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Effect of moisture regimes and weed management on weeds, yields and economics of direct seeded rice

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Abstract
A field experiment was conducted during rainy (*kharif*) season of 2016 at Crop Research centre Pusa, Bihar to investigate the "Effect of Moisture Regimes and Weed Management on weeds, yield and economics of Direct Seeded Rice"**.** The treatments consisted of three moisture regimes in main plots and five weed management practices in sub plots. The results showed that weed density and weed dry weight was minimum and grain yield, gross return and net return were found to be maximum with I_1 moisture regimes which were significantly superior to I_2 and I_3. B: C ratio was maximum with I_1 moisture regime which was statistically at par with I_2 and significantly superior to I_3.With regard to weed management lowest weed density and weed dry weight was found with W_4 treatment which was significantly superior to all the treatments. Maximum weed control efficiency and minimum weed index was observed with W_3 among all the herbicidal treatments, though weed control efficiency was the highest with W_4 treatment. Grain yield and gross return were recorded maximum with W_4 treatment of weed management which was significantly superior to W_2, W_1 and W_5 but was statistically at par with W_3 treatment. Net return was recorded maximum with W_3 treatment which was significantly superior to W_4 and W_5 but was statistically at par with W_2 and W_1. B: C ratio was recorded maximum with W_2 treatment which was significantly superior to W_4 and W_5 but was statistically at par with W_3 and W_1 treatments.

Keywords: grain yield, weed management, moisture regimes, herbicides, direct seeded rice

Introduction
Rice is one of the most staple food crops for more than half of the world population. Asia is the home of rice as its cultivation secure livelihood for more than two billion people. Among the rice growing countries, India ranks first in area of 44.1 million ha, second in production of 106.7 million tonnes with an average productivity of 2.4 t/ha (INDIA STAT-Advance Estimate 2016-17). Traditionally puddling follow by transplanting of rice seedling is the most common method of rice cultivation although this practice is labour water and energy intensive whereas direct seeded rice in non-puddled condition eliminates the needs of raising, maintaining and subsequent transplanting of seedling. Thus it saves labour and water. Besides early maturity of crops, it allows timely sowing of subsequent crop too. It needs only 34% of total labour and save 27% of total cost of transplanting (Mishra and Singh, 2011). However this shift has brought new challenge weed which reduces the yield upto 50-90% (Rao *et al*. 2007) [15]. Weed compete with crop for light nutrient, water and space from their early growth stage hence the growth of crops slow down and grain yield decreases. So, control of weed is important which can be accomplished by cultural, mechanical and chemical methods. Out of three, chemical method is more efficient in timely and quickly controlling of weeds. In chemical method, pre-emergence application is vital for effective and efficient control of weeds where weeds compete with main crop from the date of germination and weeds emerging later stage are controlled by post emergence herbicides. Hence the present study was put forth on "Effect of moisture regimes and weed management on weeds, yield and economics of direct seeded rice".

Material and Methods
A field experiment was conducted during rainy (*kharif*) season of 2016 at Crop Research centre, Department of Agronomy, DRPCAU, Pusa, Bihar, situated at 25° 59' North latitude and 85°48´ East longitude with an altitude of 52.92 meters above mean sea level. Climate of the study site was sub-tropical and sub humid with an average rainfall of 1276.1 mm out of which nearly 1026.0 mm is received during the monsoon between June to September. The experiment was laid out in split plot design (SPD) with three replications.

In main plots treatments were I_1-Irrigation at 3 days disappearance of ponded water (DPW) I_2-Irrigation at 5 days disappearance of ponded water and I_3-Irrigation at 7 days disappearance of ponded water and in sub plots W_1-Chlorimuron + Metsulfuron @ 20 + 4 g/ha at 15 DAS, W_2-Pendimethalin @ 1 kg/ha at 0-3 DAS *fb* Chlorimuron + Metsulfuron @ 20 + 4 g/ha at 15 DAS, W_3-Pendimethalin @ 1 kg/ha at 0-3 DAS *fb* Bispyribac sodium @ 30 g/ha at 20 DAS, W_4-Weed free (20, 40 and 60 DAS) and W_5-Weedy check. Sugandh-5 was taken as test of cultivar. Soil of the experimental plot was sandy loam in texture, alkaline in reaction (pH 8.4), low in available N 152 kg/ha (Alkaline permanganate method, Subbiah and Asija 1956), P_2O_5 19.23 kg/ha (Olsen's method (1954) and K_2O 122 kg/ha (Flame photometer method, Jackson, 1967). The crop was fertilized with 120-60-40-25 kg/ha N-P_2O_5-K_2O and $ZnSO_4$. Half (50%) dose of nitrogen and total phosphorus and potash and $ZnSO_4$ (25 kg/ha) were applied as basal and remaining dose of nitrogen was applied in two equal splits (25% N at active tillering and 25% N at panicle initiation stage). The required cultural practices and plant protection measures were followed as per recommended package. The crop was harvested when 90% of the grains were golden yellow. The grains were threshed, cleaned and sun dried to record the grain yield (t/ha) on the net plot basis. The weed index WI (%) was calculated on the basis of reduction in grain yield in treated plot in comparison with hand weeding plot.

$$\text{WI (\%)} = \frac{X-Y}{X} \times 100$$

Where,
X= yield from weed free plots
Y = yield from treated plots

Weed density/m^2 and dry matter accumulation of weeds (g/m^2) were recorded at different growth stages from the quadrate measuring 0.25 X 0.25 m^2.The weed were counted and removed for recording their biomass. Weed samples were sun dried and later oven dried at 70±1°C for 48 hours until constant weight was attained. The weed control efficiency (WCE) was calculated by using the formula on dry weight basis.

$$\text{WCE (\%)} = \frac{X-Y}{X} \times 100$$

Where,
X = Dry weight of weed in un-weeded check.
Y = Dry weight of weed under the treatment for
Which WCE is being calculated

The data collected from the experiment were subjected to statistical analysis by using ANOVA as suggested by Gomez and Gomez (1984).

Discussion

Weed parameter

Weed parameters are measured in terms of weed density, weed dry weight, weed control efficiency and weed index as shown in table: 1. it was observed that weed density and weed dry weight decreased with progressive age of crop. It might be due to effective control of weed from the beginning of the crop. Data pertaining to weed density and weed dry weight revealed significant difference among different moisture regimes. Both weed population and weed bio-mass accumulation per unit area were less with 3 days disappearance of pounded water. In sub plot treatments, weed population and weed bio-mass accumulation per unit area was observed to be the minimum in sole application of herbicides than Weedy check whereas, the combination of pre and post applications were much effective in comparison to their sole application. The reason behind was mixture of herbicides showed broad spectrum control of weeds. Similarly, Weed free (20, 40 and 60 DAS) was ahead of pre and post applications of herbicides. This might be due to timely reduction of weeds below threshold level by intercultural operation, Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha was ahead of Pendimethalin *fb* Chlorimuron + Metsulfuron. This might be due to more bioefficacy of Bispyribac sodium in controlling both the narrow and broad-leaves weeds, mainly grassy weeds. Similar results were obtained by Kailkhura *et al*. (2015) and Sangeetha *et al*. (2015) [5, 15]. Quite in league with the weed population and weed biomass, the weed control efficiency was the best at 90 DAS with hand weeding thrice (72.04%) while rest of the treatment followed the descending trend in the order of Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha (64.11%), Pendimethalin @ 1 kg/ha *fb* Chlorimuron + Metsulfuron @ 20 + 4 g/ha (56.97%), Chlorimuron + Metsulfuron @ 20 + 4 g/ha (47.23%). The reason attributes is better growth of crops with more yields and yield attributing characters, hence less loss due to weeds in these plots. Weed index showed how much yields of crop is affected due to weeds in field. Lower weed index denotes less loss due to weed, It follow trends opposite to the weed control efficiency with minimum (5%) value was found with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha at 20 DAS. Similar finding was reported by Kashid *et al*. (2015) and Mohapatra *et al*. (2016) [6, 10, 12].

Yield and Economics

Grain yield

Grain yield was significantly influenced by moisture regimes and weed management as shown in table: 2. Maximum value was recorded with irrigation at 3 DPW (36.24 q/ha) which was significantly superior to remaining treatments and minimum value was obtained with irrigation at 7 DPW during the crop period. The grain yield of a crop is the combined effect of various growth and development parameters. In the present investigation, almost all the growth and development characters seemed to be increased by increasing moisture regimes while under moisture stress condition, the photosynthesis activities were reduced owing to closure of stomata which resulted in reduced supply of CO_2 and the capacity of protoplasm to carry out photosynthesis efficiency. Reduced translocation might have hindered the further accumulation of the end products, while it was reverse in case of treatment receiving sufficient water throughout the growing period. These finding were collaborated with the results of Kumar *et al*. (2015), Das *et al*. (2016), and Nayak *et al*. (2016). Among the different weed management practices pertaining to growth and yield attributes, yields of Weedy check was recorded minimum among the several treatments whereas hand weeding was recorded maximum and was statistically at par with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha. Similar result was obtained by Upasani *et al*. (2014). This might be due to lesser crop weed competition in hand weeding which led to higher crop growth, yield characters and less weed density and dry weight and thus more economic yield as compared to other treatments.

Pre-emergence followed by post-emergence application of herbicide is less effective as compared to hand weeding but close to it in controlling weeds. Similar result was obtained by Kaur and Singh (2015).

Economics

The economics of crops was measured in terms of gross return, net return and B: C ratio as shown in table: 2. Data recorded under different components revealed that gross return was increased with increasing biological yield of direct seeded rice obtained under different treatments. Quite in league with the performance as regards to growth and development of direct seeded rice, gross return was maximum (63757 ₹/ha)with moisture regime of 3 days disappearance of ponded water and minimum with irrigation at 7 days disappearance of ponded water. In case of weed management, maximum (62602 ₹/ha) gross return was recorded with hand weeding at 20, 40, and 60 DAS and minimum in Weedy check. This was due to significant increase in grain and straw yield in hand weeding being statistically at par with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha as compared to other treatments. Similar trend was observed by Khasid *et al*. (2015) and Netam *et al*. (2016).

Significantly higher (31322 ₹/ha) net return was recorded with irrigation at 3 days disappearance of ponded water as compared to 5 and 7 days disappearance of ponded water. This is due to higher yield and lower cost of cultivation with 3 days disappearance of ponded water as compared to other irrigation treatment. Similar result was found by Das *et al*. (2016). In weed management higher (28649 ₹/ha) net return was recorded with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha which outclassed Weed free (20, 40 and 60 DAS) and Weedy check and were statistically alike to chemical treatments. This might be due to less cost involved in chemical treatments per unit of yield obtained. These finding were in agreement with Kaur and Singh (2015).

The maximum (0.96) B: C ratio was recorded with irrigation at 3 days disappearance of ponded water and minimum with 7 days disappearance of ponded water (0.61). This might be due to more net return per unit of cost involved in 3 days disappearance of ponded water as compared to others treatments. These finding were in agreement with Shekara *et al*. (2010) and Nayak *et al*. (2016) [8, 10, 12]. In weed management, highest (0.96) B: C ratio was recorded with Pendimethalin @ 1 kg/ha *fb* Chlorimuron + Metsulfuron @ 20 +4g/ha which was superior to Weed free (20, 40, and 60 DAS) and Weedy check and was statistically alike to either as sole post-emergence application or in combination with pre-emergence application. Among pre and post combinations, Pendimethalin @ 1 kg/ha *fb* Chlorimuron + Metsulfuron @ 20 + 4 g/ha outclassed Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha. This might be due to less cost involved in Chlorimuron + Metsulfuron as compared to Bispyribac sodium. This result is in accordance with finding of Narolia *et al.* (2014) and Mohapatra *et al*. (2016) [6, 10, 12].

Table 1: Effect of moisture regimes and weed management on weeds of direct seeded rice.

Treatments	Weed density/m^2		Weed dry weight/m^2		Weed control efficiency (%) at 90 DAS	Weed index (%)
	60 DAS	90 DAS	60 DAS	90 DAS		
Moisture regimes						
I_1-Irrigation at 3 days disappearance of ponded water	12.42 (153.75)*	10.06 (100.70)	19.41 (376.25)	15.50 (239.75)		
I_2-Irrigation at 5 days disappearance of ponded water	15.44 (237.89)	12.05 (144.70)	24.29 (589.50)	19.26 (370.44)		
I_3-Irrigation at 7 days disappearance of ponded water	19.02 (361.26)	15.40 (236.60)	29.62 (876.84)	23.72 (562.13)		
SEm±	0.42	0.33	0.54	0.51	-	
CD (P=0.05)	1.64	1.29	2.12	1.98	-	
Weed management						
W_1-Chlorimuron + Metsulfuron @ 20+4 g/ha at 15 DAS	15.88 (251.67)	12.86 (164.87)	25.61 (655.37)	19.81 (391.93)	43.78	14.09
W_2-Pendimethalin @ 1 kg/ha at 0-3 DAS *fb* Chlorimuron + Metsulfuron @ 20+4 g/ha at 15 DAS	12.95 (167.20)	10.49 (100.54)	20.62 (425.68)	16.15 (260.32)	54.80	7.05
W_3-Pendimethalin @ 1 kg/ha at 0-3 DAS *fb* Bispyribac sodium @ 30 g/ha at 20 DAS	10.80 (116.14)	8.75 (76.06)	17.22 (296.03)	13.47 (180.94)	62.88	5.00
W_4-Weed free (20, 40 and 60 DAS)	8.41 (70.22)	6.81 (45.87)	13.07 (170.32)	10.49 (109.54)	72.00	-
W_5-Weedy check	30.10 (905.51)	24.38 (593.88)	45.6 (2086.16)	37.54 (1408.75)	-	27.99
SEm±	0.68	0.57	0.76	0.88	-	-
CD (P=0.05)	2.03	1.70	2.25	2.61	-	-

Table: 2 Effect of moisture regimes and weed management on yield and economices of direct seeded rice.

Treatments	Grain yield (q/ha)	Gross return (₹/ha)	Net return (₹/ha)	B: C ratio
Moisture regimes				
I_1-Irrigation at 3 days disappearance of ponded water	36.24	63757	31322	0.97
I_2-Irrigation at 5 days disappearance of ponded water	32.01	56392	25957	0.87
I_3-Irrigation at 7 days disappearance of ponded water	26.68	47147	17712	0.61
SEm±	0.68	1191	1191	0.04
CD (P=0.05)	2.66	4678	4678	0.17
Weed management				
W_1-Chlorimuron + Metsulfuron @ 20+4 g/ha at 15 DAS	30.52	53850	25934	0.92
W_2-Pendimethalin @ 1 kg/ha at 0-3 DAS *fb* Chlorimuron + Metsulfuron @ 20+4 g/ha at 15 DAS	32.92	57934	28534	0.96
W_3-Pendimethalin @ 1 kg/ha at 0-3 DAS *fb* Bispyribac sodium @ 30 g/ha at 20 DAS	33.74	59414	28649	0.93
W_4-Weed free (20, 40 and 60 DAS)	35.62	62602	23722	0.61
W_5-Weedy check	25.42	45026	18145	0.67
SEm±	0.84	1489	1489	0.05
CD (P=0.05)	2.51	4425	4425	0.14

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