. Any delay in weeding will lead to increased weed biomass which has a negative correlation with yield. Integrated weed management approach based on a critical period of crop weed competition, involving different direct and indirect control measures, has been developed and has to be adopted to overcome weed problem in direct-seeded rice sustainably.

Weed flora in Rice

About 350 species have been reported as weeds of rice, of which grasses are ranked as first followed by

Table 1. Major weeds in direct seeded rice fields in Asia.

Scientific Name	Family
<i>Echinochloa colona</i>	Poaceae
<i>Echinichloa crus-galli</i>	Poaceae
<i>Digitaria setigera</i>	Poaceae
<i>Eleusine indica</i>	Poaceae
<i>Echinochloa glabrescens</i>	Poaceae
<i>Ischaemum rugosum</i>	Poaceae
<i>Digitaria ciliaris</i>	Poaceae
<i>Oryza sativa</i> (weedy rice)	Poaceae
<i>Leptochloa chinensis</i>	Poaceae
<i>Paspalum distichum</i>	Poaceae
<i>Cyperus iria</i>	Cyperaceae
<i>Cyperus difformis</i>	Cyperaceae
<i>Cyperus rotundus</i>	Cyperaceae
<i>Fimbristylis miliacea</i>	Cyperaceae
<i>Monochoria vaginalis</i>	Pontederiaceae
<i>Ipomoea aquatica</i>	Convolvulaceae
<i>Sphenoclea zeylanica</i>	Sphenocleaceae
<i>Ludwigia octovalvis</i>	Onagraceae
<i>Ludwigia adscendens</i>	Onagraceae
<i>Eclipta prostrata</i>	Asteraceae
<i>Commelina benghalensis</i>	Commelinaceae

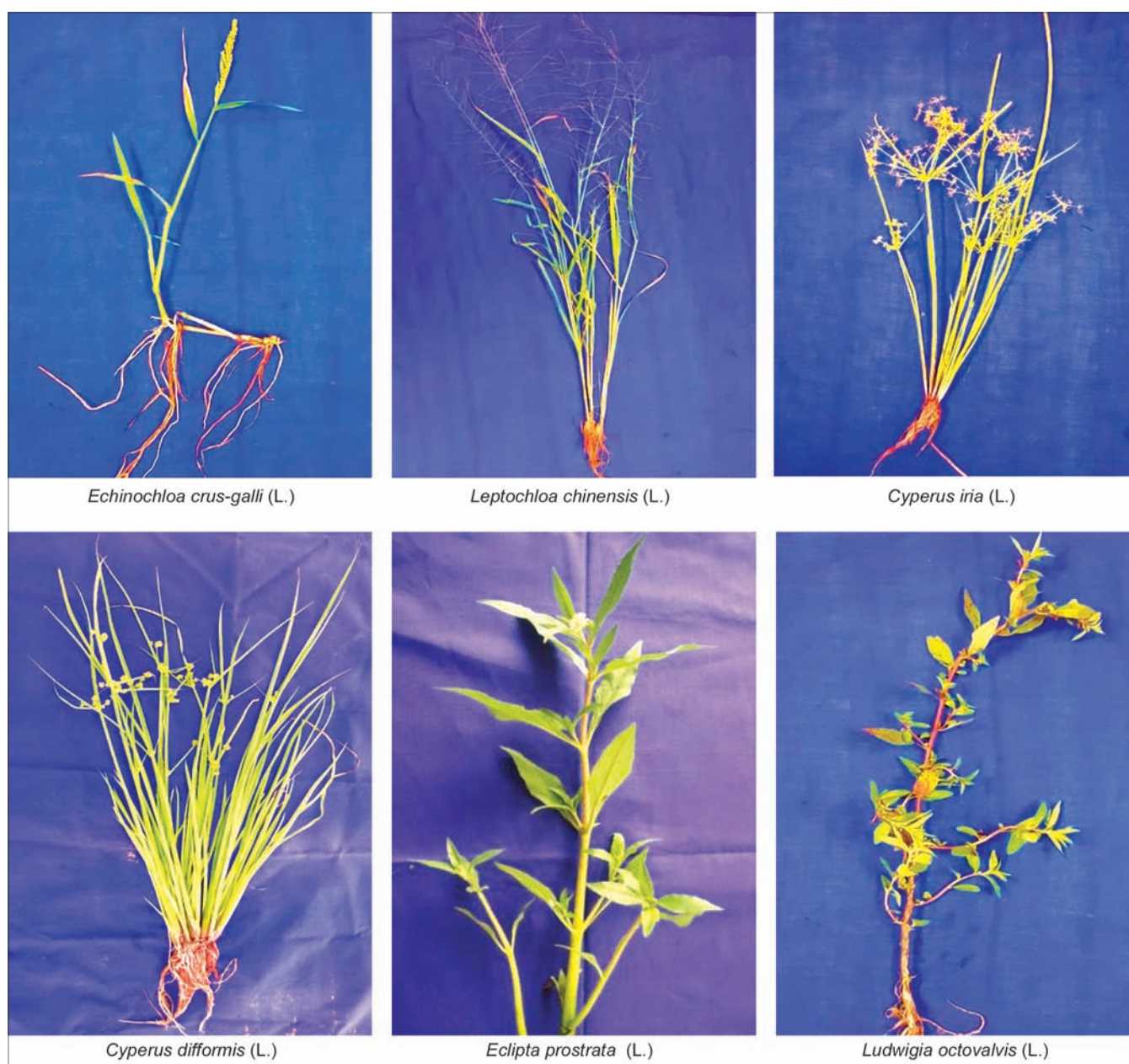


Fig. 1. Weed flora observed in direct-seeded rice

sedges and broadleaf weeds. Different rice ecosystems and cultural practices mostly determine dominant weed species/group, rice-weed competition and eventually, the weed control strategy. Changes in crop establishment, from transplanting to direct seeding also resulted in marked changes in the composition of weed flora. Adoption of direct-seeding technology may result in weed flora shifts towards more difficult to control and competitive grasses and sedges. The major weeds associated with the direct-seeded rice (DSR) were listed in the Table 1 and Fig. 1.a-f.

WEED MANAGEMENT OPTIONS IN RICE

Preventive Methods

Prevention of weed seed dispersal

Prevention, the most basic of all weed control methods, restricts introduction and spread of weeds. Prevention aims more at minimizing weed seed banks and check the entry of new weeds in crop fields to prevent further infestation. The key weed species of rice are often dispersed through natural means (animal, human, mechanical, etc.). Preventive measures compliment curative tactics like the use of herbicides by restricting weed

dispersal and preventing weed seed bank build up.

Prevention of crop seed contamination with weed seeds

Rice seed contaminated with weeds is one of the major causes of weed infestation, especially in direct-seeded rice. On average, 466 weed seeds/kg rice seeds including 314 weedy rice seeds, which is forty-seven-fold higher than permitted national purity level were observed in Vietnam. An important rice weed, *Leptochloa chinensis* has reportedly been introduced in northern Italy through contaminated seeds. The prevention of weed seed

contamination in DSR becomes more important than in TPR as a higher seeding rate is used per unit of the area under DSR.

Cultural methods

Stale seed bed

Practicing stale seed-bed (SSB) after one and two irrigations with a successive application of herbicides reduced weed density by 44–68% and 77–85%, respectively, over a control in India. The weed seed bank depletion due to SSB provides a less competitive environment for rice during the initial stage.

Field preparation

The seedbed preparation under DSR, includes one or two deep ploughing through disc followed by a cultivator, 2–3 harrowings, breaking up big clods and land leveling. Good land preparation provides a weed-free seedbed, which reduces weed densities by up to 49%, saves labour for manual weeding.

Increasing crop competitiveness

The crop growth is favoured by selection of cultivars, adjusting plant geometry, seed rate and spacing, would give an initial advantage for competing against weeds.

Seed priming

Higher and synchronized emergence of primed seeds can ensure vigorous crop stand with rapid canopy development giving rice plants a preliminary advantage over weeds. A robust seedling stand obtained from primed seeds enhanced rice competitiveness against weeds and improved tolerance to environmental stress.

Crop rotation

By its nature, crop rotation disrupts regeneration niches of weed species and prevents the build-up of adapted weed species. Rotating rice with mungbean was effective for weedy rice control because volunteer rice seedlings failed to survive in mungbean. Rotation combinations of 25 crops reduced weed density compared to monoculture.

Seeding density

Seeding density of a crop determines solar radiation interception, canopy coverage and biomass accumulation which have a cumulative effect on its weed suppressive ability. Higher seeding rate develops a canopy rapidly and consequently suppresses weeds more effectively, and in contrast, the lower seeding rate results in sparse stands and encourage weed growth. It is reported that *Echinochloa crus-galli* and *Leptochloa chinensis* densities were reduced at higher rice seeding rates of 200 kg/ha and 100 kg/ha, respectively.

Physical method

Hand weeding

Hand weeding is very easy and environment-friendly but tedious and highly labour intensive, and; thus, is not an economically viable option for the farmers. It has been estimated that 150-200-labour-day/ha are required to keep rice crop free of

weeds. Moreover, morphological similarity between grassy weeds and rice seedlings makes hand weeding difficult at the early stages of growth.

Mechanical weeding

Mechanical weeding had the advantage of economical, non-polluting without residual problems and it is relatively safe for the operator. It has been reported that rotary weeder weeding had the advantage of 10.9% of increased crop yield/ha rather than using hand weeding.

Chemical method

Herbicides provide superior weed control and are more labour efficient than manual or mechanical methods of weed management. A list of some promising herbicides used in direct-seeded rice field with their active ingredients, application time and target weed groups has been presented in Table 2. It was observed from a field experiment which was conducted at Pandit Jawaharlal

Table 2. Promising herbicides used in direct seeded rice cultivation

Herbicides	Time of application (DAS)	Dose	Application	Targeted control
Pendimethalin	0-3	1000 g a.i/ha	Pre-emergence	Annual grasses and broadleaved weeds
Oxadiargyl	3-5	100 g a.i/ha	Pre-emergence	Annual grasses, sedges and some broadleaved weeds
Pyrazosulfuron	0-3	20 g a.i/ha	Pre-emergence	Broadleaved and sedges
Bispyribac sodium	10-14	25-30 g a.i/ha	Contact herbicide for early post emergence application	Broad spectrum of weed control except <i>Leptochloa chinensis</i>
Chlorimuron + metsulfuron	0-3/10-14	4 g a.i/ha	Pre-emergence and early post emergence	Broadleaved and sedges
Bensulfuron methyl	6-10	300-500 g a.i/ha	Pre-emergence and early post emergence under wet/standing water conditions	Effective against almost all annual and perennial broad-leaved weeds and some sedges during
Cyhalofop butyl	10-14	100 g a.i/ha	Early post emergence herbicide	Effective against <i>E. crusgalli</i> and <i>L. chinensis</i> until four leaf stage. Tank mixed with Sulfonyl urea gives wide spectrum of weed control
Penoxsulam + cyhalofop butyl	6-10	12.5 g + 62.5 g a.i/ha	Early post emergence herbicide	Effective against <i>E. crusgalli</i> , <i>L. chinensis</i> , <i>C. iria</i> , <i>F. miliacea</i> and <i>C. difformis</i> under saturated condition



Fig. 2. a. Experimental lay out b. Pre -emergence application of pendimethalin c. Pre -emergence application of Oxadiargyl d. Pre -emergence application of Pyrazosulfuron.

Table 3. Economics of weed management treatments in direct-seeded rice

Treatments	Grain yield (t/ha)	Gross returns (₹ 10 ³ /ha)	Net returns (₹ 10 ³ /ha)	B:C ratio
Bispyribac-sodium	2.60	52.60	27.28	1.07
Pendimethalin fb bispyribac-sodium	3.18	63.67	36.72	1.34
Oxadiargyl fb bispyribac-sodium	3.01	59.08	32.63	1.24
Pyrazosulfuron fb bispyribac-sodium	2.90	58.91	32.89	1.26
Pendimethalin fb bispyribac-sodium fb manual weeding	3.86	77.52	47.78	1.60
Mechanical weeding thrice	2.09	41.95	16.80	0.65
Manual weeding thrice	3.61	72.63	42.43	1.40
Unweeded control	1.23	24.29	1.14	0.04

Nehru College of Agriculture and Research Institute, Karaikal, Puducherry U.T during *rabi* (September 2016- January 2018) indicated the efficacy of herbicides combinations for control of complex weed flora in direct-seeded rice (Fig. 2.a-d).

Integrated weed management approach

Integration of diverse technologies is essential for weed management because weed communities are highly responsive to management practices and environmental conditions. Various weed control methods for DSR have been assessed, but complete reliance on one strategy fails to provide full control for weeds. A higher seed rate and fertilizer for

stimulating initial growth, later on, limits the herbicide as an effective weed management approach. Under DSR, stale seedbed followed by retention of crop residues followed by applications of early and late post-

emergence herbicides can substantially reduce weed densities. Sequential application of pre and post-emergence application of pendimethalin and bispyribac-sodium herbicides integrated with hand weeding resulted in better yield and economics in DSR at Karaikal, Puducherry UT (Table 3). Further, Integration of pretilachlor (PE) either with one hand weeding at 30 DAS or with brown manure through *Sesbania aculeata* or *Sesbania rostrata* provided desirable weed management during the critical growth period of DSR.

SUMMARY

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, stale seed-bed preparation, crop rotation along with a rotation of herbicides with different mode of actions followed by manual weeding and rouging after mid-stage of rice growth. Need-based chemical weed management through herbicide, herbicide mixtures, identification of new herbicides against a wide spectrum of weeds, and use of herbicide tolerant rice, would help in achieving a long-term and sustainable weed control in DSR. Judicious mix of more than one method is warranted to keep the weeds under control for higher productivity in direct-seeded rice cultivation.

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