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## Effect of crop establishment methods and weed management practices on crop performances and economics of direct seeded rice (*Oryza sativa* L.)

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### Abstract

A field experiment was undertaken during *kharif* season of the year 2011-2012 at the Research Farm of Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar to study the effect of crop establishment methods and different weed management practices on growth, yield, economics, and uptake of N, P and K under direct seeded rice. The drum seeded in puddled condition obtained the significantly highest yield attributes, yield, profitability and uptake of N, P and K as compared to wet seeded and dry seeded rice. Rice established by drum seeded in puddled condition had improved the grain yield by 8.80% to 20.36%, and benefit cost ratio by 1.07 times to 1.16 times as compared to wet and dry seeded rice. Applications of pre-emergence pendimethalin and post-emergence bispyribac ( $W_6$ ) showed maximum increment in yield attributes, viz. plant height (8.03%), no. of tillers (39.11%), plant dry matter production (32.16%), and crop growth rate (447.2%) over weedy check ( $W_8$ ). Treatment,  $W_6$  maintained the highest value of grain and straw yield i.e. 35.55 q ha<sup>-1</sup> and 52.57 q ha<sup>-1</sup>, respectively. On the basis of benefit cost ratio the weed management practices,  $W_3$  (pre-emergence application of pretilachlor @ 0.75 kg ha<sup>-1</sup>) maintained the highest benefit cost ratio (1.29) and lowest was recorded with hand weeding ( $W_7$ ).

**Keywords:** Crop establishment, direct seeded rice, economics, weed management, yield etc.

### Introduction

Rice is grown in both *kharif* and *Rabi* seasons under diverse ecological and climatic conditions apart from socio-economic diversities of the state. Direct seeded culture has become increasingly important in rice cultivation due to scarcity of farm labour and higher water requirement and higher production cost of transplanted rice (Azmi and Baki, 2007) <sup>[1]</sup>. Direct seeded rice needs only 34% of the total labour requirement and saves 27% of the total cost of the transplanted crop (Mishra and Singh, 2011) <sup>[8]</sup>. Direct seeding of rice also allows early establishment of the succeeding wheat crop. Sowing of pre-germinated rice seeds under puddled condition either manually or drum seeding method reduces the demand of water for puddling and reduces the emergence of weed flora by placing the seed, stems and stolons of weed into sub-surface. Dry seeding with subsequent saturated soil condition reduces the amount of water required during puddling and thus reduces overall water demand.

The direct seeded rice culture is subjected to greater weed competition than transplanted rice because both weed and crop seeds emerge at the same time and compete with each other from the germination resulting in less grain yield. Manual removal of weeds is labour intensive, tedious, back breaking and does not ensure weed removal at critical stage of crop-weed competition due to non-availability of labours. A very large number of herbicides are there which have been observed to have effective control of weeds in direct seeded rice. However, selecting a particular herbicide or its combination with mechanical weed management require thorough probe. While, selecting a weed control measure it is equally important to keep economic aspects under consideration. Hence, the present investigation is planned to study the Effect of crop establishment methods and weed management practices on crop performances, yield, nutrient uptake and economics of direct seeded rice.

### Materials and Methods

The experiment was conducted during one *kharif* season (2011-12) at Research farm of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar.

The experiment site was situated on the southern bank of the river Budhi Gandak at 25.59° N and 84.40° E with an altitude of 52.30 m above the mean sea level. The soil was sandy loam in texture with alkaline pH (8.79), medium in organic carbon content (4.0 g kg<sup>-1</sup>) and available N, P and K (90.31, 7.55 and 45.20 mg kg<sup>-1</sup>), respectively. The average maximum and minimum temperature varied from 28.8-34.3 °C and 16.3-27.2 °C, respectively. The total rainfall and humidity recorded during cropping period was 662.3 mm, and 86-93%, respectively. These were touches the maximum value at 29<sup>th</sup> standard week. The experiment was laid out in strip plot design, replicated thrice within a plot and involved twenty four treatment combinations (Table 1). The seed rate of 55 kg ha<sup>-1</sup> was used in all establishment methods. The crop was fertilized at the rate of 150 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 40 kg K<sub>2</sub>O ha<sup>-1</sup> in all the treatments. Nitrogen was applied through urea in three equal splits (sowing time, active tillering stage and panicle initiation stage); P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied as single basal dose in the form of diammonium phosphate (DAP) and muriate of potash (MOP) along with one third dose of nitrogen at the time of crop sowing. Total five irrigations were done when available soil moisture became 50% in direct seeded rice and only saturation levels were maintained. Herbicides were applied through knap-sac sprayer fitted with flat fan nozzle. Yield attributing characters, i.e. plant height, no. of tillers, plant dry matter production, crop growth rate, and harvest index were recorded at the time of harvesting. The height of randomly selected five tagged rice plants in net plot area was measured from the base of the plant to the tip of the upper most leaf. No. of tillers was counted in per square meter areas. For estimation of plant dry matter the plants enclosed in a quadrant of 0.50 m<sup>2</sup> placed randomly in the border area and was uprooted from each plot. The samples were washed, sun dried and then kept in oven at 65 °C till constant weight reached. The dry matter production was converted into g m<sup>-2</sup>. Crop growth rate (CGR) indicates the rate at which the crop is growing. It is expressed as g of dry matter produced per day m<sup>-2</sup>. The harvest index was calculated by biological and economic yield as described by Singh and Stockopf (1971) [12]. Grain and straw yield were determined from the net plot area and was weighed in kg and converted into q ha<sup>-1</sup>. The nutrient uptake by the crop was calculated by multiplying the nutrient content with dry matter yield. The nutrient content in grain and straw were determined as per the standard procedure (Tondon, 2005) [16]. Protein content in grain was calculated with multiplying the N content with 6.25. Economics of different treatments was calculated by taking into account the prevailing market price of inputs and produce. Gross returns were worked out for each treatment based on quality and market prices of the produce. The net returns were worked out by deducting the cost incurred from the gross returns of the particular treatment. Benefit cost (B: C) ratio was incurred by dividing the net return with cost of cultivation. Statistical analysis was performed using the SPSS statistical package.

## Results and Discussion

### Yield attributes

The highest yield attributes (Table 2), viz. plant height, no. of tillers, plant dry matter production, crop growth rate and harvest index were recorded in drum seeded puddled condition (E<sub>3</sub>) which was followed by wet seeded-broadcasting of sprouted seeds under puddled condition (E<sub>1</sub>)

and dry seeded in rows at 20 cm apart (E<sub>2</sub>). The improvement of yield attributes under the treatment of drum seeded in puddled condition, mainly due to lowest weed population (Singh, and Singh, 2010) [13]. Besides, the puddling virtually destroys the structure of soils completely dispersing their soil particles. Such a condition is favourable for rice growth as there is considerable reduction in the rate of percolation, which increases the period of submergence after each irrigation. The dispersal of soil particles and continued submergence or saturated regime under puddled conditions is unfavorable for the growth of weeds (De Datta, 1981) [4]. Applications of pre-emergence pendimethalin and post-emergence bispyribac (W<sub>6</sub>) showed maximum increment in yield attributes, viz. plant height (8.03%), no. of tillers (39.11%), plant dry matter production (32.16%), and crop growth rate (447.2%) over weedy check (T<sub>8</sub>). However, all other pre-emergence herbicidal applications (Butachlore, pretilachlor, pendimethalin) or bispyribac in combinations with butachlore or pretilachlor (W<sub>1</sub>, W<sub>2</sub>, W<sub>3</sub>, W<sub>4</sub> and W<sub>5</sub>) were superseded by two hand weeding so far as these characteristics were concerned due to lowest weed-crop competition during the crop growth. The highest harvest index was obtained with W<sub>1</sub>. The results are close agreement with the works of Dwivedi *et al.* (1991) [5], Singh and Namdeo (2004) [14], and Singh *et al.* (2005) [11].

### Yield

Yield data revealed that among the crop establishment methods (Table 2), rice establishment by drum seeded in puddled condition (E<sub>1</sub>) produced significantly highest grain and straw yields of rice as compared to rest of the treatments (E<sub>1</sub> and E<sub>2</sub>). The establishment method, E<sub>3</sub> has improved the grain and straw yield of rice by 8.80-20.36% and 5.12-11.11%, respectively as compared to establishment methods, E<sub>1</sub> and E<sub>2</sub> due to less weed population and higher yield attributes. Our results are in agreement with the findings of Bohra *et al.* (2006) [3], Bhagat *et al.* (2009) [2], Kumar *et al.* (2010) [7], and Singh and Singh (2010) [13].

With the applications of weed management practices (Table 2), viz. W<sub>6</sub>, W<sub>7</sub>, W<sub>4</sub>, W<sub>2</sub>, and W<sub>3</sub> were produced statistically similar effect on grain yield (average 34.84 q ha<sup>-1</sup>) of rice and also statistically superior to rest of the weed management practices, namely W<sub>1</sub>, W<sub>5</sub> and W<sub>8</sub>. Likewise, weed management practices, viz. W<sub>6</sub>, W<sub>7</sub> and W<sub>4</sub> were produced statistically similar effect on straw yield with an average value of 51.72%, and also significantly superior to rest of weed management practices, i.e. W<sub>1</sub>, W<sub>2</sub>, W<sub>3</sub>, W<sub>5</sub> and W<sub>8</sub>. The improvement in grain and straw yield can be attributed to marked improvement in yield attributes, dry matter accumulation, and better weed control efficiency. The minimum grain yield was recorded under weedy check which was attributed to more weed growth and poor yield attributes. The results are commensurate with the earlier findings of Tamilselvan and Budhar (2002) [15], Mohan *et al.* (2005) [9], and Jayadeva *et al.* (2009) [6].

### Economics

Economic analysis of data (Table 2) showed that drum seeded in puddled condition (E<sub>3</sub>) obtained the highest gross return, net return and benefit cost (B:C) ratio as compared to wet seeded (E<sub>1</sub>) and dry seeded (E<sub>2</sub>) rice. The treatment E<sub>3</sub> has enhanced the gross return by 1.04-1.08 times, whereas, net return and benefit cost ratio by 1.07-1.16 times when

compared to treatment E<sub>1</sub> and E<sub>2</sub> due to better crop growth and yield.

When compared to different weed management practices, the treatment combining pre-emergence application of pretilachlor followed by post-emergence application of bispyribac (W<sub>4</sub>) had incurred the highest gross return which was closely followed by W<sub>6</sub> and W<sub>7</sub>. Among the pre-emergence applications of pretilachlor herbicide gave the maximum gross return followed by pendimethalin and butachlor. Whereas, the minimum gross return was obtained with weedy check (W<sub>8</sub>). Similarly, weed management practice, W<sub>4</sub> incurred the highest net return which was statistically at par with rest of the weed management practices except W<sub>1</sub>, W<sub>7</sub> and W<sub>8</sub>.

All the herbicidal weed management practices (W<sub>1</sub> to W<sub>6</sub>) recorded higher B:C ratio i.e. 1.13-1.29 than two hand weeding (W<sub>7</sub>) and weedy check (W<sub>8</sub>) due to better growth and yield. Two hand weeding with B: C ratio of 0.58 was superior only to the control weedy check (0.67). Among the three pre-emergence applications, pretilachlor recorded the highest B: C ratio closely followed by butachlor and pendimethalin. Pre-emergence application of pretilachlor (W<sub>3</sub>) also superseded all the three combinations of pre and post emergence applications, i.e. W<sub>3</sub>, W<sub>2</sub>-butachlor + bispyribac, W<sub>4</sub> - pretilachlor + bispyribac and W<sub>6</sub>-pendimethalin + bispyribac. The highest net return and benefit: cost ratio under W<sub>3</sub> treatments was owing to more grain yield and comparatively low cost of pretilachlor. All these findings with regard to economics of this investigation were in agreement with those

reported by Mukherjee and Maity (2010) [10].

### Nutrient uptake

Different crop establishment methods and weed management practices were produced the significant effect on cumulative uptake of N, P and K by crop and weed (Table 3). Drum seeded in puddled condition has recorded the highest uptake of N, P and K as compared to rest of the weed management practices might be due to highest grain and straw yield. Among the weed management practices, all the herbicidal treatments and hand weeding recorded the significantly higher N, P and K uptake which ranged between 88.61 kg ha<sup>-1</sup> and 97.93 kg ha<sup>-1</sup>, 23.95 kg ha<sup>-1</sup>, and 27.13 kg ha<sup>-1</sup> and 133.53 kg ha<sup>-1</sup> and 149.81 kg ha<sup>-1</sup>, respectively. This result is also in agreement with earlier results advocated by Kumar *et al.* (2010) [7].

### Protein content

Protein content in grain was not significantly influenced with the adoption of crop establishment methods and weed management practices (Table 3). However, the highest protein content was obtained with E<sub>3</sub> (9.37%) and W<sub>6</sub> (9.39%) due to better weed control efficiency and crop growth.

On the basis of foregoing finding it can be concluded that drum seeded in puddled condition of rice with the application of Pendimethalin @ 1.0 kg ha<sup>-1</sup> *fb* (pre-emergence) followed by bispyribac @ 25 g ha<sup>-1</sup> (post-emergence) was found to be most effective in respect of weed control and yield attributes, yield and profitability of direct seeded rice.

**Table 1:** Effect of crop establishment methods and weed management practices on yield attributes of direct seeded rice at maturity/harvest.

Treatments	Plant height (cm)	No. of tillers (m <sup>-2</sup> )	Plant dry matter production (g m <sup>-2</sup> )	Crop growth rate (g day <sup>-1</sup> m <sup>-2</sup> )	Harvest Index (%)
<b>Establishment methods</b>					
E <sub>1</sub>	77.23	211.12	799.87	4.84	40.88
E <sub>2</sub>	75.75	187.87	771.14	4.38	39.78
E <sub>3</sub>	79.13	231.62	837.91	5.38	41.71
SEm±	0.43	0.48	20.35	0.29	1.28
CD (P=0.05)	1.71	1.90	N.S	NS	NS
<b>Weed management</b>					
W <sub>1</sub>	77.47	202.00	754.30	3.32	41.86
W <sub>2</sub>	78.26	218.00	830.40	5.44	41.40
W <sub>3</sub>	78.03	212.33	809.66	4.88	41.55
W <sub>4</sub>	78.53	224.66	840.96	5.57	40.80
W <sub>5</sub>	77.23	202.33	784.43	4.29	41.20
W <sub>6</sub>	78.93	230.00	851.73	5.91	40.34
W <sub>7</sub>	78.80	227.00	842.65	5.60	40.65
W <sub>8</sub>	73.06	165.33	644.44	1.08	38.36
SEm±	0.43	1.00	31.45	0.46	0.62
CD (P=0.05)	1.31	3.04	95.40	1.42	1.90

**Table 2:** Effect of crop establishment methods and weed management practices on yield and economics of direct seeded rice.

Treatments	Grain yield (q ha <sup>-1</sup> )	Straw yield (q ha <sup>-1</sup> )	Gross return (₹ ha <sup>-1</sup> )	Net return (₹ ha <sup>-1</sup> )	B:C ratio
<b>Establishment methods</b>					
E <sub>1</sub>	32.70	47.29	47968	24376	1.05
E <sub>2</sub>	29.56	44.74	46133	22540	0.97
E <sub>3</sub>	35.58	49.71	49738	26146	1.13
SEm±	0.91	0.90	638	638	0.02
CD (P=0.05)	3.57	3.55	2507	2508	0.10
<b>Weed management</b>					
W <sub>1</sub>	31.63	43.93	45964	24536	1.14
W <sub>2</sub>	34.36	48.64	50296	27092	1.16
W <sub>3</sub>	33.60	47.26	49215	27727	1.29
W <sub>4</sub>	35.35	51.29	52444	29181	1.24
W <sub>5</sub>	32.26	46.04	47406	25168	1.13
W <sub>6</sub>	35.55	52.57	52386	28373	1.18
W <sub>7</sub>	35.36	51.62	51993	19159	0.58
W <sub>8</sub>	22.80	36.63	33870	13596	0.67
SEm±	0.94	1.07	1401	1401	0.05
CD (P=0.05)	2.87	3.27	4250	4250	0.17

**Table 3.** Effect of crop establishment methods and weed management practices on total (crop + weed) uptake of NPK nutrients and protein content in grain under direct seeded rice.

Treatments	N (kg ha <sup>-1</sup> )	P (kg ha <sup>-1</sup> )	K (kg ha <sup>-1</sup> )	Protein content in grain (%)
<b>Establishment methods</b>				
E <sub>1</sub>	92.47	25.27	140.77	9.32
E <sub>2</sub>	91.3	24.6	138.25	9.19
E <sub>3</sub>	93.4	25.88	142.79	9.37
SEm±	1.52	0.33	3.11	0.06
CD (P=0.05)	2.99	0.67	6.21	NS
<b>Weed management</b>				
W <sub>1</sub>	88.61	23.95	133.53	9.25
W <sub>2</sub>	95.41	26.04	143.35	9.35
W <sub>3</sub>	93.73	25.54	140.73	9.33
W <sub>4</sub>	98.41	27.03	148.93	9.37
W <sub>5</sub>	92.07	25.04	139.25	9.27
W <sub>6</sub>	97.93	27.13	149.81	9.39
W <sub>7</sub>	97.68	27.00	148.81	9.37
W <sub>8</sub>	75.25	20.27	120.45	9.02
SEm±	3.05	0.70	4.17	0.08
CD (P=0.05)	4.29	1.15	6.67	NS

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