Interventional weed management methods in direct seeded rice

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Summary Rice (*Oryza sativa* L.) is the most important staple food crop of India. A shift in crop establishment from traditional manual transplanting of seedlings to direct-seeding has occurred in many Asian countries, including in India. Direct seeded rice has many advantages over transplanted rice. It consumes less water and matures earlier than the transplanted crop. However, weeds are the most important biotic constraint in direct seeded rice production. A field experiment was carried out during 2016–2017 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry Union Territory, India to study the effect of interventional weed management strategies on the diverse weed flora, rice yield and benefit:cost ratio in direct seeded rice under unpuddled conditions.

Grassy weeds dominated the weed flora, with jungle rice (*Echinochloa colona* (L). Link) the major weed. A higher jungle rice population was noticed when weed management was done through manual weeding with a rotary weeder. Integration of herbicide and manual (hand) weed control resulted in a lower population of jungle rice, which resulted in better weed control, higher rice yield and a superior benefit:cost ratio. Uncontrolled weeds lead to 71% yield loss in direct seeded rice.

Keywords Herbicides, manual weeding, benefit:cost ratio.

INTRODUCTION

Rice is the most important food crop for half of the world population. The global grain provides 35–80% of total calorie uptake to more than 2.7 billion people. It is the most important staple food crop of India, grown over an area of 42.2 million ha with a production of 84.74 million t. A number of factors including: inadequate availability of water supplies; along with increased labour costs; labour shortages at the peak of planting activities; and declining profitability of rice production, have encouraged many rice farmers in south east Asian countries, including India, to shift from transplanting to direct-seeding in irrigated areas. Relatively inexpensive and cost-efficient herbicides and early maturing modern varieties have helped this change. Direct-seeding rice production systems are subject to greater weed pressure than conventionally transplanted systems. This is because weeds are suppressed by flooding and transplanted rice seedlings have a 'head start' over germinating weed seedlings (Moody 1983). Direct seeding is practised in two forms: wet-seeding; and dry-seeding. In wet-seeded rice, pre-germinated seeds are broadcast onto the puddled soil. In dry-seeding rice, non-pre-germinated seeds are sown onto dry-ploughed, unpuddled soil that could be dry or moist.

The most important problem in direct seeded rice is weed competition. Failure to manage the weeds could result in 50–90% rice yield loss (Chauhan and Johnson 2011). Considering this, we conducted a field experiment to study the effect of interventional weed management methods in direct seeded rice under unpuddled situation at Karaikal, Puducherry Union Territory, India.

MATERIALS AND METHODS

A field experiment was conducted at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry (11°56′ N latitude, 79°53′ E longitude, altitude 8 m), Puducherry Union Territory between September 2016 – January 2017. The soil was sandy clay loam in texture, at pH: 6.94, low in available nitrogen (119 kg ha^{-1}) and high in available phosphorus (24 kg ha^{-1}) and potassium (366 kg ha^{-1}). The experiment was laid out in randomised block design with ten treatments. The treatments were: mechanical weeding using a rotary weeder at 20, 40 and 60 days after sowing (DAS) (T_1); 3 manual (hand) weeding events occurring at 20, 40 and 60 days after sowing (DAS) (T_2); post-emergence application of bispyribac sodium 25 g ai ha^{-1} (T_3); or along with chlorimuron + metsulfuron 4 g ai ha^{-1} (T_4); pre-emergence application of oxadiargyl 100 g ai ha^{-1} followed by (*fb*) post-emergence application of bispyribac sodium 25 g ai ha^{-1} (T_5); or pyrazosulfuron ethyl 20 g ai ha^{-1} *fb* post-emergence application of bispyribac sodium 25 g ai ha^{-1}(T_6); pre-emergence application of pendimethalin 1000 g ai ha^{-1} *fb* post-emergence application of bispyribac sodium 25 g ai ha^{-1} (T_7); pre-emergence application of pendimethalin 1000 g ai ha^{-1} *fb* one manual (hand) weeding at 40 DAS (T_8);

pre-emergence application of pendimethalin 1000 g ai ha^{-1} *fb* one manual (hand) weeding at 40 DAS (T_9); and an unweeded control (T_{10}).

The relative density of jungle rice for each treatment was recorded with a quadrat (0.25 m × 0.25 m) placed randomly at four spots in each plot at 80 DAS, and computed using the procedure suggested by Raju and Reddy (1998). Weed control efficiency (WCE, %) was calculated using the formula WCE = (weed biomass in non-treated plot-weed biomass in treated plot/ weed biomass in non-treated plot) × 100. The rice cultivar ADT 46 was sown with the spacing of 25 cm × 10 cm, and all the recommended package of practices except weed control were adopted during the period of experimentation. The data on rice grain yield were subjected to statistical scrutiny as per the lsd procedure in Panse and Sukhatme (1967). The Benefit:Cost (B:C) ratio was calculated using the existing market rates.

RESULTS

The major weed flora observed in the experimental field were jungle rice (*Echinochloa colona* (L.) Link), Chinese sprangletop (*Leptochloa chinensis* (L.) Nees), eclipta (*Eclipta prostrata* (L.) L.), small flowered nutsedge (*Cyperus difformis* (L.)), rice flatsedge (*Cyperus iria* L.) and lesser fimbristylis (*Fimbristylis littoralis* Gaud). Analyses of the relative weed densities revealed that jungle rice was the major grassy weed infesting the experimental field (Table 1). Sequential pre- and post-emergence application of pendimethalin and bispyribac sodium herbicides, respectively, integrated with hand weeding, resulted in lower jungle rice weed density (46.4%) and higher weed control efficiency (94.1%). However, a single application of post-emergence application of bispyribac sodium alone resulted in poor weed control efficiency (51.5%).

A higher rice yield and better B:C ratio was observed with sequential applications of pre- and post-emergence application of pendimethalin and bispyribac sodium herbicides alone when integrated with manual (hand) weeding (3.64–3.84 t ha^{-1} and 1.65–1.72, respectively).

DISCUSSION

Sequential applications of pre- and post-emergence application of pendimethalin and bispyribac sodium herbicides integrated with manual weeding effectively reduced jungle rice density by 49.2% when compared to the unweeded control. Das and Duary (1998) indicated that pendimethalin, which belongs to dinitroanaline group, prevents germination and arrests root and shoot development of susceptible weeds by acting as mitotic poison (microtubule assembly inhibitor). In contrast, large numbers of jungle rice plants were recorded with mechanical weeding using rotary weeder. This was due to the escape of the target weed in the intra-row area and the availability of light for the germination of weed seeds. Benvenuti and Macchia (1995) indicated that light plays an important role in the germination of some weed species to overcome the dormancy. Chauhan (2012) observed that light stimulates the germination of jungle rice.

Table 1. The effect of weed management interventions on weed, crop and economics in direct seeded rice. The text '*fb*' denotes 'followed by'.

Treatment	Jungle rice relative density (%)	Weed control efficiency (%)	Rice yield (t ha^{-1})	B:C ratio
Mechanical weeding with rotary weeder thrice	87.8	48.6	1.84	0.50
Manual weeding alone thrice	69.2	86.5	3.52	1.24
Bispyribac-sodium	60.5	51.5	2.60	1.20
Bispyribac + (chlorimuron + metsulfuron)	83.3	66.7	2.80	1.27
Oxadiargyl *fb* bispyribac	91.8	71.5	3.20	1.47
Pyrazosulfuron *fb* bispyribac	91.3	80.7	3.04	1.49
Pendimethalin *fb* bispyribac	78.1	77.0	2.86	1.17
Pendimethalin *fb* bispyribac *fb* manual weeding	46.4	94.1	3.84	1.65
Pendimethalin *fb* manual weeding	68.5	88.2	3.64	1.72
Unweeded control	91.3	–	1.12	0.05
LSD (P<0.05)	–	–	0.78	v

Uncontrolled weeds resulted in a 71% yield loss compared to the sequential application of pre- and post-emergence applications of pendimethalin and bispyribac sodium integrated with hand weeding. Economically, the application of pre-emergence pendimethalin integrated with a manual weeding at 40 DAS was superior to other weed management interventions. Therefore, results of the present study clearly indicate the supremacy of interventional methods in tackling weed problem in direct seeded rice.

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