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Original Research Article

Effect of Moisture Regimes and Weed Management on Direct Seeded Rice

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Keywords

Grain yield, Growth character, Moisture regimes, Herbicides, Direct Seeded Rice

A B S T R A C T

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 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 plant height (104.1 cm), number of tillers/m^2 (290.77/m^2), leaf area index (5.06), crop growth rate (15.05 g/m^2/day), number of panicles/m^2 (221.05/m^2) number of spikelets/panicle (86.20), grain yield (36.24 q/ha) were found to be maximum with 3 days disappearance of ponded water (I_1) which were significantly superior to 5 days disappearance of ponded water (I_2) and 7 days disappearance of ponded water (I_3). Water productivity (4.03 ₹ /m^3) was found to be maximum with 3 days disappearance of ponded water which was statistically at par with 5 days disappearance of ponded water and significantly superior to 7 days disappearance of ponded water. Water Use Efficiency were not influenced by moisture regimes treatment. With regard to weed management plant height (101.77 cm), number of tillers/m^2 (284.24/m^2), LAI (4.95), crop growth rate (14.70 g/m^2/day), number of panicles/m^2 (17.26), number of spikelets/panicle (84.7), grain yield(35.6 q/ha), Water Use Efficiency (52.48 kg/ha-cm) 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. Water productivity (4.18₹ /m^3) 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 treatment. Thus moisture regime at 5 days disappearance of ponded water and Pendimethalin @ 1 kg/ha at 0-3 DAS *fb* Bispyribac sodium @ 30 g/ha at 20 DAS was found to be optimum for Direct Seeded Rice.

Introduction

Rice (*Oryza sativa*) is one of the most staple food crops for more than half of the world population by providing 25% calories and 20% protein. Asia is the home of rice as more than 2 billion people get 60-70% of their energy requirement from rice and its derived products. 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).

In India rice is grown under three major ecosystems *i.e.* rainfed upland (16%), irrigated land (45%) and rainfed low land (39%) (Anonymous, 2010). Traditionally puddling followed by transplanting is the popular means of cultivation, which not only leads to wastage of water but also a costly,

cumbersome and time consuming process. It results in degradation of soil and other resources. Production by this method requires approximately 3000 to 5000 lit of water to produce 1 kg of rice. But in recent years, this has posed an immense threat due to limitation of water. It is forecasted that by 2025 over 17 million ha and 22 million ha irrigated rice area of Asia may experience physical and economic water scarcity, respectively (Toung and Bouman, 2003).

The increase in water scarcity and declining rate of per capita fresh water availability along with increasing demand of food has made the present researcher to look for alternate options which increase the water use efficiency (WUE) along with saving of water. Under such situation, interventions in the form of mechanized transplanting or direct seeding of rice is the need of hour.

Direct seeding 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 crop, it allows timely sowing of subsequent crop too. It needs only 34% of total labour and saves 27% of total cost of transplanting (Mishra and Singh, 2011).

Production practices of rice cultivation are shifting from low land rice to direct seeded rice to make more efficient use of irrigation water. This shift has brought weed problem, a new challenge which reduces the yield up to 50 to 90% (Rao *et al*., 2007). Weeds compete with crop for light, nutrient, water and space in absence of standing water because both seeds of crop and weeds emerge almost at the same time. 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. But in spite of the usage of all such herbicidal combinations, lot of escapes or regeneration has been noticed. Therefore, considering the long window of emergence of diverse type of weeds in *kharif* season the purpose can't be solved by one-time application of herbicide alone. Considering these problems, application of several herbicides in combination or in sequence can be utilized in controlling complex and diverse weed flora.

Materials 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 amount of applied irrigation water was measured through 7.5 cm throat size Parshall flume, applying 6 cm of water at each irrigation. It may be noted that depth of irrigations refers to the depth of water applied and not depth of standing water on the plots. The time of irrigation for every plot was computed by using given depth of irrigation, area of the plots and discharge rate. It was calculated by using given formula:

$$T = \frac{A \times D}{Q}$$

Where Q is the rate of discharge (litre/s), A is the area of the plot (m^2), D is the depth of irrigation (cm) and t is the time of irrigation (s). Water requirement was calculated by adding effective rainfall during crop growth period, amount of irrigation water applied. The data collected from the experiment were subjected to statistical analysis by using ANOVA as suggested by Gomez and Gomez (1984).

Results and Discussion

Growth characters

The growth of plants was measured in terms of plants height, numbers of tillers, leaf area index and crop growth rate which vary significantly under varying moisture regimes and weed management (Table-1). The maximum plant height (104.12 cm) was recorded at harvest with irrigation at 3 days disappearance of ponded water (3 DPW) which was significantly superior to 5 and 7 DPW. This might be due to favourable moisture regime as rice is a water loving plant. Adequate supply of water maintained good establishment of root and various metabolic processes that performed better nutrient mobilization which resulted in maximum plant height. It was in conformity with the results of Das *et al*. (2016) and Harishankar *et al*. (2016). In sub plot treatments the maximum plant height was recorded under three hand weeding which was significantly superior to all except Pendimethalin @ 1 kg/ha *fb B*ispyribac sodium @ 30 g/ha. This might be due to effective weed control by hand weeding which results in less or no crop weed competition for nutrient, light, moisture and space so more accumulation of photosynthate and subsequently resulted in more plant height.

Maximum numbers of tillers (290.77/m^2) were recorded at 60 DAS with 3 DPW which was significantly superior to 5 and 7 DPW. This might be due to sufficient moisture and more frequent wetting at later stages of crop growth facilitates to produced and survive more number of tillers. Similar opinion had been expressed by Kumar *et al.* (2013) and Dari *et al*. (2017). In sub plot treatments, maximum number of tillers/m^2 was observed with Weed free (20, 40 and 60 DAS) which was at par with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha

and significantly superior to rest of the treatments. This was due to the fact that weed free environment helped the crop for better establishment and their subsequent growth. Among the herbicidal treatments maximum tillers/m^2 recorded with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha. This might be due to effective control of weeds with pre and post emergence herbicides resulted in favourable environment for growth and development of crop. Similar opinion had been expressed by Narolia *et al*. (2014) and Raj *et al*. (2016).

Maximum LAI was recorded at 60 DAS (5.06) with irrigation at 3 DPW which was significantly superior to 5 and 7 DPW. This was due to adequate supply of moisture which favoured more number of large size leaves. Similar result was also noticed by Kumar *et al*. (2015). Different weed management treatments significantly affect the LAI at 60 DAS. Weed free (20, 40 and 60 DAS) was significantly superior to rest of the treatments except Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha. This might be due to less crop-weed competition throughout the crop growth period thus crop enjoyed favorable conditions with respect to light, space and nutrients etc. Less LAI obtained with Weedy check might be due to more crop-weed competition leads to less numbers of tillers and the number of leaves. Similar view was expressed by Parthipan *et al*. (2013).

Irrespective of stages of growth, maximum CGR (15.05 g/m^2/day) was recorded at 90 DAS with irrigation at 3 DPW which was significantly superior to rest of the treatments and minimum with irrigation at 7 DPW. This may be due to maximum plant height, more numbers of tillers and more number of leaves. Similar result was found by Kumar *et al*. (2015) and Das *et al*. (2016). In context of sub plot treatments, highest CGR was recorded under Weed free condition due to better nutrient availability and absence of crop weed competition for other growth factors which prevent the mortality of tillers and premature senescence of leaves and thus more accumulation of dry matter which was significantly superior to rest of the treatments except Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha and minimum CGR was recorded with Weedy check due to more competition between crop and weeds lead to less plant population and dry matter production.

Yield attributing characters

Yield attributes were significantly influenced by both moisture regimes and weed managements (Table 2). Maximum number of panicles/m^2 (221.05/m^2) was observed with 3 DPW. This might be due to higher number of tillers with adequate moisture supply. Minimum panicles/m^2 was observed with 7 DPW which attributed moisture stress at active tillering stage which increased the mortality of productive tillers and reduced the number of panicles/m^2. These results were supported by Das *et al.* (2016) and Nayak *et al.* (2016). In sub plot treatments, the highest number of panicles/m^2 was counted under Weed free (20, 40 and 60 DAS). This might be due to minimum weed population and biomass at different growth stages resulting more number of panicles, which was at par with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha and lowest being noted in Weedy check. This result was in close conformity to Netam *et al.* (2016) and Raj *et al*. (2016).

Number of spikelets/panicle (86.20) depends on the efficient translocation of photosynthates from source to sink. Higher the translocation of photosynthate more will be the number of spikelets.

Table.1 Effect of moisture regimes and weed management on growth characters of direct seeded rice

Treatments	Plant height (cm)	Number of tillers/m^2	Leaf area index	CGR (g/m^2/day)
Moisture regimes				
I_1	104.12	290.77	5.06	15.05
I_2	93.65	261.56	4.56	13.50
I_3	75.47	214.32	3.73	10.91
SEm±	1.42	5.24	0.09	0.32
CD (P=0.05)	5.57	20.58	0.36	1.24
Weed management				
W_1	87.05	248.94	4.34	12.68
W_2	94.84	264.88	4.61	13.57
W_3	98.88	276.12	4.81	14.29
W_4	101.77	284.24	4.95	14.70
W_5	72.85	203.58	3.54	10.53
SEm±	1.55	5.15	0.09	0.37
CD (P=0.05)	4.61	15.30	0.27	1.11

I_1-Irrigation at 3 days disappearance of ponded water, I_2-Irrigation at 5 days disappearance of ponded water, I_3-Irrigation at 7 days disappearance of ponded water, 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), W_5-Weedy check.

Table.2 Effect of moisture regimes and weed management on yield attributes, yield, WUE, and Water productivity of direct seeded rice

Treatments	No. of panicle/m^2	Number of spikelets/ panicle	Grain yield (q/ha)	Water use efficiency (kg/ha-cm)	Water productivity (₹ /ha)
Moisture regimes					
I_1	221.05	86.20	36.24	46.58	4.03
I_2	195.23	76.13	32.01	48.64	3.94
I_3	162.77	63.48	26.68	44.62	2.96
SEm±	4.11	1.60	0.68	1.11	0.19
CD (P=0.05)	16.14	6.29	2.66	NS	0.77
Weed management					
W_1	186.18	72.61	30.52	44.88	3.77
W_2	200.79	78.30	32.92	48.51	4.17
W_3	205.80	80.26	33.74	49.70	4.18
W_4	217.26	84.72	35.62	52.48	3.44
W_5	155.06	60.47	25.42	37.50	2.65
SEm±	5.18	2.02	0.84	1.27	0.22
CD (P=0.05)	15.39	6	2.51	3.78	0.67

I_1-Irrigation at 3 days disappearance of ponded water, I_2-Irrigation at 5 days disappearance of ponded water, I_3-Irrigation at 7 days disappearance of ponded water, 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), W_5-Weedy check

Significant difference in number of spikelets/panicle had been observed with irrigation at 3 DPW. This might be due to regular supply of moisture with 3 DPW in comparison to others. At optimum moisture level all the physiological activities of plant worked properly which resulted in better translocation of photosynthates from source to sink. This is in close conformity to Kumar *et al.* (2015). Weed free plot experienced maximum number of spikelets/panicle which was par with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha and minimum was observed with Weedy check. This might be due to lower weed population provided favourable and least crop-weed competition environment to the crop, which resulted in higher photosynthatic rate, better translocation of sink in comparison to Weedy check. Netam *et al.* (2016) and Raj *et al*. (2016) also came with these thoughts.

Grain yield

Grain yield was influenced significantly due to moisture regimes and 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).

Water studies

Data with respect to WUE and water productivity have been presented in table 2. In moisture regime, WUE was found to be non-significant. However, the maximum was found with irrigation at 5 DPW (48.64 kg/ha-cm) followed by 3 and 7 DPW. Irrigation at 3 DPW gave lower WUE though its grain yield was higher. This might be due to higher use of water but yield did not increased relative to the water applied. This finding was confirmed by Shekara *et al.* (2010) and Nayak *et al.* (2016). The maximum water use efficiency was recorded with Weed free (20, 40 and 60 DAS) which was statistically at par with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha and minimum value was found with Weedy check. This might be due to the reason that WUE is directly proportional to economic yield and due to higher yield in hand

weeding plots higher WUE was obtained.

Water productivity decreased with increase in moisture stress from 3 to 7 DPW. This might be due to decreasing net return with increasing soil moisture stress. Significantly higher water productivity was found with irrigation at 3 days disappearance of ponded water, which was significantly superior to 7 days disappearance of ponded water but was statistically at par with 5 days disappearance of ponded water. Das *et al.* (2016) confirmed the similar result. Maximum water productivity was recorded with Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha as compared to others treatments. Hand weeding incurred lower water productivity as compared to Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha because net return was less in Weed free (20, 40 and 60 DAS) as compared to Pendimethalin @ 1 kg/ha *fb* Bispyribac sodium @ 30 g/ha.

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