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Influence of Nitrogen and Weed Management Practices on Productivity of Transplanted Rice (*Oryza sativa* L.)

M. Patra, A.K. Behura, K. Sar* and A.A. Prusty

Department of Agronomy, Faculty of Agricultural Sciences (IAS), Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar 751 030, Odisha, India

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Abstract

A field experiment was conducted at the Research Farm, Institute of Agricultural Sciences, SOA, Bhubaneswar during *Kharif*, 2019. The experiment was laid out in split-plot design with three replications. The treatment comprised of three nitrogen levels (30, 60 and 90 kg ha^{-1}) assigned in the main plot and six weed management practices *viz*., penoxsulam + cyhalofop butyl @ 125 g ha^{-1} at 20 DAT *fb* one hand weeding at 40 DAT, penoxsulam + cyhalofop butyl @ 125 g ha^{-1} at 20 DAT, bispyribac sodium @ 25 g ha^{-1} at 20 DAT *fb* one hand weeding at 40 DAT, bispyribac sodium @ 25 g ha^{-1} at 20 DAT, two hand weeding at 20 & 40 DAT, weedy check were assigned in the sub plot. The soil of the experimental site was sandy loam in texture with pH value of 5.7. Application of 90 kg N ha^{-1} recorded highest grain and straw yield and it was at par with application of 60 kg N ha^{-1}. Among the weed management practices two hand weeding recorded the highest grain yield (5.01 t ha^{-1}) followed by penoxsulam+cyhalofop butyl *fb* one hand weeding (4.81 t ha^{-1}). The nitrogen level of 90 kg N ha^{-1} along with post-emergence application of penoxsulam+cyhalofop butyl @ 125 g/ha registered highest net return of Rs. 53,976 ha^{-1} and Rs. 53,569 ha^{-1}, respectively with B:C ratio of 2.23 in each case.

Keywords: Bispyribac sodium, Cyhalofopbutyl, Energy efficiency, Nitrogen, Penoxsulam, Transplanted rice and Weed management

Introduction

Rice (*Oryza sativa* L.) is the staple food for more than 60 per cent of the world population and its cultivation secures a livelihood for more than three billion people. (Manisankar et al.,2020). Rice production has a pivotal role in our national economy. Our national food security hinges on the growth and stability of rice production. There is always a growing demand for rice in India due to the burgeoning population. Increasing rice productivity is essential to keep pace with the rapidly growing population. Among the several constraints of low yield of rice in India, the deficiency of nitrogen in the most of the rice-growing soils, its poor recovery by the crop and severe weed competition are the main limiting factors. Efforts taken to improve rice productivity envisage judicious management of the above limitations. Rising cost of labour and their reduced availability demandsalternate methods. At present no single approach either the use of herbicides or manual/mechanical weeding is effective in containing weed menace. Therefore, there is a need to optimize the rate of nitrogen for effective growth and yield of rice as well as using herbicides judiciously to maintain favourable crop-weed balance.With this background, the present experiment was conducted to study the effect of various doses of nitrogen and herbicides on the weed dynamics and productivity of rice.

*Author for Correspondences: Phone: 9497233293, Email: koushiksar1@gmail.com

Materials and Methods

The field investigation was carried out during *kharif* season, 2019 at Agricultural Research Station, Binjhagiri, Chatabar, Faculty of Agricultural Sciences, IAS, SOADU, Bhubaneswar. The soil of the experimental field was sandy loam in texture with slightlyacidic in reaction. The experiment was laid out in split-plot design with three replications. The treatment comprised of three nitrogen levels *viz*., 30, 60 and 90 kg ha^{-1}, assigned in the main plot and six weed management practices *viz*., Penoxsulam + cyhalofop butyl @ 125 g ha^{-1} at 20 DAT *fb* one hand weeding at 40 DAT, Penoxsulam +cyhalofop butyl @ 125 g ha^{-1} at 20 DAT, Bispyribac sodium @ 25 g ha^{-1} at 20 DAT *fb* one hand weeding at 40 DAT, Bispyribac sodium @ 25 g ha^{-1} at 20 DAT, Two hand weeding at 20 & 40 DAT, Weedy check was also assigned in the sub plot.Spacing 20 cm x 10 cm was maintained in transplanting. Seed rate taken into account was 50kgha^{-1}. Phosphorous and potassium fertilizers were applied @ 30 kg P_2O_5 and 30 kg K_2O ha^{-1} in the experimental field. Nitrogen was applied through urea, P_2O_5, and K_2O through SSP and MOP, respectively. One-third dose of nitrogen as per the treatment and a full dose of phosphorous and potash were applied as basal at the time of transplanting and rest two third of N at tillering and panicle initiation stage as per the treatment. Herbicides were applied with the help of hand operated knapsack sprayer fitted with flat fan nozzle. All other recommended agronomic practices were followed and plant protection measures were adopted as per requirement. Weed count was recorded by placing 50cm x 50 cm quadrates from the marked sampling area of 1.0 m^2 in each plot and after drying them in hot air oven at 70^o C, weed dry weight was recorded. The data were subjected to square root transformation to normalize their distribution. The crop was harvested by serrated edged sickles manually at physiological maturity. At first, the border rows around individual plots were harvested and removed leaving only the net plot area. Harvesting of each net plot area was done separately and the harvested material from each plot was carefully bundled, tagged, and taken to the threshing floor and kept separately for sun drying. Each bundle was weighed after proper sun drying and then threshed plot-wise. The grain yield was recorded separately after winnowing and cleaning. The straw yield was calculated by subtracting seed yield from the bundle weight and was converted to t ha^{-1} based on the net plot size harvest. The grain yield was adjusted to 12% moisture content after air drying for a period of 14 days. Analysis of variance (ANOVA) was done to determine the treatment effects (Gomez and Gomez, 1984). The levels of treatment were compared by critical difference at 5% level of probability. Weed data (density and dry weight) was square root transformed [$\sqrt{(x + 0.5)}$] as and where required.

Result and Discussion

Effect on weeds

There were 13 different species of weeds consisting of three grasses, four sedges, and six broadleaf weeds belonging to eight different families. Among the monocot (grasses) weeds, *Echinochloa colonum*, *Echinichloa crusgalli*, *Ischaemum rugosum*, and sedges like *Cyperus iria*, *Cyperus difformis*, *Fimbristylis miliaceae*, *Scirpus supinus* and the broad leaf weeds like *Alternanthera philoxeroides*, *Ludwigia parviflora*, *Aeschynomene indica*, *Monochoria vaginalis*, *Ammannia baccifera*, *Commelina benghalensis* were the dominant weeds.

Results revealed that irrespective of treatments the weed density was the highest at 30 DAT and thereafter decreased till harvest except for the treatment weedy check plots. Nitrogen dose and weed control treatment had a remarkable effect on the weed population throughout the growth stages. Among the nitrogen levels, the maximum average weed abundance was recorded with the application of 60 kg N ha^{-1} at 30 DAT which was however at par with that of weed density at 90 kg N ha^{-1}. At 60 DAT weed density increased significantly with successive increase in N dose from 30 to 60 kg ha^{-1}

Table 1. Weed densityand weed dry weight as influenced by N levels and weed management practices for transplanted rice

	Weed density(No. m^{-2})				Weed dry weight(g m^{-2})			
	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest
Treatments								
N levels (kg ha^{-1})								
30	5.05 (25.0)	3.73 (13.4)	1.92 (3.1)	1.91 (3.1)	1.54 (1.8)	1.26 (1.0)	1.26 (1.0)	1.22 (0.9)
60	5.41 (28.7)	4.13 (16.5)	1.93 (3.2)	1.90 (3.1)	1.71 (2.4)	1.46 (1.6)	1.37 (1.3)	1.29 (1.1)
90	5.21 (26.6)	3.96 (15.1)	2.22 (4.4)	1.91 (3.1)	1.84 (2.8)	1.32 (1.2)	1.36 (1.3)	1.19 (0.9)
SE(m)±	0.06	0.08	0.03	0.05	0.02	0.05	0.02	0.05
CD(P=0.05)	0.25	0.32	0.12	-	0.09	-	-	-
Weed management practices								
Penoxsulam + cyhalofop butyl @ 125 g ha^{-1} at 20 DAT *fb* one hand weeding at 40 DAT	3.92 (14.8)	1.78 (2.6)	1.76 (2.5)	1.48 (1.6)	1.54 (1.8)	0.86 (0.3)	0.92 (0.4)	0.73 (0.3)
Penoxsulam + cyhalofop butyl @ 125 g ha^{-1} at 20 DAT	4.74 (21.9)	4.73 (21.8)	2.40 (5.2)	1.99 (3.4)	1.71 (2.4)	1.49 (1.7)	1.09 (0.6)	1.05 (0.6)
Bispyribac sodium @ 25 g ha^{-1} at 20 DAT *fb* one hand weeding at 40 DAT	4.31 (18.0)	1.81 (2.7)	1.63 (2.1)	1.74 (2.5)	1.68 (2.3)	0.90 (0.5)	0.96 (0.5)	0.90 (0.5)
Bispyribac sodium @ 25 g ha^{-1} at 20 DAT	5.19 (26.4)	5.27 (27.2)	2.33 (4.9)	2.00 (3.5)	1.67 (2.2)	1.24 (1.0)	1.18 (0.9)	1.02 (0.6)
Two hand weeding at 20 and 40 DAT	4.32 (18.1)	1.47 (1.6)	1.27 (1.1)	1.06 (0.9)	1.00 (0.5)	0.52 (0.1)	0.62 (0.2)	0.57 (0.1)
Weedy check	8.83 (77.4)	8.99 (80.3)	3.37 (10.8)	3.26 (10.1)	2.57 (6.1)	3.04 (8.7)	3.20 (9.7)	3.13 (9.2)
SE(m)±	0.43	0.32	0.17	0.14	0.11	0.20	0.16	0.15
CD(P=0.05)	1.27	0.98	0.51	0.44	0.33	0.60	0.49	0.49

Figures in parentheses are the original values. The data was transformed to SQRT ($\sqrt{x+0.5}$) before analysis

but at 90 kg N ha^{-1} it remained at par with that of 60 kg N ha^{-1}. At 90 DAT the weed density followed an increasing trend with successive increase in nitrogen levels from 30 to 90 kg ha^{-1}. The increase in weed density with the application of nitrogen corroborates the findings of Singh et al., 2018. The weed density recorded at harvest was the lowest in comparison to their preceding stages irrespective of nitrogen levels. The reason for this decrease at the harvesting stage may be due to senescence and a decrease in metabolic activities. This finding is in agreement with that of Panda et al. *(*2016).Similar trend was followed in weed dry weight also.At 30 DAT the dry weight of weed was the highest at 90 kg N ha^{-1} which was 19.5 and 7.6 % higher than the dry weight of weeds with the application of 30 and 60 kg N ha^{-1}, respectively. The dry weight of weeds increased by 9.94, 13.7, 8.02, and 5.4% with an increase in N level from 30 to 60 kg ha^{-1} at 30, 60, 90 DAT, and at harvest, respectively. The increase in dry weight of weeds due to the application of 90 kg N ha^{-1} over 60 kg N ha^{-1} was not significant at 60, 90 DAT, and at harvest.

Among all the weed control treatments, the highest weed density and dry weight was recorded under weedy check plotin all growth stages. All the herbicide treatments brought significant reduction in the weed population compared to the unweeded control. Lowest density and dry weight of total weed was recorded under two hand weeding and it was at par with post-emergence application with penoxsulam + cyhalofop butyl *fb* one hand weeding and bispyribac sodium *fb* one hand weeding. The percentage of decrease in weed density under two hand weeding as compared to the weedy check control was 51.1, 83.6, 62.3, and 67.5 at 30, 60, 90, and at harvest, respectively. The finding was in conformity with the finding of Deiveegan et al., 2017.

Effect on crop growth

Application of 90 kg N ha^{-1} gave the higher grain yield (4.72 t ha^{-1}), it was at par with the grain yield recorded at 60 kg N ha^{-1}(4.57 t ha^{-1}). The extent of increase in grain yield due to application of 60 kg N ha^{-1} over 30 kg N ha^{-1} was 13.4%, while, subsequent increase in grain yield at 90 kg N ha^{-1} over 60 kg N ha^{-1} was only 3.2%. The lowest grain yield 4.03 t ha^{-1}was recorded at the lowest level of nitrogen (30 kg ha^{-1}). The increase in grain yield at higher nitrogen rates could be attributed to improved growth and yield attributes in high nitrogen application. The findings are in conformity with the result of Hitesh et al., 2018. Highest straw yield (6.24 t ha^{-1}) was also recorded with the application of 90 kg N ha^{-1} which was 3.8 and 15.1% more than the yield recorded with the application of 60 and 30 kg N ha^{-1}, respectively. Similar findings were also reported by Gunri et al., 2004. All the weed management treatments gave significantly higher grain yield to the extent of 31.0 to 46.2 % than the weedy check (3.29 t ha^{-1}). The highest grain (5.01 t ha^{-1}) and straw yield was recorded under two hand weedings at 20 and 40 DAT and was at par with the application of either penoxsulam + cyhalofop butyl followed by one hand weeding andpenoxsulam + cyhalofop butyl alone.Penoxsulam + cyhalofop butyl and bispyribac sodium followed by one hand weeding were statistically at par. The lowest grain(3.29 t ha^{-1}) and straw yield (6.24 t ha^{-1}) was recorded in unweeded control. High grain yield in treatments with application of penoxsulam + cyhalofop butyl *fb* one hand weeding and bispyribac sodium followed by one hand weeding could be attributed to better weed control and high values of yield attributes than other treatments. Similar finding was reported by Deiveegan et al., 2017. Harvest index was not influenced significantly due to nitrogen levels and weed control practices. Among the different levels of nitrogen, highest harvest index was recorded with application of 90 kg N ha^{-1} followed by 60 kg N ha^{-1} and 30kg N ha^{-1}. Among the different weed control practices, the highest harvest index value of 43.25% was recorded under two hand weeding followed by the treatment with the application of penoxsulam+cyhalofop butyl (43.23%).

*Table2:*Effect of treatments on yield, harvest index,weed index, herbicide efficiency index, and energy utilization of transplanted rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Weed index (%)	Herbicide Efficiency index	Energy utilized by rice (Kcal)
N levels (kg ha^{-1})						
30	4.03	5.30	43.14	19.5	0.58	608.96
60	4.57	6.00	43.20	8.7	0.94	738.36
90	4.72	6.24	43.07	5.7	1.14	768.12
SE(m)±	0.04	0.05	0.02	-	-	-
CD(P=0.05)	0.19	0.23	-	-	-	-
Weed management practices						
Penoxsulam + cyhalofop butyl @ 125 g ha^{-1} at 20 DAT fb one hand weeding at 40 DAT	4.81	6.35	43.08	4.0	2.00	791.64
Penoxsulam + cyhalofop butyl @ 125 g ha^{-1} at 20 DAT	4.76	6.25	43.23	5.0	1.35	759.47
Bispyribac sodium @ 25 g ha^{-1} at 20 DAT fb one hand weeding at 40 DAT	4.46	5.85	43.14	10.9	1.26	737.32
Bispyribac sodium @ 25 g ha^{-1} at 20 DAT	4.31	5.67	43.18	13.9	0.96	713.45
Two hand weeding at 20 and 40 DAT	5.01	6.57	43.25	-	2.9	866.38
Weedy check	3.29	4.38	42.94	34.3	-	623.49
SE(m)±	0.12	0.14	0.08	-	-	-
CD(P=0.05)	0.38	0.48	0.25	-	-	-

Application of 90 kg N ha^{-1} registered lowest WI value (5.7 %) followed by 60 and 30 kg N ha^{-1} with corresponding values 8.7 and 19.5 %, respectively. Among the herbicide treatments, application of penoxsulam + cyhalofop butyl *fb* one hand weeding at 20 DAT registered minimum WI value (4.0), while that for unweeded control was the highest (34.3 %). This might be due to the efficient control of weeds by the herbicide application.

The herbicide efficiency index and energy utilized by rice as affected by nitrogen levels and weed management practices was presented in Table 2. The results revealed that with progressive increase in nitrogen levels, there was an increase in herbicide efficiency index from 0.58 at 30 kg N ha^{-1} to 0.94 and 1.14 at 60 and 90 kg N ha^{-1}, respectively. Among the weed management practices, two hand weeding at 20 and 40 DAT recorded highest herbicide efficiency index (2.9). It was followed by penoxsulam+cyhalofop butyl with one hand weeding with herbicide efficiency index of 2.00 and alone application of penoxsulam+cyhalofop butyl (1.35). Prasad et al. (2001) experimented using bispyribac sodium at three different doses (25, 30, and 50 g ha^{-1}) and observed highest herbicide efficiency index of 3.39 at dose of 50 g ha^{-1}. The energy utilized with respect to nitrogen levels was highest at 90 kg N ha^{-1} (768.12 kcal) followed by 60 kg N ha^{-1} (738.36 kcal) and 30 kg N ha^{-1} (608.96 kcal). Among the weed management practices, the maximum energy utilization (866.38 kcal) by rice was noticed in the treatment of two hand weeding at 20 and 40 DAT followed by the treatment penoxsulam + cyhalofop butyl with one hand weeding (791.64 kcal) and penoxsulam + cyhalofop butyl alone (759.47 kcal).

The highest net return (Rs.54,393 ha^{-1}) was observed with the application of nitrogen at 90 kg ha^{-1} combined with two hand weeding followed by t 90 kg N ha^{-1} along with herbicidal treatment of penoxsulam + cyhalofop butyl (Rs.53,976 ha-1) and 90 kg N ha^{-1} along with same herbicide *fb*one hand weeding (Rs. 52,395 ha^{-1}). Lowest net return was recorded in the treatment with 30 kgN$ha^{-1}$with weedy check (Rs. 25,758 ha^{-1}). Application of nitrogen at 90 kg ha^{-1} combined with penoxsulam + cyhalofop butyl fetched the highest B: C ratio and was at par with the treatment of 60 kg N ha^{-1} along with the same herbicide (Table 3).

The study conducted to evaluate the influence of different levels of nitrogen and weed management

Table 3. Effect of N levels and weed management practices on economics of transplanted rice

Treatment details	Cost of cultivation (Rs ha^{-1})	Net return (Rs.ha^{-1})	B: C ratio
N 30 kg/ha + penoxsulam+cyhalofop butyl @ 125 g/*ha fb* one hand weeding	45,586	39,050	1.85
N 30 kg/ha + penoxsulam+cyhalofop butyl @ 125 g/ha	42,786	41,027	1.95
N 30 kg/ha + bispyribac sodium @ 25 g/ha *fb*one hand weeding	44,511	32,550	1.73
N 30 kg/ha + bispyribac sodium @ 25 g/ha	41,711	33,236	1.79
N 30 kg/ha + two hand weeding	48,836	39,648	1.81
N 30 kg/ha + weedy check	39,036	22,715	1.58
N 60 kg/ha + penoxsulam+cyhalofop butyl @ 125 g/ha fb one hand weeding	46,006	51,583	2.12
N 60 kg/ha + penoxsulam+cyhalofop butyl @ 125 g/ha	43,206	53,569	2.23
N 60 kg/ha+ bispyribac sodium @ 25 g/ha fb one hand weeding	44,931	44,388	1.98
N 60 kg/ha + bispyribac sodium @ 25 g/ha	42,131	43,836	2.04
N 60 kg/ha + + two hand weeding	49,256	50,784	2.03
N 60 kg/ha + weedy check	39,456	24,243	1.61
N 90 kg/ha + penoxsulam+cyhalofop butyl @ 125 g/ha *fb* one hand weeding	46,426	52,395	2.12
N 90 kg/ha + penoxsulam+cyhalofop butyl @ 125 g/ha	43,626	53,976	2.23
N 90 kg/ha + bispyribac sodium @ 25 g/ha *fb* one hand weeding	45,351	47,925	2.05
N 90 kg/ha + bispyribac sodium @ 25 g/ha	42,551	48,222	2.13
N 90 kg/ha + two hand weeding	49,676	54,393	2.09
N 90 kg/ha + weedy check	39,876	27,376	1.68

practices on productivity of transplanted rice revealed that application of 90 kg N ha^{-1} along with weed management by two hand weeding at 20 and 40 DAT recorded lowest weed population and higher productivity and profitability in rice as compared to other treatments but it was closely followed by the nitrogen level either 90 or 60 kg N ha^{-1} along with post-emergence application of penoxsulam + cyhalofop butyl @ 125 g ha^{-1}.

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