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Growth and yield of direct seeded rice as influenced by split application of nitrogen and weed control practices

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Abstract
A study was carried out during Kharif 2015 and 2016 to evaluate the effect of four nitrogen and six weed management practices on drymatter and nutrient removal by weed in direct seeded rice on a sandy loam soil at the Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experiment was laid out in split plot design with 3 replications. The results revealed that Nitrogen significantly affect the growth characters of rice crop *viz.* plant height, number of tillers m $^{-1}$ row length, dry matter accumulation /25cm row length with the application of ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage +¼ at heading stage and was found at par with 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage than other nitrogen treatments during both years of experimentation. Among weed management practices, 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 recorded maximum growth attributes during both the years of study and it was at par with hand weeding twice at 20 and 40 DAS. The highest grain yield of 4560.00 and 4210.25 Kg ha^{-1} were 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 and was at par with two hand weedings at 20 and 40 DAS (4776.75 and 4380.50 Kg ha^{-1}) during 2015 and 2016, respectively. Whereas, 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 was least effective and recorded minimum yield. Whereas, harvest index was not significantly influenced by nitrogen and weed management treatments.

Keywords: Growth, direct seeded rice, weed management, harvest index and yield

Introduction

Rice (*Oryza sativa* L.) in one of the most important cereal crops of the worlds in terms of food, area and production. It is life for more than half of humanity and about 90% of the world's rice is produced as well as consumed in Asia. To sustain present food self-sufficiency and to meet future food requirements, India has to increase its rice productivity by 3% per annum but the possibility of expanding the area under rice in near future is limited. In the Indo-Gangetic Plains, rice is traditionally transplanted in June/July manually in standing water after puddling. There is direct need for change in rice establishment methods to improve productivity, economics and long-term sustainability. Depending upon water and labour scarcity, farmers are changing both tillage and rice establishment methods (puddled transplanting to dry direct seeding in unpuddled soil. Direct seeded rice (DSR) has many advantages like earlier establishment and crop maturity by 7–10 days, lesser methane emission, less labour-intensive thus saving cost of production and avoiding deterioration of soil properties (Kaur and Singh, 2015) [5]. Major constraint for low yield in rice is the unbalanced and injudicious use of fertilizer. Generally 50% of the applied nitrogen is used by rice plant and the rest of it is lost through volatilization, denitrification and or leaching and there by resulting in very low N-use efficiency. Nitrogen use efficiency may increased through, appropriate level and split application. For efficient management of N in the cropping systems, adequate rate, appropriate source and timing of application during crop growth cycle play an important role. Split application is one of strategies for efficient use of N fertilizers throughout the growing season by synchronizing with plant demand, reducing denitrification losses and improved N uptake for maximum straw and grain yield, and harvest index in DSR (Fageria, 2010 and Lampayan *et al.*, 2010) [4, 10]. Weed is one of the major constraints for low productivity of direct seeded rice (Angiras, 2002) [1]. In direct-seeded upland rice, weeds pose serious competition to the crop in early stage and cause heavy reduction in rice yield. Weed flora in DSR is very complex and a single use of a pre- or post-emergence herbicide does not provide effective weed control in DSR.

The use of herbicide combinations, whether the herbicides are applied simultaneously (tank-mixed) or sequentially, generally improves weed control compared with a single herbicide application (Khaliq *et al*., 2013) [7]. Application of different herbicides as a tank mixture may prove helpful in delaying the problem of herbicide resistance as well as a shift in weed flora.

Material 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 *p*H 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 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.

Results and Discussion

Plant height

The data on plant height recorded at 30, 60, 90 DAS and at harvest stage was significantly influenced by different nitrogen and weed management treatments. Among nitrogen treatments, application of 1/4 N at basal + 1/4 N at active tillering stage + 1/4 N at panicle initiation stage + ¼ N at heading stage recorded significantly maximum plant height than ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage and ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage but it was at par with the application of 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage at 60, 90 DAS and at harvest. At 30 DAS, the maximum plant height was recorded with nitrogen application of 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage which was significantly superior to ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage and other treatments were at par with each other during both the years of experimentation. The minimum plant height was recorded with the application of ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage however, it was at par with the application of ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage at all stages of crop growth during both the years of study. It was probably due to better availability of nitrogen at critical growth stages and also low weed infestation during these stage, resulting in favourable conditions for growth and development of crop. All these might have resulted more cell division and cell elongation in meristematic tissues of plant which led to significant increase in plant height under these nitrogen treatments. These results were in conformity with the findings of Singh *et al*. (2015) [15], Kumar *et al*. (2015) [8].

Among weed management practices, 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 had maximum plant height and was at par with two hand weedings at 20 and 40 DAS at all the stages of observation during both the years and both had taller plants than other treatments. At 30 and 60 DAS these two treatments were at par with the application of bispyribac at 25 g a.i. ha^{-1} + pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS however, at later stages it was significantly superior and next best treatment at all the crop growth stages during both the years. 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 recorded minimum plant height and was at par with the application of 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 at all the crop growth stages during both the years of experimentation. The lowest plant height was recorded under weedy check at all the crop growth stages of direct seeded rice during 2015 and 2016.

Number of tillers (m^{-1} row length)

The data indicated that, there was an increase in the number of tillers up to 60 DAS, and thereafter, a gradual reduction in number of tillers was recorded till harvest stage of the crop. The number of tillers of direct seeded rice were significantly affected by nitrogen and weed management treatments.

Data indicated that the 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 number of tillers which was significantly superior to ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage and ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage and it was found at par with 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage at all the crop growth stages during both the years. The minimum number of tillers was observed with the application of ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage. However, it was at par with the application of ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage at all the stages of direct seeded rice during both the years of experimentation. Sathiya and Ramesh (2009) [14] also observed taller plants, increased tiller production and finally dry matter accumulation by rice with application of 150 kg N ha^{-1} in four splits recorded higher dry matter.

Amongst weed management practices, the highest number of tillers were recorded with two hand weedings at 20 and 40 DAS, however, it was at par with 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 which was found significantly superior to rest of the treatments at all the stages of crop growth during both the years. The next best treatment was the application of bispyribac at 25 g a.i. ha^{-1} + pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS in both years and it was at par with bispyribac at 25 g a.i. ha^{-1} + azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25% at 15-20 DAS at 60 DAS and at harvest and at remaining stages it was significantly different. The minimum number of tillers was recorded under oxadiargyl at 90 g a.i. ha^{-1} (PE) fb bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS. However, it was at par with the application of 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 at all the stages of direct seeded rice during 2015 and 2016. Weedy check recorded the lowest number of tillers during both years at all the stages of direct seeded rice. However, all weed management practices were significantly superior to weedy check at all the crop growth stages during both the years of experimentation. The weeds were controlled effectively under these treatments and this could be attributed to higher weed control efficiency as a result of which crop confronted minimum competition from weeds for growth factors like moisture, nutrient, light and space. The maximum growth characters were obtained under two hand weedings were also given by Murthy *et al*. (2012) [11] and Kaur and Singh (2015) [5].

Dry matter accumulation (g 25 cm^{-1} row length)

The dry matter accumulation increased progressively till the harvest stage of direct seeded rice, irrespective of treatments. Various nitrogen treatments resulted in significant variation in dry matter accumulation at all the growth stages during both the years of observation. The higher dry matter accumulation recorded with 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 significantly superior to ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage and ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage, however, it was at par with the application of 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage at all growth stages of crop during both the years of experimentation. The minimum dry matter accumulation of crop was recorded with the application of ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage and was at par with the application of ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage at all the stages of crop growth during both the years of study. This might be due to fact that in this treatment nitrogen was applied within one month including basal application which led to heavy weed infestation and more nitrogen losses in the treatment. Consequently, crop suffered on account of both high weed competition and nutrient deficiency in the treatment affected plant growth attributes to a significant level under this treatment. The similar results were given by Singh *et al.* (2006) [16] and Rehman *et al*. (2013) [13].

It is further evident from data that significantly higher dry matter accumulation by crop was noted under tank mixture of herbicides as compared to other herbicides application. The maximum dry matter accumulation was recorded with bispyribac at 25 g a.i. ha^{-1} + azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS which was found significantly superior to rest of the treatments but it was at par with two hand weedings at 20 and 40 DAS treatment at 90 DAS and harvest during both the years. The next best treatment was the application of bispyribac at 25 g a.i. ha^{-1} + pyrazosulfuron at 20 g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS in accumulating maximum drymatter at all the stages of crop in both years. The minimum dry matter accumulation was recorded under oxadiargyl at 90 g a.i. ha^{-1} (PE) fb bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS, however, it was at par with the application of 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 at all the stages of direct seeded rice during both the years.

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 recorded maximum growth characters as reported by Chauhan *et al*. (2015) [3] and Bhurer *et al*. (2013) [2]. They reported that the treatment, which had minimum total weed dry weight, produced maximum rice dry matter accumulation. Weedy check recorded smaller plants, minimum number of tillers and minimum drymatter accumulation of direct seeded rice. Similar result was also reported by Walia *et al*. (2012) [17] and Bhurer *et al*. (2013) [2].

Grain yield (kg ha^{-1})

Among the nitrogen treatments, application of ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage + ¼ N at heading stage produced maximum grain yield of 4091.89 and 3783.53 kg ha^{-1} in 2015 and 2016 respectively, was at par (3988.33 and 3633.83 kg ha^{-1}) with the application of 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage and was significantly superior to ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage and ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage during first and second year of experimentation. Significantly the minimum grain yield (3651.17 and 3316.48 kg ha^{-1}) was recorded with the application of ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage which was at par (3841.15 and 3496.08 kg ha^{-1}) with the application of ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage during first and second year of study, respectively. The increased grain was perhaps the result of reduced weed population and their dry weight, better weed control efficiency and the improvement of yield attributes like number of panicles m^{-2}, number of grains per panicle, panicle length, panicle weight and 1000-grain weight. These findings were in conformity with the results of Singh *et al*. (2015) [15] and Kumawat *et al*. (2017) [9].

The perusal of data clearly revealed that weed management treatments significantly influenced the grain yield of direct seeded rice during both the years. The maximum grain yield of 4766.75 and 4380.50 kg ha^{-1} was recorded under two hand weedings at 20 and 40 DAS which was at par with 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 which recorded 4560.00 and 4210.25 kg ha^{-1} during first and second year, respectively and significantly superior to rest of the weed management treatments during both the years. The minimum grain yield (3665.75 and 3323.45 kg ha^{-1}) was recorded with the 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 however which was at par (4036.75 and 3723.88 kg ha^{-1}) with 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 during first and second year of study, respectively. All weed management treatments were found superior over weedy check which produced lowest grain yield of 1965.00 and 1698.50 kg ha^{-1} during first and second year, respectively. The increased yield in these treatments might be due to cumulative effect of lower weed population, dry weight, higher weed control efficiency and increased number of panicle bearing tillers per unit area, filled grains per panicle and test weight. The minimum grain yield was recorded under weedy check which was attributed due to maximum weed population, weed dry weight and poor yield attributing characters. The maximum grain and straw yield was recorded under two hand weedings as reported by Yadav *et al*. 2014 [18] and Ramesh *et al*. 2015 [12]

The data showed that nitrogen and weed management treatments had no significant affect on harvest index during both the years of experimentation.

Table 1: Effect of nitrogen management and weed management practices on plant height (cm) at different growth stages of direct seeded rice

Treatments	30 DAS		60 DAS		90 DAS		At harvest	
	2015	2016	2015	2016	2015	2016	2015	2016
Nitrogen management								
N_1- ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage	33.72	30.16	73.86	69.93	88.50	85.68	89.50	87.22
N_2- ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage	32.81	28.67	72.62	69.24	84.18	82.02	85.00	82.39
N_3- 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage	34.26	31.53	74.69	72.55	90.79	88.00	91.58	89.11
N_4- ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage	35.70	32.22	77.50	73.89	95.01	93.22	97.85	95.15
S.Em±	1.01	0.80	1.02	0.97	1.30	1.52	1.80	2.08
CD (P=0.05)	NS	NS	3.51	3.35	4.51	5.25	6.24	7.18
Weed management practices								
W_0 - Weedy check	27.20	24.29	66.34	63.63	77.80	75.52	78.64	77.50
W_1- Two hand weedings at 20 and 40 DAS	37.52	32.05	77.52	74.88	98.05	95.75	98.75	94.08
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	34.31	31.60	75.08	71.79	89.33	86.76	90.26	89.17
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	35.87	32.32	76.52	73.02	92.01	89.00	93.00	90.81
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	33.51	30.57	74.27	70.84	88.25	86.10	89.25	88.25
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	36.33	33.03	77.07	74.25	96.00	92.00	96.24	91.00
S.Em±	1.31	1.00	1.44	0.67	0.74	1.22	1.43	1.54
CD (P=0.05)	3.75	2.85	4.10	1.92	2.11	3.49	4.07	4.39

Table 2: Effect of nitrogen management and weed management practices on number of tillers (m^{-1} row length) at different growth stages of direct seeded rice

Treatments	30 DAS		60 DAS		90 DAS		At harvest	
	2015	2016	2015	2016	2015	2016	2015	2016
Nitrogen management								
N_1- ½ N at basal + ¼ Nat active tillering stage + ¼ N at panicle initiation stage	45.01	43.51	75.18	69.29	68.09	66.41	61.63	60.21
N_2- ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage	41.67	40.08	71.95	66.24	65.18	63.42	57.87	56.16
N_3- 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage	49.37	46.13	78.78	73.00	71.59	69.97	65.55	63.01
N_4- ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage	51.34	49.03	80.87	75.51	73.48	72.19	66.97	65.75
S.Em±	0.85	0.99	1.46	1.39	1.36	1.14	1.74	1.55
CD (P=0.05)	2.93	3.41	5.07	4.80	4.71	3.96	6.03	5.36
Weed management practices								
W_0 - Weedy check	34.12	31.23	63.75	57.83	56.28	55.04	50.06	48.63
W_1- Two hand weedings at 20 and 40 DAS	54.84	52.48	85.16	79.03	77.63	76.34	71.19	68.85
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	46.59	44.41	76.68	70.18	69.92	67.21	62.17	60.52
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	48.78	46.94	78.63	73.68	71.50	70.14	65.12	63.54
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	45.28	43.94	74.63	68.66	68.02	66.37	61.34	59.96
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	52.47	49.88	81.32	76.65	74.14	72.88	68.16	66.21
S.Em±	0.92	1.26	1.48	1.39	1.36	1.21	1.38	1.40
CD (P=0.05)	2.62	3.60	4.22	3.97	3.88	3.45	3.95	4.01

Table 3: Effect of nitrogen management and weed management practices on plant dry matter production (g / 25 cm row length) of direct seeded rice

Treatments	30 DAS		60 DAS		90 DAS		At harvest	
	2015	2016	2015	2016	2015	2016	2015	2016
Nitrogen management								
N_1- ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage	9.75	9.09	28.78	28.56	56.19	54.11	61.29	59.65
N_2- ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage	8.69	7.78	26.39	23.91	51.89	49.46	57.87	54.99
N_3- 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage	10.47	9.46	30.70	29.60	57.08	54.88	63.04	60.44
N_4- ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage	11.56	10.07	32.78	30.06	59.52	57.66	64.59	62.47
S.Em±	0.36	0.31	0.86	0.76	1.29	1.53	1.68	1.17

CD (P=0.05)	1.24	1.06	2.97	2.64	4.46	5.30	5.83	4.03
Weed management practices								
W_0 - Weedy check	6.58	5.91	20.23	19.41	40.78	39.82	45.45	43.45
W_1- Two hand weedings at 20 and 40 DAS	12.83	11.93	35.33	33.32	65.57	63.85	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	10.00	8.66	29.80	26.45	56.43	53.02	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	10.83	9.69	31.58	30.83	60.35	58.31	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	8.96	8.15	27.56	26.44	50.92	48.35	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	11.50	10.87	33.47	31.76	62.96	60.82	69.03	67.87
S.Em±	0.47	0.35	1.04	0.95	1.64	1.63	1.33	1.21
CD (P=0.05)	1.36	1.00	2.96	2.73	4.70	4.67	3.81	3.45

Table 4: Effect of nitrogen management and weed management practices on grain yield and harvest index of direct seeded rice

Treatments	**Grain yield (Kg ha^{-1})**		**Harvest index (%)**	
	2015	**2016**	**2016**	**2015**
Nitrogen Management				
N_1- ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage	3841.15	3496.08	39.55	38.42
N_2- ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage	3651.17	3316.48	39.30	38.15
N_3- 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage	3988.33	3633.83	39.92	38.54
N_4- ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage +¼ N at heading stage	4091.89	3783.53	40.03	38.81
S.Em±	87.15	90.75	0.50	0.61
CD (P=0.05)	301.59	314.05	NS	NS
Weed Management Practices				
W_0 - Weedy check	1965.00	1698.50	37.33	35.26
W_1- Two hand weedings at 20 and 40 DAS	4766.75	4380.50	40.84	39.84
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	4036.75	3723.88	39.75	38.68
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	4364.56	4008.30	40.14	39.24
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	3665.75	3323.45	38.53	37.38
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	4560.00	4210.25	40.48	39.67
S.Em±	123.66	147.97	1.05	1.18
CD (P=0.05)	353.43	422.93	NS	NS

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