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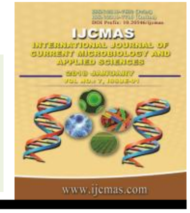

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Influence of Nitrogen and Weed Management Practices on Growth and Yield of Direct Seeded Rice (*Oryza sativa* L.)

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A B S T R A C T

A field experiment was conducted during rainy (*kharif*) season of 2015 and 2016 to study the effect of nitrogen and weed management in direct seeded rice (*Oryza sativa* L.) Nitrogen management significantly reduced the population of grasses, sedges and broad leaved weeds and increased weed control efficiency and increased growth attributes and yield of crop. The results indicated that the minimum population of grasses, sedges and broad leaved weeds, weed dry weight and maximum weed control efficiency and maximum crop growth attributes and yield was recorded with the application of ¼ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage + ¼ N at heading stage. Application of ½ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage recorded higher population of grasses, sedges and broad leaved weeds and dry weight during both the years. The various weed management treatments significantly decreased the population and dry weight of weed and increased the weed control efficiency, crop growth characters and yield when compared with the weedy check. Two hand weedings at 20 and 40 DAS and bispyribac at 25 g a.i. ha^{-1} + azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS recorded minimum weed population and dry weight of weed and increased the weed control efficiency, crop growth characters and yield of the crop when compared to other treatments.

Introduction

Rice is a staple food for more than half of the world population, is commonly grown by transplanting seedlings into puddled soil in Asia. This production system is labor, water, and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce. It also deteriorates the physical properties of soil, adversely affects the performance of succeeding upland crops, and contributes to methane emissions. These factors demand a major shift from puddled transplanting to direct seeding of rice (DSR) in irrigated rice ecosystems.

Direct seeding of rice in the Indo-Gangetic plains has begun and farmers are finding the new technology attractive. The productivity of the DSR was on a par with transplanting and the net profit was higher. In spite of the weed menace, farmers in eastern U.P. and Bihar opt for dry-DSR when it is difficult for them to complete rice transplanting in time or water supplies are uncontrolled such as low or upland rice ecologies (Singh *et al.,* 2010). Nitrogen is a key nutrient in determining the level of crop productivity. The efficiency of applied nitrogen is very low and varies from 20 to 25% in upland rice crop due to the oxidized condition prevailing in uplands and concomitant heavy nitrogen loss through percolating water. Hence, fractional application of nitrogen in right amount and proportion, and when it is needed the most seems to be a practical proposition. Weed is one of the major constraints for low productivity of upland rice (Angiras, 2002). In direct-seeded upland rice, weeds pose serious competition to the crop in early stage and cause heavy reduction in rice yield. Uncontrolled weeds reduce the yield up to 80% in direct-seeded upland rice. Weed control also facilitates higher absorption of applied nutrient, thus increases the efficiency of fertilizers application to the crops (Amarjit *et al.,* 2006). Manual and mechanical methods are not effective in controlling sedges and broad-leaved weeds in direct-seeded rice because of the high labour cost, scarcity of labour during the critical period of weed competition and unfavorable weather at weeding time. Hence usage of herbicides is becoming increasingly popular as a viable alternative to hand weeding. To avoid undesirable weed shift and herbicide resistance in weeds, the continuous use of herbicides with similar mode of action has to be restricted. But in spite of the usage of all such herbicidal combinations, control failures, lot of escapes or regeneration in some of the weed species have been recently noticed in DSR at many locations. Therefore, considering the emergence of diverse weed types in rainy (*kharif*) season, the purpose cannot be solved by one-time application of herbicide alone. Considering these problems, we have to apply several herbicides in combination or in sequence, other than the already used combinations, which can provide more useful solution in controlling complex and diverse weed flora in DSR (Raj *et al.,* 2013). Fractional application of nitrogen in right amount and proportion coupled with weed control practices facilitates higher absorption of applied nitrogen and thus increasing efficiency of fertilizer nitrogen.

Materials and Methods

A field experiment was conducted during rainy (*kharif*) season of 2015 and 2016 at Agricultural Research Farm, Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The soil was Gangetic alluvial having Sandy clay loam in texture with pH 7.60. It was moderately fertile, being low in available organic carbon (0.40%), available N (198.38 kgha^{-1}), and medium in available P (17.78 kg ha^{-1}) and K (216.32 kg ha^{-1}). The experiment was laid out in split-plot design with three replications. The nitrogen management subjected to main plots while weed management in sub plots. A combination of 24 treatments consisting of 4 nitrogen management, viz. N_1 - ½ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage, N_2 - ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage, N_3 - 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage and N_4 - ¼ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage + ¼ N at heading stage and 6 weed management treatments, viz. W_0 - Weedy check, W_1- Two hand weedings at 20 and 40 DAS, W_2 - Pendimethalin 1.0 kg a.i ha^{-1} (PE) fb Bispyribac at 25 g a.i ha^{-1} + NIS (0.25%) at 15-20 DAS, W_3 - Bispyribac at 25 g a.i. ha^{-1} + Pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS, W_4 - Oxadiargyl at 90 g a.i. ha^{-1} (PE) *fb* Bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS and W_5 -

Bispyribac at 25 g a.i. ha^{-1} + Azimsulfuron at 17.5 g a.i. ha^{-1}) + NIS (0.25 %) at 15-20 DAS. A uniform dose of 150 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} were applied in all the plots. Full dose of phosphorus and potash were applied as basal application and nitrogen was applied as treatment wise. 'HUR 105' variety of rice @ 35 kg ha^{-1} was used for seeding of rice. The total rainfall received during crop season was 871.5 and 1187.8 during first and second year, respectively. Although distribution of rainfall was less in first year but they are uniform as compared to second year in crop period. The required quantity of pre-emergence and post-emergence herbicides was sprayed as per treatment using spray volume of 600 litres of water ha^{-1} with the help of knap sack sprayer fitted with flat fan nozzle. The data on weeds were subjected to square-root transformation ($\sqrt{x + 0.5}$) to normalize their distribution.

Results and Discussion

Effect on weed

Grassy weeds were predominant in DSR followed by sedges and broad leaved weeds, respectively. The dominant weed species observed in the experimental field were *Echinocloa crus-galli*, *Echinocloa colona*, *Cynodon dactylon*, *Cyperus rotundus*, *Cyperus iria*, *Eclipta alba* and *Caesulia axillaris* during both the years of study.

Weed population

Among various nitrogen management treatments, nitrogen application of ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage was the most effective in reduced population of grasses, sedges and broad leaved weeds (No. m^{-2}) at 60 DAS and recorded significantly lower weed population and was comparable to N_3 - 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage (Table 1). Nitrogen application of ½ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage recorded significantly maximum weed population at 60 DAS during both the years of study. This might be due to the fact that treatments in which equal amounts of nitrogen were applied with more number of splits at critical growth stages. These results are in conformity with the findings of Chaudhary *et al.,* (2011).

All the weed management practices showed significant effect on weeds and had less weed growth as compared to weedy check which recorded maximum weed population. Among the weed management treatments, two hand weedings at 20 and 40 DAS and application of bispyribac at 25 g a.i. ha^{-1} + azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS were more efficient in minimizing weed infestation and weed growth than other weed management treatments followed by bispyribac at 25 g a.i. ha^{-1} + pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS. Application of oxadiargyl at 90 g a.i. ha^{-1} (PE) *fb* bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS had minimum efficacy in these respect during both the years of study. This might be due to tank mix application for controlling diverse group of weeds at a time in direct seeded condition. The tank mix application of such suitable herbicides performed better against diverse weed flora as compared to application of a single herbicide. These findings may be supported by Kumar *et al.,* (2013).

Weed dry weight

Total weed dry weight was significantly influenced by different nitrogen and weed management practices. Application of ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage recorded minimum weed dry weight and the maximum weed dry weight was recorded with the application of ½ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage (Table 1). This might be due to the fact that application of less amount of nitrogen at the time of sowing or with in the month of crop growth from sowing reduces the weed population by reducing the availability of nitrogen to the weed germination and for the growth of the weeds, so that adversely affected the growth and development of weeds in direct seeded rice. These findings are similar with the results reported by Singh and Singh (2007).

Among weed management practices, minimum total weed dry weight was recorded under two hand weedings at 20 and 40 DAS followed by bispyribac at 25 g a.i. ha^{-1} + azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS. The next best treatment was bispyribac at 25 g a.i. ha^{-1} + pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS. The reason behind this integration of pre- and post-emergence herbicides minimized the weed dry weight. Wallia *et al.,* (2008) reported that integration of pre-emergence application of pendimethalin followed by post emergence of azimsulfuron resulted in effective weed control. The maximum weed dry weight recorded in weedy plots in respect to other treatment.

Weed control efficiency

Weed control efficiency indicates the relative efficacy of weed management practices over weedy check. Under different nitrogen treatments, nitrogen application of ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage +¼ at heading stage recorded highest weed control efficiency due to lower dry matter accumulation of weeds at all the stages of crop growth during both the years of study (Table 1). This was followed by 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage. However, nitrogen application at ½ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage had minimum weed control efficiency than other nitrogen treatments due to higher dry weight of weeds. Same results were given by Singh *et al.,* (2005).

Among various weed management practices, two hand weedings at 20 and 40 DAS recorded higher weed control efficiency than other weed management practices which might be due to lower weed dry matter accumulation. The result find ample support from the findings of Murthy *et al.,* (2012). Followed by application of bispyribac at 25 g a.i. ha^{-1} + azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS and bispyribac at 25 g a.i. ha^{-1} + pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS recorded highest weed control efficiency during both the years.

This might be due to lower weed dry matter accumulation under these treatments and effective control of complex weed flora i.e grasses, sedges and broad leaved weeds. Tank mix application of herbicides controls wide spectrum of weeds effectively compared to sequential application of single herbicides. These results were in conformity with the findings of Ghosh *et al.,* (2017).

Effect on crop growth

Plant population was not affected due to application of different nitrogen schedule. Significantly taller plant and maximum dry matter accumulation 25 cm^{-1} row length were recorded under nitrogen application of ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage which was at par with application of 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage than other nitrogen management treatments during both the years of experimentation (Table 2).

Table.1 Effect of nitrogen and weed management practices on density of weeds, dry weight and WCE at 60 DAS of direct seeded rice

Treatments	Grasses (No. m^{-2})		Sedges (No. m^{-2})		Broad leaved weeds (No. m^{-2})		Weed dry weight (g m^{-2})		WCE (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Nitrogen management										
N_1- ½ at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage	13.54 (186.02)	15.53 (243.89)	10.15 (103.85)	10.82 (118.13)	7.88 (63.87)	8.20 (69.11)	8.79 (77.60)	9.51 (91.10)	24.29	23.29
N_2- ¼ N at basal + ½ N at active tillering stage + ¼ at panicle initiation stage	13.19 (175.92)	15.00 (227.50)	9.71 (95.13)	10.32 (107.47)	7.34 (55.55)	7.76 (61.84)	8.48 (72.23)	9.18 (84.84)	29.53	28.56
N_3- 1/3 N at basal + 1/3 N at active tillering stage + 1/3 n at panicle initiation stage	12.71 (163.92)	14.46 (211.89)	9.19 (85.68)	9.77 (96.66)	6.89 (49.09)	7.40 (56.46)	8.17 (67.11)	8.88 (79.37)	34.52	33.18
N_4- ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage +¼ at heading stage	12.44 (156.58)	14.21 (203.61)	8.98 (81.42)	9.62 (93.43)	6.78 (47.42)	7.23 (53.74)	8.00 (64.32)	8.71 (76.42)	37.24	35.65
SEm±	0.120	0.187	0.137	0.113	0.097	0.094	0.090	0.090	-	-
CD (P=0.05)	0.416	0.648	0.474	0.392	0.337	0.325	0.310	0.311	-	-
Weed management practices										
W_0 - Weedy check	16.17 (253.23)	17.93 (321.61)	11.72 (137.86)	12.49 (156.24)	10.16 (103.32)	10.70 (114.55)	10.14 (102.49)	11.04 (118.77)	0.00	0.00
W_1- Two hand weedings at 20 and 40 DAS	11.07 (122.15)	12.86 (165.08)	8.00 (63.78)	8.53 (72.48)	5.72 (32.28)	6.16 (37.53)	7.36 (53.75)	7.79 (63.25)	47.56	46.75
W_2 - Pendimethalin at 1.0 kg a.i. ha^{-1} (PE) fb Bispyribac at 25 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	12.84 (164.55)	14.79 (218.66)	9.46 (89.34)	10.12 (102.24)	7.02 (49.10)	7.37 (54.19)	8.27 (68.04)	9.04 (81.38)	33.62	31.48
W_3 - Bispyribac at 25 g a.i. ha^{-1} + Pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	12.31 (151.40)	14.23 (202.36)	9.21 (84.72)	9.83 (96.43)	6.81 (46.12)	7.24 (52.12)	8.04 (64.30)	8.80 (77.02)	37.26	35.15
W_4- Oxadiargyl at 90 g a.i. ha^{-1} (PE) *fb* Bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	13.25 (175.31)	15.10 (228.05)	9.78 (95.32)	10.38 (107.51)	7.23 (52.02)	7.61 (57.65)	8.48 (71.58)	9.22 (84.64)	30.17	28.74
W_5- Bispyribac at 25 g a.i. ha^{-1} + Azimsulfuron at 17.5 g a.i. ha^{-1}) + NIS (0.25 %) at 15-20 DAS	12.05 (145.10)	13.85 (191.69)	8.85 (78.05)	9.42 (88.63)	6.43 (41.04)	6.78 (45.72)	7.88 (61.73)	8.54 (72.55)	39.77	38.92
SEm±	0.126	0.198	0.146	0.119	0.103	0.099	0.087	0.109	-	-
CD (P=0.05)	0.361	0.567	0.418	0.341	0.295	0.283	0.247	0.312	-	-

Table.2 Effect of nitrogen and weed management practices on crop growth characters in direct seeded rice

Treatments	Plant population at 20 DAS (no. m^{-2})		Plant height (cm)		Number of tillers (m^{-1} row length)		Dry matter production (g / 25 cm row length)	
	2015	2016	2015	2016	2015	2016	2015	2016
Nitrogen management								
N_1- ½ at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage	41.67	39.21	85.00	82.39	57.87	56.16	57.87	54.99
N_2- ¼ N at basal + ½ N at active tillering stage + ¼ at panicle initiation stage	42.26	39.81	89.50	87.22	61.63	60.21	61.29	59.65
N_3- 1/3 N at basal + 1/3 N at active tillering stage + 1/3 n at panicle initiation stage	43.27	41.22	91.58	89.11	65.55	63.01	63.04	60.44
N_4- ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage +¼ at heading stage	45.57	42.81	97.85	95.15	66.97	65.75	64.59	62.47
SEm±	0.98	1.00	1.80	2.08	1.74	1.55	1.68	1.17
CD (P=0.05)	NS	NS	6.24	7.18	6.03	5.36	5.83	4.03
Weed management practices								
W_0 - Weedy check	36.11	33.55	78.64	77.50	50.06	48.63	45.45	43.45
W_1- Two hand weedings at 20 and 40 DAS	46.63	43.78	98.75	94.08	71.19	68.85	72.57	70.36
W_2 - Pendimethalin at 1.0 kg a.i. ha^{-1} (PE) fb Bispyribac at 25 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	43.81	41.35	90.26	89.17	62.17	60.52	60.80	57.30
W_3 - Bispyribac at 25 g a.i. ha^{-1} + Pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	44.59	42.55	93.00	90.81	65.12	63.54	65.37	62.95
W_4- Oxadiargyl at 90 g a.i. ha^{-1} (PE) *fb* Bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	42.32	40.32	89.25	88.25	61.34	59.96	56.97	54.39
W_5- Bispyribac at 25 g a.i. ha^{-1} + Azimsulfuron at 17.5 g a.i. ha^{-1}) + NIS (0.25 %) at 15-20 DAS	45.68	43.12	96.24	91.00	68.16	66.21	69.03	67.87
SEm±	0.96	1.01	1.43	1.54	1.38	1.40	1.33	1.21
CD (P=0.05)	2.75	2.89	4.07	4.39	3.95	4.01	3.81	3.45

Table.3 Effect of nitrogen and weed management practices on Yield (t ha^{-1}) in direct seeded rice

Treatments	Grain yield (t/ha)		Straw yield (t/ha)	
	2015	**2016**	**2015**	**2016**
Nitrogen management				
N_1- ½ N at basal + ¼ Nat active tillering stage + ¼ N at panicle initiation stage	3.65	3.30	5.53	5.25
N_2- ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage	3.84	3.48	5.69	5.44
N_3- 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage	3.99	3.62	6.03	5.74
N_4- ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage	4.09	3.77	6.14	5.87
SEm±	0.08	0.09	0.10	0.11
CD (P=0.05)	0.29	0.31	0.33	0.37
Weed management practices				
W_0 - Weedy check	1.97	1.70	3.32	2.99
W_1- Two hand weedings at 20 and 40 DAS	4.77	4.38	6.90	6.61
W_2 - Pendimethalin at 1.0 kg a.i. ha^{-1} (PE) fb Bispyribac at 25 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	4.04	3.72	6.05	5.83
W_3 - Bispyribac at 25 g a.i. ha^{-1} + Pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	4.36	3.91	6.17	5.98
W_4- Oxadiargyl at 90 g a.i. ha^{-1} (PE) *fb* Bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS	3.67	3.32	5.73	5.54
W_5- Bispyribac at 25 g a.i. ha^{-1} + Azimsulfuron at 17.5 g a.i. ha^{-1}) + NIS (0.25 %) at 15-20 DAS	4.56	4.21	6.72	6.40
SEm±	0.13	0.15	0.15	0.13
CD (P=0.05)	0.36	0.42	0.44	0.37

It was probably due to better availability of nitrogen at critical growth stages and also low weed infestation during these stage, resulting in favorable conditions for growth and development of crop. These results were in conformity with the findings of Kumar *et al.,* (2015). The maximum number of tillers m^{-1} row length were recorded under nitrogen application of ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage might be due to ample space and nutrient available for emergence and growth of lateral shoots (tillers).

Amongst various weed management treatments, hand weeding twice at 20 and 40 DAS and the application of Bispyribac at 25 g a.i. ha^{-1} + Azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS increased growth attributes like number of plant population m^{-1} row length, number of tillers m^{-1} row length and dry matter accumulation 25 cm^{-1} row length during both the years of experimentation. The weeds were controlled effectively under these treatments during both the years of experimentation. This could be attributed to higher weed control efficiency under these treatments. These findings are reported by Bhurer *et al.,* (2013).

Effect on crop yield

Application of ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage was recorded maximum grain and straw yield followed by 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage than other nitrogen treatments and was on par to each other (Table 3). The increased grain and straw yield was perhaps the result of reduced weed density and their dry weight, better weed control efficiency. These findings were in conformity with the results of Kumawat *et al.,* (2017). The minimum grain and straw yield was recorded under nitrogen application of ¼ N at basal + ½ at N active tillering stage + ¼ N at panicle initiation stage and ½ N at basal + ¼ at N active tillering stage + ¼ N at panicle initiation stage. Amongst various weed management treatments, hand weeding twice at 20 and 40 DAS and the application of Bispyribac at 25 g a.i. ha^{-1} + Azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS resulted in significantly higher grain and straw yield (Table 3) than other weed management treatments. The increased yield in these treatments might be due to cumulative effect of lower weed density, dry weight, and higher weed control efficiency. The maximum grain and straw yield was recorded under Bispyribac at 25 g a.i. ha^{-1} + Azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS as given by Ghosh *et al.,* (2017).

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