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Nutrient uptake, use efficiency and yield of rice as influenced by time of transplanting and nitrogen levels

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ABSTRACT

An experiment was conducted during Kharif, 2016 to investigate the influence of transplanting dates and nitrogen levels on productivity of transplanted fine rice. Experiment was laid out in factorial randomized block design with two transplanting dates (i.e. D_1-15th and D_2-30th July) as one factor and four levels of nitrogen (i.e. 0, 30, 60 and 90 kg N/ha) as second factor. Time of transplanting did not influence growth, yield attributes and yield. However, among different levels of nitrogen, significantly highest yield and yield attributes were recorded with 60 kg N/ha. Significantly highest straw yield was recorded with 90 kg N/ha. Rice transplanted on 15th July proved to be superior with respect to gross returns (Rs.70337.50/ha), net return (Rs.38259.28/ha) and B: C ratio (1.19) to that of 30th July transplanting. Whereas among nitrogen levels highest gross returns (Rs.79307.50/ ha), net returns (Rs.52314.96) and B: C (1.94) ratio were obtained with application of 60 kg N/ha.

Key words: *Nitrogen levels, transplanting dates, nutrient uptake, nutrient efficiency*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crop of India as well as world. Out of many fine rice varieties, traditional varieties cultivated in India are tall and constitute a sizeable proportion of export but productivity of fine rice is very low as compared to other varieties. The Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu is also involved in developing rice cultivars and has recently developed fine rice cultivar SJR-129 which is an early maturity variety having plant height of 110-115 cm with high yield potential of about 44 q/ha. Due to its early maturity it provides edge over other existing fine rice cultivars under rice wheat cropping system in Jammu region. Apart from this due to its short statured nature it is resistant to lodging and also moderately resistant to stem borer, leaf folder and bacterial leaf blight. Productivity and quality of a crop depends on the environmental conditions and the agronomic practices and in case of rice especially on the times of transplanting and nutrient management. Time of transplanting is one of important agronomic strategies to exploit full potential of a variety and its photoperiod sensitivity so as to harness maximum production with improved quality of grain. Usually, yield declines when planting is delayed beyond optimum time. Too early or too late transplanting cause yield reduction due to crop sterility and lower number of productive tillers respectively (Nazir, 1994). Yoshida (2001) reported that rice plants require a particular temperature for its phenological development such as panicle initiation; flowering, panicle exertions from flag leaf sheath and maturity and these are very much influenced by planting dates. Further, quality traits of aromatic rice are known to be highly influenced by temperature particularly at the time of flowering, grain filling and maturity. Hence, the optimum time of transplanting play an important role in boosting the yield and quality of basmati rice.

Besides transplanting date, nutrition is an important factor which tremendously affects the grain yield of fine rice. Among the nutritional factors, nitrogen (N) is essential for rice and usually it is the most yield-limiting nutrient in irrigated rice production around the world (Samonte et al., 2006). Rice plants require nitrogen during vegetative stage to promote growth and tillering, which in turn determines number of panicles. Nitrogen also plays a role in grain filling, improving the photo-synthetic efficiency and promoting carbohydrate accumulation in culms and leaf sheaths (Mae, 1997). Fine rice responds differently to nitrogen application as compared to coarse rice. The application of nitrogen fertilizer in fine rice either in excess or less than the optimum rate affects both yield and quality of rice to a remarkable extent. Therefore, nitrogen is the key input for increasing the productivity of fine rice (Mahajan et al., 2010). Inadequate application of nitrogen resulted in reduced leaf area, thereby, limiting light interception, photosynthesis and finally biomass growth, grain yield and water productivity (Sinclair, 1990). On the other hand, high nitrogen may lead to lodging, increased incidence of insect-pest attack and resulted in lower grain quality of rice. Hence, it becomes imperative to know the optimum dates of transplanting as well as dose of nitrogen to use farm resources efficiently for quantitative and qualitative increase in rice production.

MATERIALS AND METHODS

A field experiment was conducted at the research farm of Division of Agronomy, Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu during *kharif* 2016. The experimental soil was sandy clay loam in texture medium in available phosphorus and potassium, low in organic carbon and available nitrogen. The experiment was conducted in factorial randomized block design with three replications. The treatment consisted of two times of transplanting (*i.e.*, D_1 and D_2) as one factor and four levels of nitrogen (*i.e.*, 0, 30, 60, 90 kg N/ha) as second factor. Seedlings of 30 days of newly developed fine rice cultivar 'SJR-129' were transplanted on 15th and 30th July under puddled conditions at spacing of 20 × 10 cm. Full dose of phosphorus and potassium along with one third of nitrogen were applied as basal dose at the time of sowing and remaining one third of nitrogen was applied in two equal splits, one third at tillering stage and the one third was applied at panicle initiation stage. Dried grain and straw subsamples were analyzed for Kjeldahls N. Nitrogen uptake (kg/ha) in grain, straw and total (grain + straw) was estimated as product of N content and plant yield (grain, straw and total). Different estimates on N efficiencies were made by using the following calculations as:

$$\text{Nitrogen use efficiency} = \frac{\text{Grain yield in treated plot (kg/ha) - grain yield in control plot (kg/ha)}}{\text{Amount of nitrogen applied (kg/ha)}}$$

$$\text{Apparent recovery (\%)} = \frac{\text{N uptake in treated plot (kg/ha) - N uptake in control plot (kg/ha)}}{\text{Amount of nitrogen applied (kg/ha)}}$$

$$\text{Nitrogen-efficiency ratio (NER)} = \frac{\text{Dry matter yield at harvest (kg/ha)}}{\text{N accumulation in crop at harvest (kg/ha)}}$$

Physiological efficiency index of absorbed nitrogen (PEIN) of the treatments was calculated as ratio of kg grain produced to a kg of nitrogen uptake in above-ground dry matter at harvest (Isfan, 1990).

$$\text{Physiological efficiency index PEIN} = \frac{\text{Grain yield produced (kg/ha)}}{\text{N uptake in above dry matter at harvest(kg/ha)}}$$

Statistical analysis

Analysis of variance was performed to determine the effects of transplanting dates and N levels, and their interaction using Opstat (2 factor) developed by CCSHAU, Hisar. The interpretation of treatments effects were made on the basis of critical difference at 5 % probability level. The key for degrees of freedom

Table 1. Analysis of Variance (ANOVA)

Source of Variation	Degree of Freedom
Replication (r-1)	3-1=2
Factor a (a-1)	2-1=1
Factor b (b-1)	(4-1)=3
Factor a (a-1) × Factor b(b-1)	(2-1)× (4-1)=3
Error (r-1)(2n-1)	(3-1) × (23-1)=14
Total (rab-1)	23

used in analysis of variance is presented in Table 1.

RESULT AND DISCUSSION

Yield attributes

The times of transplanting did not influence the number of tillers significantly at harvest and other yield attributing characters, *viz*. number of panicles/m^2, total grains/panicle, number of filled grains/panicle and 1000-grain weight (g). Whereas among the nitrogen levels significantly highest number of panicles/m^2, total grains/panicle, number of filled grains/panicle and 1000-grain weight (g) were recorded with 60 kg N/ha which was however statistically at par with 90 kg N/ha (Table 2). This improvement in yield attributing characters of rice might have happened due to high production of photosynthates with increased nitrogen application and their effective translocation from source to sink which led to the proper formation of grains during grain filling period. Further increase in level of nitrogen reduced the yield attributing characters which may be caused by an increase in competition for metabolic supply among tillers causing heavy drain on soluble carbohydrates. Similar findings were also reported by Singh et al. (2005), Mittotiya (2006), Laroo et al. (2007), Pandey et al. (2007) and Singh et al. (2008).

Yield

The time of transplanting did not influence significantly the grain and straw yields of rice. However, there was significant increase in grain as well as straw yield of rice with an increase in level of nitrogen. Significantly highest grain yield was recorded with 60 kg N/ha which was statistically at par with 90 kg N/ha. Increased number of panicles/m^2, total grains/panicle, number of filled grains/panicle and 1000-grain weight (g) was mainly responsible for the increased yield at this level of nitrogen along with efficient translocation of photosynthates from source to sink. These results are in close conformity with the findings of Jahan et al. (2014), and Pradhan et al. (2014). Further increase in level of nitrogen reduced the yield attributing characters and yield ultimately which may be caused by an increase in competition for metabolic supply among tillers causing heavy drain on soluble carbohydrates. Similar findings were also reported by Parihar (2004); Singh et al. (2005); Mittotiya (2006); Laroo et al. (2007); Pandey et al. (2007) and Singh et al. (2008).

Table 2. Effect of times of transplanting and nitrogen levels on yield attributing characters.

Treatments	No. of tiilers at harvest	No. of panicles /m^2	Total grains /panicle	No. of filled grains /panicle	1000-grain weight(g)
Times of transpla-nting					
15th July	235.67	228.28	104.22	82.62	23.15
30th July	233.33	226.10	103.67	80.14	22.63
SEm (+)	0.78	0.73	0.18	0.82	0.17
CD (5%)	NS	NS	NS	NS	NS
Nitrogen levels					
N_0	204.00	196.99	96.89	77.09	21.49
N_{30}	232.00	228.10	101.46	79.35	22.40
N_{60}	248.33	242.40	106.00	84.02	23.80
N_{90}	250.67	238.28	105.19	81.82	23.14
SEm (+)	4.31	2.71	1.56	0.73	0.27
CD (5%)	13.09	8.14	3.48	2.20	0.68
Interaction	NS	NS	NS	NS	NS

However, significantly highest straw yield was recorded with 90 kg N/ha which remained statistically at par with 60 kg N/ha This might have happened due to the reason that application of nitrogen promote tillering in rice, increased photosynthetic activity and dry matter production that led to the increased straw yield. Similar results were also reported by Laroo et al. (2007); Murthy et al. (2012); Pradhan et al. (2014).

Nitrogen uptake and efficiencies

There was no significant effect of time of transplanting on nutrient uptake by rice. However, the grain, straw and total nitrogen uptake by rice increased significantly with levels of nitrogen. Significantly highest grain and total nitrogen uptake of rice were recorded with 60 kg N/ha which was statistically at par with 90 kg N/ha. It might be due to the fact that higher concentration of nitrogen in grain as compared to straw which led to highest uptake by rice crop and due to significant highest grain yield at 60 kg N/ha. Similar results were also reported by Zaidi and Tripathi (2007). However, significantly highest nitrogen uptake by straw was recorded with 90 kg N/ha which was statistically at par with 60 kg N/ha. This might have resulted due to vigorous growth of rice with increased nitrogen level that led to maximum dry matter production which resulted in higher straw yield. These results are in

Table 3. Effect of times of transplanting and nitrogen levels on nitrogen uptake and use efficiency.

Treatments	Total nitrogen uptake	NUE (kg grain /kg N)	Apparent nitrogen recovery (%)	Nitrogen efficiency ratio (%)	Physiological efficiency index of N
Times of transplanting					
15th July	66.49	12.00	29.94	138.80	58.05
30th July	64.81	13.66	29.53	152.97	54.01
SEm (+)	0.90	1.66	2.29	3.78	1.69
CD (5%)	NS	NS	NS	11.48	NS
Nitrogen levels					
N_0	49.36			136.91	62.74
N_{30}	63.30	20.16	46.46	112.98	57.25
N_{60}	77.42	21.05	46.75	153.67	52.03
N_{90}	74.51	10.11	25.71	179.99	52.10
SEm (+)	1.27	2.34	3.23	5.35	2.39
CD (5%)	3.86	7.12	9.82	16.23	7.26
Interaction	NS	NS	NS	NS	NS

Table 4. Effect of times of transplanting and nitrogen levels on relative economics.

Treatments	Cost of Cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B: C ratio
Times of transplanting				
15th July	32078.22	70337.50	38259.28	1.19
30th July	32078.22	67092.50	35014.28	1.09
SEm (+)	-	0.63	0.08	0.72
CD (5%)	-	NS	NS	NS
Nitrogen levels				
N_0	26364.72	55500.00	29135.28	1.11
N_{30}	26639.72	66242.50	39602.78	1.49
N_{60}	26992.54	79307.50	52314.96	1.94
N_{90}	27351.24	73245.50	45894.26	1.68
SEm (+)	-	2020	2139	0.08
CD (5%)	-	6061	6418	0.24
Interaction	NS	NS	NS	NS

conformity with findings of Chopra and Chopra (2000).

The times of transplanting did not show significant influence on the agronomic nitrogen-use efficiency (NUE), apparent N recovery (%) and physiological efficiency index of nitrogen (PEIN). However, nitrogen-efficiency ratio (NER) was significantly influenced by different transplanting dates.

Whereas, nitrogen levels had significant effect on NUE, apparent N recovery (%), NER and PEIN (Table 3). Agronomic NUE and apparent N recovery declined significantly as N applied to rice is subjected to leaching and denitrification losses (Prasad, 1998) at highest level of nitrogen. 'The highest N- efficiency ratio, which indicated the efficiency of N utilization by rice (kg dry-matter produced/kg nitrogen uptake) and physiological efficiency index of nitrogen (ratio of kg grain produced/kg N uptake in above- ground plant dry matter at maturity) were observed at the highest level of nitrogen and at control respectively which were significantly higher than other nitrogen levels.

Relative economics

The data in respect of economic returns presented in Table 4 revealed that 15th July transplanting recorded maximum gross returns, net returns and B: C ratio as compared to rice transplanted on 30th July. However among different nitrogen levels, the application of 60 kg N/ha resulted in maximum gross return, net return and benefit: cost ratio closely followed by 90 kg N/ha. The possible reason could be that the respective treatment increased crop growth, yield attributes culminating into higher grain and straw yield. Higher economic returns were generated by virtue of higher crop yield. These results are in line with findings of Pradhan et al. (2014). The lowest net returns and benefit: cost ratio was realized under control.

CONCLUSIONS

Our study concluded that overall performance of rice stays unaffected with respect to different transplanting dates. However, application of nitrogen affects its performance significantly. Application of 60 kg N/ha was the optimum dose of nitrogen for yield maximization along with higher net returns, gross returns as well as B: C ratio irrespective of whether rice transplanted on 15th July and 30th July under subtropical irrigated conditions of Jammu region.

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