

## Effect of crop establishment methods and weed management practices on weed flora and yield of direct-seeded rice (*Oryza sativa*)

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Received : June 2015; Revised accepted : February 2016

### ABSTRACT

A field investigation was conducted during the rainy (*kharif*) season of 2011 and 2012 at Varanasi, Uttar Pradesh, to study the effect of crop-establishment methods and weed-management practices on weed flora and yields of direct seeded rice (*Oryza sativa* L.). Among crop-establishment methods, bed planting of directed seeded rice (DSR) markedly reduced weed density of various weed flora and their dry weight than zero-till and conventional planting, thus resulting in the lowest weed index. Bed planting markedly improved grain weight/panicle but recorded significantly lowest number of tillers/m<sup>2</sup> at harvesting among all the crop-establishment methods. Consequently, crop-establishment methods failed to influence grain and straw yields and harvest index at significant level. Integration of brown manuring practice (knock down of *Sesbania* at 25 days after sowing (DAS) by 2,4-D @ 0.5 kg/ha) with either pendimethalin @ 1.0 kg/ha or bispyribac-sodium @ 0.025 kg/ha or both was significantly superior in suppressing weed infestations with lesser weed index and higher weed-control efficiency, yield attributes, yields and harvest index. No-till method and integrated weed-management by pendimethalin followed by brown manuring of *Sesbania* had higher remuneration among the crop-establishment methods and weed-management practices respectively.

**Key words :** Bed planting, Bispyribac-sodium, Brown manuring, Direct seeded rice, No-till

Rice is the most important crop of the world as it feeds about 70% of the world's population. It occupies approximately 153 m ha globally, of which 134 m ha is in Asia (Rao *et al.*, 2007). In the present scenario, looming scarcity of water and labour due to population explosion and urbanization, poses a serious threat to sustainability of traditional methods of rice production. Direct-seeded rice (DSR) can address these problems, as it requires lesser amount of water and labour force than conventional transplanting. Besides these, it improves soil physical structure, reduces methane emission, facilitates timely planting of next season crop and crop diversification due to 7–10 days earlier crop maturity. Resource-conserving techniques like zero tillage and bed planting have been successful in enhancing production of wheat, but their feasibility in rice production is yet to be confirmed.

Transition of crop-establishment method from traditional transplanting to DSR may result in shift towards

more difficult-to-control competitive grasses and sedges (Kumar and Ladha, 2011). Aerobic edaphic conditions under non-flooded condition in DSR stimulate germination of diverse weed species. Severe crop–weed competition for growth factors like light, water, nutrient and space, begins from the early stage due to simultaneous emergence of weeds and rice in DSR. Hand-weeding is difficult at early stage because several grassy weeds resemble rice seedling morphologically during this stage. Application of selective herbicides can solve this problem and be of help at the time of labour unavailability for weed control during peak period. However, over-dependence on herbicides for weed control can trigger evolution of herbicide resistant weeds and cause pollution of environment. Co-culturing of *Sesbania* with rice and then knocking down with 2, 4-D has been reported to smother various weed species and enhance yield of rice. Random integration of certain weed-management practices is not the solution for minimizing weed problems. It is imperative to identify effective weed-management practices and work out their feasibility for integrating them for better weed control and higher yield. Keeping these points in view, the present experiment was taken up, to study the impact of

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crop-establishment methods and weed-management practices on weed flora and yields of direct-seed rice.

### MATERIALS AND METHODS

A field experiment was conducted during the rainy (*khari*) season of 2011 and 2012 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The soil was sandy loam, with pH 7.64, low in available organic carbon (0.33%), available nitrogen (180.0 kg/ha), and medium in available phosphorus (19.1 kg/ha) and potassium (217.9 kg/ha). The experiment was laid out in a split-plot design keeping 3 crop-establishment methods, viz. conventional planting (thorough land preparation followed by dry seeding of rice in lines with *kudal*), bed planting (after thorough land preparation, beds of 37 cm wide and 30 cm width furrow between 2 beds and 22 cm height was made and 2 lines of rice were sown on each bed by *kudal*) and no-till planting (application of glyphosate 1 kg/ha as pre-planting to control perennial and other annual weeds followed by dry seeding of rice in line) in the main plot and weed-management practices, viz. pendimethalin (pre-emergence) 1 kg/ha, bispyribac-sodium (early post-emergence) 0.025 kg/ha, brown manuring (*Sesbania* knock down by 2,4-D 0.50 kg/ha at 25 DAS), pendimethalin followed by (*fb*) brown manuring, pendimethalin *fb* bispyribac-sodium, pendimethalin *fb* bispyribac-sodium *fb* brown manuring, weed-free (hand-weeding at 15, 30, 45, 60 and 75 DAS) and weedy check in sub-plots during both the years and replicated 4 times. Rice variety 'Sarju 52' was sown during the last week of June in both the years following the seed rate of 30 kg/ha and 20 cm-row-row spacing. *Sesbania* was seeded in between rows of rice at the rate of 15 kg/ha. Application of herbicides was done according to treatments using knap-sack sprayer fitted with flat-fan nozzle. The spray volume of pre-emergence herbicides and post-emergence herbicides was 600 litres/ha. The crop was raised under irrigated condition under the recommended package of practices. Species-wise weed density and their total dry weight were measured at 60 DAS by placing a quadrat of 50 cm × 50 cm randomly at 3 places in each plot. These were subjected to square-root transformation before analysis. Weed-control efficiency at 60 DAS was calculated as per Tripathi and Mishra (1971). Biometric characters and yields (grain and straw) of the crop were measured at harvest stage. Weed index was calculated according to the formula given by Gill and Kumar (1969). The data were pooled and average for 2 years was analyzed by the analysis of variance technique. Prevailing price of inputs in the market during 2011 and 2012 were used to calculate the economics. The benefit: cost ratio (BCR) was worked out on the basis of gross

returns (₹/ha) and cost of cultivation (₹/ha).

### RESULTS AND DISCUSSION

#### Weed flora

The major weed flora observed in experimental field included *Echinochloa crusgalli* (L.) Beauv., *Echinochloa colona* (L.) Link. among grasses; *Cyperus iria* Linn., *Cyperus rotundus* Linn., *Fimbristylis miliacea* (L.) Vahl, among sedges and *Caesulia axillaris* (L.) Rottb. and *Eclipta alba* (L.) Hassk. among broad-leaf weeds. Density of weed species and their dry weight varied significantly at 60 DAS irrespective of crop-establishment methods and weed-management practices (Table 1). In general, *Echinochloa crus-galli* was the most dominant weed among all the weed species.

At 60 DAS, both bed planting and no-till significantly reduced the density of all weed species, except *Cyperus rotundus*, and both were significantly better than conventional method (Table 1). Bhuyan *et al.* (2012) reported that bed planted crop had lesser weed density than conventionally planted DSR. Averaged over 2 years, bed planting recorded the lowest dry weight of weeds at 60 DAS, which was closely followed by no-till method.

Adoption of integrated weed-management practices exhibited lesser weed infestation with higher weed-control efficiency than sole weed-management practice and sequential herbicide application (Table 1). Application of pendimethalin *fb* brown manuring resulted in the lowest density of *Echinochloa crus-galli* at 60 DAS, which was statistically lower than the other weed-management practices except pendimethalin *fb* bispyribac-sodium *fb* brown manuring. However, application of pendimethalin *fb* bispyribac-sodium *fb* brown manuring proved most effective method against other weed species at this stage. As a consequence, treatments, viz. pendimethalin *fb* brown manuring and pendimethalin *fb* bispyribac-sodium *fb* brown manuring, recorded significantly lower dry weight of weed and higher weed-control efficiency than the other weed management practices at this stage. The lowest density of *Echinochloa crussgalli* was observed under pendimethalin *fb* brown manuring, being significantly lower than the other weed-management practices except pendimethalin *fb* bispyribac-sodium *fb* brown manuring. These might be due to synergistic effect of smothering action of brown manuring plus suppressive impact of herbicides (pendimethalin and bispyribac-sodium) on diverse weed flora. Mukherjee and Maity (2011) and Kumar and Ladha (2011) emphasized that integration of herbicides (pre-/ and post-emergence) with brown manuring could increase weed-control efficiency by reducing growth of diverse weeds in DSR.

**Table 1.** Influence of crop-establishment methods and weed-management practices on weed density, weed dry weight and weed-control efficiency (WCE) at 60 days after sowing in direct seeded rice (pooled data of 2 years)

Treatment	Density of major weed species (Nos./m <sup>2</sup> )							Weed dry weight (g/m <sup>2</sup> )	WCE (%)
	<i>Echinochloa crus-galli</i>	<i>Echinochloa colona</i>	<i>Cyperus rotundus</i>	<i>Cyperus iria</i>	<i>Fimbristylis miliacea</i>	<i>Eclipta alba</i>	<i>Caesulia axillaris</i>		
<b>Crop establishment method</b>									
Conventional	7.3 (53.2)	5.6 (30.3)	4.5 (19.9)	4.5 (19.7)	3.8 (14.0)	3.8 (14.1)	3.2 (9.5)	13.0 (168.7)	-
Bed-planting	6.3 (39.1)	5.4 (28.6)	4.3 (17.5)	4.1 (16.4)	3.42 (11.2)	3.5 (11.4)	2.9 (8.1)	11.6 (134.6)	-
No-till	6.5 (41.7)	5.80 (33.2)	4.5 (19.4)	4.5 (19.3)	3.51 (11.8)	3.6 (12.7)	3.0 (8.5)	12.3 (150.5)	-
SEM±	0.17	0.12	0.09	0.05	0.07	0.06	0.04	0.15	-
CD (P=0.05)	0.59	0.43	NS	0.16	0.25	0.20	0.15	0.53	-
<b>Weed-management practice</b>									
Pendimethalin @ 1 kg/ha	7.8 (60.5)	6.1 (36.9)	5.1 (25.7)	4.7 (21.6)	4.3 (17.7)	4.0 (15.3)	3.6 (12.5)	13.9 (192.0)	52.4
Bispyribac-sodium @ 0.025 kg/ha	7.1 (49.3)	6.1 (36.9)	4.7 (21.9)	4.7 (21.1)	3.7 (13.2)	3.7 (13.3)	3.3 (10.5)	12.6 (158.3)	60.7
Brown manuring	7.3 (53.3)	6.4 (39.9)	4.4 (19.0)	4.2 (17.2)	3.6 (12.2)	3.5 (11.6)	2.8 (7.6)	13.4 (179.4)	55.5
Pendimethalin fb brown manuring	4.2 (17.5)	4.5 (19.6)	4.0 (15.2)	3.5 (11.4)	3.0 (8.2)	3.2 (9.7)	2.4 (5.1)	9.2 (84.0)	79.2
Pendimethalin fb bispyribac-sodium	5.5 (30.1)	4.7 (21.8)	3.9 (14.6)	3.9 (14.4)	3.1 (9.1)	3.3 (10.5)	2.6 (6.3)	10.6 (111.3)	72.4
Pendimethalin fb bispyribac-sodium fb	4.3 (18.3)	3.3 (10.7)	3.4 (11.3)	3.2 (9.7)	2.4(5.4)	2.7 (6.7)	2.1 (4.0)	9.1 (81.6)	79.8
Brown manuring	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	100.0
Weedy-check	11.4 (128.4)	9.0 (79.8)	6.7 (43.9)	7.3 (52.3)	5.8 (31.6)	5.9 (34.6)	4.9 (23.5)	20.1 (403.3)	0.0
SEM±	0.12	0.10	0.08	0.05	0.06	0.07	0.04	0.11	-
CD (P=0.05)	0.35	0.28	0.23	0.13	0.16	0.18	0.12	0.31	-

Data were subjected to square root ( $\sqrt{x+0.5}$ ) transformation; figures in parentheses are original values

**Yield attributes and yield**

The establishment of DSR by bed planting (Table 2) markedly improved grain weight/panicle but exhibited significantly lowest number of tillers/m<sup>2</sup> at harvesting among the crop-establishment methods. Possible reason behind this might be wider spacing in bed planting (20 cm–47 cm–20 cm) due to which number of tillers/unit area was reduced and higher grain weight/panicle in bed planting failed to compensate this. Borrell *et al.* (1997) and Choudhury and Singh (2007) also reported similar findings. Consequently, variation in grain and straw yields and harvest index of DSR due to crop establishment methods was non-significant. The lowest weed index was observed under bed planting followed by no-till.

Integrated weed-management practices, pendimethalin fb brown manuring and pendimethalin fb bispyribac-sodium fb brown manuring resulted n marked increase in biometric attributes and lower weed index, which resulted in significantly higher grain and straw yields than the other weed-management practices (Table 2). This might be due to lesser crop-weed competition for growth factors under integrated weed-management practices (Mishra and Singh, 2008; Maity and Mukherjee, 2011). The increase in grain and yield under treatments pendimethalin fb brown manuring and pendimethalin fb bispyribac-sodium fb brown manuring was 187.67% and 188.36% over weedy check respectively. Similarly, 72.17% and 72.48% higher straw yield under treatments pendimethalin fb brown manuring and pendimethalin fb bispyribac-sodium fb brown manuring over weedy check, respectively, was recorded. All the weed-management practices had statistically higher harvest index than weedy check.

**Economics**

The gross return obtained by yield of crop varied greatly due to different treatments, which ultimately influenced the net returns and benefit: cost ratio. No-till method revealed the maximum value of net returns among all the crop-establishment methods (Table 2). Consequently, the highest benefit: cost ratio was registered under no-till method (Table 2). This is mainly owing to saving in labour, power and capital as land preparation was under this treatment. As a result, there was reduction in overall cost of production, thus leading to maximum net returns and benefit: cost ra-

**Table 2.** Influence of crop-establishment methods and weed-management practices on yield attributes, yields, harvest and weed index and economics of direct-seeded rice (pooled data of 2 years)

Treatment	No. of tillers/m <sup>2</sup> at harvest	Grain weight (g)/panicle	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Weed index (%)	Gross returns (×10 <sup>3</sup> ₹/ha)	Net returns (×10 <sup>3</sup> ₹/ha)	Benefit: cost ratio
<i>Crop establishment method</i>									
Conventional	274	2.6	3.5	5.0	40.4	29.0	43.0	14.3	1.50
Bed planting	187	3.1	3.5	5.0	40.1	23.4	43.2	13.4	1.46
No-till	280	2.8	3.7	5.2	41.0	26.3	46.3	18.4	1.66
SEm±	5.75	0.05	0.09	0.07	0.56	–	–	–	–
CD (P=0.05)	19.90	0.17	NS	NS	NS	–	–	–	–
<i>Weed-management practice</i>									
Pendimethalin @ 1 kg/ha	224	2.7	3.3	4.6	41.6	31.5	40.9	14.3	1.54
Bispyribac-sodium @ 0.025 kg/ha	250	2.8	3.5	5.0	41.4	27.1	43.6	16.3	1.60
Brown manuring	231	2.8	3.1	4.5	40.9	35.3	38.7	13.2	1.52
Pendimethalin fb brown manuring	257	3.0	4.2	5.6	42.7	12.5	52.1	24.6	1.90
Pendimethalin fb bispyribac-sodium	248	2.9	3.8	5.3	41.5	21.6	46.9	17.6	1.61
Pendimethalin fb bispyribac-sodium fb brown manuring	261	3.1	4.2	5.6	42.7	12.1	52.4	22.4	1.75
Weed-free	279	3.3	4.8	6.5	42.4	0.0	59.8	20.5	1.52
Weedy check	227	2.1	1.5	3.3	30.7	69.7	18.9	-5.9	0.76
SEm±	5.27	0.04	0.07	0.10	0.68	–	–	–	–
CD (P=0.05)	14.89	0.12	0.20	0.28	1.92	–	–	–	–

tio. The lowest net returns and benefit: cost ratio were recorded under bed planting method because of higher cost of cultivation and lower gross return due to reduced grain yield. Tripathi *et al.* (1999) expressed similar views.

Economic evaluations of the weed-management practices revealed that the higher net returns and benefit: cost ratio were recorded under application of pendimethalin fb brown manuring than the other weed-management practices (Table 2). This could be attributed to higher grain yield of rice along with the low cost of *Sesbania* seed and herbicides (pendimethalin and 2, 4-D). Also, this treatment gave higher net returns and benefit: cost ratio than application of pendimethalin fb bispyribac fb brown manuring due to extra cost of application of bispyribac incurred in the latter treatment. We confirm the findings of Maity and Mukherjee (2011).

Based on 2 years study, it may be concluded that establishment of DSR by no-till following pre-planting application of glyphosate @ of 1 kg/ha and management of diverse weed flora by application of pendimethalin @ 1.0 kg a.i/ha followed by brown manuring of *Sesbania* at 25 DAS by 2,4-D @ 0.5 kg a.i/ha should be done for sustaining higher yield and remuneration.

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