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Response of Different Cultivars of Basmati Rice (*Oryza sativa*) on Nutrient Uptake and Quality Parameters under Direct Seeding

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ABSTRACT

A field experiment was conducted at Student's Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana. The experiment was conducted in split plot design with 12 treatment combinations *viz.,* two basmati cultivars (Pusa Basmati 1121 and Punjab Basmati 2) in main plots and combination of three N rates and two time of application in sub plots (40 kg/ha at 0, 15, 50 DAS, 40 kg/ha at 0, 21, 65 DAS, 60 kg/ha at 0, 15, 50 DAS, 60 kg/ha at 0, 21, 65 DAS, 80 kg/ha at 0, 15, 50 DAS and 80 kg/ha at 0, 21, 65 DAS) with four replications. The findings of the study revealed that the nutrient uptake of rice in Pusa Basmati 1121 was found to be significantly higher than Punjab Basmati 2. It was observed that 60 kg N/ ha performed better over recommended 40 kg N/ ha when applied in 3 splits (0, 21 and 65 DAS). The soil status after harvest of the soil showed non-significant difference in organic carbon, available P and K except N with varying nitrogen levels. Pusa Basmati 1121 was also better in quality than Punjab Basmati 2 as indicated by its higher hulled rice recovery, milled rice recovery, head rice recovery, grain L:B ratio, water absorption, elongation ratio and cooking co-efficient. The sensory evaluation parameters were significantly better in Pusa Basmati 1121 than Punjab Basmati 2.

Key Words: Basmati cultivars, quality parameters, nutrient uptake and sensory evaluation parameters.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of about 3 billion people and the demand continues to grow with increasing population (Carriger and Vallee, 2007). India accounts for 22.3 per cent of the world's production of rice. Rice is the most widely grown *kharif* crop in Punjab and occupied an area of 30.46 lakh hectares with a production of 189.57 lakh tons in 2016-17 (Anonymous, 2019). In India, rice is commonly grown by transplanting rice seedlings into puddle soils in Indo-Gangetic plains and other regions. As a result, the underground water is being over exploited by excessive pumping to meet the water need of transplanted paddy causing a sharp decline in ground water table. The preliminary research conducted at Punjab Agricultural University, Ludhiana indicated that direct seeded rice could be a viable alternative to transplanted rice. Plant genotypes are also considered as an important yield determinant on account of their morphological and physiological characteristics. The Pusa Basmati 1121 variety is famous for its unique characters of aroma, extra long slender grains with good cooking quality, longest cooked rice length (Bhattacharjee *et al*, 2002) among all the aromatic rice varieties recommended for Punjab, etc. Punjab Basmati 2 possesses extra long slender grains with excellent cooking and eating qualities. Grains of this variety are strongly scented, almost double upon cooking, are non- sticky and soft to eat.

Nitrogen is an essential constituent of proteins, chlorophyll and metabolites such as nucleotides, phosphatides, alkaloids, enzymes, hormones and vitamins etc. which have great physiological importance in plant metabolism. Apart from promoting vegetative growth, it also increases crop yield and protein content in grains. Nitrogen is an important nutrient element for rice plants,

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as 75 per cent of leaf nitrogen is associated with chloroplast which physiologically helps in dry matter production through photosynthesis (Somasundaram *et al*, 2002). With this view, an attempt is made in the present study to evaluate the effect of different levels and time of application of nitrogen on nutrient uptake, nutrient status of the soil and quality parameters of different cultivars of basmati rice under direct seeding.

MATERIALS AND METHODS

The field experiment was conducted at Student's Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana which is situated at 30°56' N latitude and 75°52' E longitude with a mean height of 247 meter above the mean sea level. The soil of the experimental field was loamy sand in texture throughout soil profile. The experiment was conducted in split plot design with 12 treatment combinations *viz.,* two basmati cultivars (Pusa Basmati 1121 and Punjab Basmati 2) in main plots and combination of three N rates and two time of applications in sub plots with four replications viz. T_1- 40 kg/ha at 0, 15, 50 DAS, T_2- 40 kg/ha at 0, 21, 65 DAS, T_3- 60 kg/ha at 0, 15, 50 DAS, T_4- 60 kg/ ha 0, 21, 65 DAS T_5- 80 kg/ha at 0, 15, 50 DAS and T_6- 80 kg/ha at 0, 21, 65 DAS. The seed rate of 20 kg/ha was used in direct seeding using 20 cm row spacing. Nitrogen was applied as per treatments *i.e.,* 40, 60 and 80 kg/ha. It was applied through urea in three equal installments according to the treatments as 1/3rd applied as basal, 1/3 at 15 DAS (days after sowing) or 21 DAS and last 1/3rd dose of nitrogen applied at 50 DAS or 65 DAS. The whole dose of P_2O_5 and K_2O was applied at the rate of 30 kg/ha at the time of field preparation. For determining NO_3-N and NH_4-N, soil samples were taken in 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil layers. A 10 g portion of the soil was extracted with 100 ml of 2M-KCl solution after shaking for 1 hr. Suspension was filtered and filtrate was analyzed for NO_3-N and NH_4-N by steam distillation using Devarda's alloy and MgO respectively (Bremner, 1965). Organic carbon was determined by Walkley and Black's rapid titration method (Walkley and Black, 1934). Available nitrogen was determined by modified alkaline permanganate method as described by Subbiah and Asija (1956) and phosphorus by method described by Olsen *et al* (1954). The intensity of colour in the extract was developed by ascorbic acid (Watanable and Olsen, 1965) and measured at 760 nm on spectrophotometer. Available potassium was extracted with neutral normal ammonium acetate solution as described by Piper (1966) and it was determined by using flame photometer. Nitrogen, phosphorus and potassium in plant (uptake) was determined by using Kjeldahl's distillation method, Vanado-Molybdo-Phsophoric yellow colour method in nitric acid (Jackson,1967) and Lange's Flame Photometer (Jackson, 1967) respectively. The per cent nitrogen in the grain was estimated using Micro Kjeldahl's method of Mckenzine and Wallace (1964) and it was multiplied by 5.95 to compute the crude protein content in grain. The grain length and breadth were measured before and after cooking of basmati samples and expressed in mm of respective values of L/B for each treatment. A panel of six semi-trained judges was formed for evaluation of sensory parameters viz., aroma, tenderness, cohesiveness and colour. The quality parameters were calculated by using the following formulas:

$$\text{Brown rice recovery (\%)} = \frac{\text{Brown rice obtained (g)}}{\text{Total paddy taken (g)}} \times 100$$

$$\text{Milled rice recovery (\%)} = \frac{\text{Milled rice obtained (g)}}{\text{Total paddy taken (g)}} \times 100$$

$$\text{Head rice recovery (\%)} = \frac{\text{Head rice obtained (g)}}{\text{Total paddy taken (g)}} \times 100$$

Elongation ratio (ER) = $\frac{LcLc}{LrLr}$ where, Lc = Length of cooked grain (mm) and Lr = Length of raw grain (mm)

Water Absorption Ratio (WAR) = $\frac{WcWc}{WrWr}$ where, Wc = Weight of cooked grain (g) and Wr = Weight of raw grain (g)

Cooking coefficient (CC) = $\frac{Lc - Lr\, Lc - Lr}{Bc - BrBc - Br}$ where, Lc = Length of cooked grain (mm), Lr = Length of raw grain (mm), Bc = Breadth of cooked grain (mm) and Br = Breadth of raw grain (mm)

RESULTS AND DISCUSSION

Soil Analysis at harvest for Nitrate-N and Ammonical-N

The NO_3-N and NH_4-N accumulated in the soil profile at various stages of rice growth presented in Table 1 indicated that the concentration of NO_3-N in the soil profile decreased with increasing stage of crop growth in each of the treatment, irrespective of the nitrogen levels. The non-significant difference in NO_3-N and NH_4-N content was observed with the different cultivars. This decrease in NO_3-N in the soil profile with increasing period of rice growth can be ascribed to higher N requirement of crop with increasing time period. Maximum NO_3-N and NH_4-N accumulation occurred in Punjab Basmati 2 closely followed by Pusa Basmati 1121. Chemical treatments supply NH_4-N to the plant for a short period but in excess amounts as reported by Hao and Chang (2002). Among nitrogen levels, maximum NO_3-N and NH_4-N accumulation was accrued in plots receiving 80 (3 splits; 0, 21, 65 DAS) kg N/ ha which was statistically at par with 60 (3 splits; 0, 15, 50 DAS) kg N/ha in case of NO_3-N accumulation and 80 (3 splits; 0, 15, 50 DAS) kg N/ ha in case of NH_4-N accumulation. Interaction effect between cultivars of basmati rice and nitrogen levels was observed to be non-significant.

Organic carbon, Available N, P and K status of the soil at harvest

The organic carbon per cent differed significantly and the available N status of the soil varied significantly amongst cultivars (Table 1). In contrast to this, the available P (19.9 kg/ ha) and K (146.1 kg ha^{-1}) status of the soil was improved in all the treatments over its initial value. It continued to increase with added fertilizers but there was no significant difference in the available P content of soil w.r.t different cultivars and nitrogen levels.

Table 1. Effect of nitrogen levels on nitrate-N, ammonical-N, organic carbon (OC), available status of soil after harvest of DSBR cultivars.

Treatment	Nitrate-N (mg/ kg)	Ammonical-N (mg/ kg)	Organic carbon (%)	Available N (kg/ ha^{1})	Available P (kg/ ha^{1})	Available K (kg/ ha^{1})
Cultivars						
Pusa Basmati 1121	4.21	15.33	0.54	196.2	21.9	148.1
Punjab Basmati 2	4.23	15.89	0.48	194.4	21.8	147.8
CD at 5%	NS	NS	0.21	NS	NS	NS
Nitrogen levels (kg ha^{-1})						
T_1	3.83	15..05	0.49	174.3	21.9	147.9
T_2	4.23	15.43	0.50	175.0	21.7	148.3
T_3	4.25	15.90	0.51	199.9	21.5	147.8
T_4	4.33	16.10	0.51	204.4	21.9	147.9
T_5	4.34	16.23	0.52	207.5	22.0	148.1
T_6	4.35	16.48	0.52	210.7	21.8	147.9
CD at 5%	0.10	0.30	NS	3.9	NS	NS
Interaction	NS	NS	NS	NS	NS	NS
Initial status	-	-	0.39	252.7	19.9	146.1

Table 2. Effect of nitrogen levels on uptake of nitrogen (N), phosphorus (P) and potassium (K) of DSBR cultivars

Treatment	N uptake (kg/ ha)		P uptake (kg/ ha)		K uptake (kg/ ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
Cultivars						
Pusa Basmati 1121	44.6	40.3	17.9	11.0	26.7	142.8
Punjab Basmati 2	37.6	37.2	14.5	10.1	23.0	135.3
CD at 5%	2.4	2.1	1.0	0.6	1.4	7.3
Nitrogen levels (kg ha^{-1})						
T_1	36.0	34.1	13.2	8.7	21.1	123.4
T_2	36.9	35.8	14.2	9.2	21.9	130.4
T_3	41.4	38.7	16.4	10.4	25.1	137.9
T_4	42.2	39.9	16.7	10.7	25.5	142.8
T_5	44.7	41.1	18.1	11.7	27.4	146.3
T_6	45.4	42.8	18.9	12.2	28.0	153.4
CD at 5%	4.0	3.7	1.6	1.0	2.4	13.4
Interaction	NS	NS	NS	NS	NS	NS

Maximum organic carbon content (0.54%), available N (196.2 kg/ ha), available P (21.9 kg/ ha), available K (148.1 kg/ ha) was obtained in cultivar Pusa Basmati 1121 which was statistically at par with Punjab Basmati 2. The increase in organic carbon content may be attributed to the higher yields under these treatments and a positive relationship also exists between shoot and root weight therefore more production of root and their subsequent decomposition might have increased the organic carbon status of soil. These results are in agreement with the findings of Singh *et al* (2000a).

The organic carbon content, available P and available K status of the soil after the harvest of crop, did not vary significantly with varying nitrogen levels whereas the available N status of the soil varied significantly with varying nitrogen levels, its content was significantly more at 80 (3 splits; 0, 21, 65 DAS) kg N/ ha which was statistically at par with 80 (3 splits; 0, 15, 50 DAS) kg N/ ha but significantly more than 40 (3 splits; 0, 15, 50 DAS) kg N/ ha, 40 (3 splits; 0, 21, 65 DAS) kg N/ ha, 60 (3 splits; 0, 15, 50 DAS) kg N/ ha and 60 (3 splits; 0, 21, 65 DAS) kg N/ ha. However, interaction among different cultivars of basmati rice with levels of nitrogen found to be non-significant.

Nitrogen (N), Phosphorus (P) and Potassium (K) uptake by grain and straw

The uptake of nutrient is a function of various factors such as climate, soil properties, application of fertilizer, rate of increase in dry matter and varieties of rice plant. Nitrogen content (percent) in grain and straw multiply with their total yield in respective treatments gives total uptake. Amongst the cultivars, (Table 2) significantly higher values for N-uptake (44.6 kg/ ha and 40.3 kg/ ha), P-uptake (17.9 kg/ ha and 11.0 kg/ ha) and K-uptake (26.7 kg/ ha and 142.8 kg/ ha) of grain and straw were found in Pusa Basmati 1121 as compared to Punjab Basmati 2. The higher N uptake may be due to more biomass attained by Pusa Basmati 1121 as compared to Punjab Basmati 2 on account of its more DMA and tillering in grain. Ramarao (2004) reported that the partitioning of N and P was more towards reproductive structure while the partitioning of K was more towards the stem in all the cultivars under evaluation. Nitrogen, an integral part of different enzymes, proteins and chlorophyll etc; has been reported to increase the cell size and cell number. Nitrogen levels significantly influenced the uptake of nitrogen, phosphorus and potassium in grains. The maximum uptake of nitrogen, phosphorus and potassium in grains was obtained with 80 (3 splits; 0, 21, 65 DAS) kg N/ ha which was found statistically at par with 80 (3 splits; 0, 15, 50 DAS) kg N/ ha and 60 (3 splits; 0, 21, 65 DAS) kg N/ ha but significantly more than other nitrogen levels. Increased phosphorus uptake in grain with increasing nitrogen levels was also reported by Rao *et al* (2007). The increase in nutrient uptake was more probably due to improvement of soil environment, which encouraged the root proliferation that in turn drew more nutrients from larger area. Similar results were also reported by Singh *et al* (2000a). The application of nitrogen had a beneficial effect on phosphorus uptake by rice, which was mainly associated with increase in yield and greater exploitation of available pool of phosphorus from the soil (Majumdar *et al*, 2005).

Quality parameters and Sensory evaluation parameters

The data on quality parameters (hulled/brown, milled, head rice recovery, grain length: breadth ratio, minimum cooking time, water absorption ratio, elongation ratio, cooking coefficient, protein) and sensory evaluation parameters (aroma, cohesiveness, tenderness, colour, overall acceptability) presented in Table 3 indicated that Pusa Basmati 1121 gave higher brown rice recovery (76.3%), milled rice recovery (67.6%), head rice recovery (51.9%) and L:B ratio (4.42) than Punjab Basmati 2 (75.4%) with non-significant difference. The long super fine kernels often exhibit white belly resulting in breakage, which lowers the head rice out-turn (Rani and Krishnaiah, 2001). Among nitrogen levels, 80 (3 splits; 0, 21, 65 DAS) kg N ha^{-1} performed better and gave significantly higher brown rice (77%), milled rice recovery (69.2%) and L:B ratio (4.48). Similar results were recorded by Vikram *et al* (2018).

Similarly, the non-significant differences were observed amongst the cultivars and the different levels of nitrogen with respect to time required for cooking, water absorption ratio and cooking coefficient. Punjab Basmati 2 (13.27 min) took maximum time for gelatinization of starch followed by Pusa Basmati 1121 (13.26 min). The size and surface area of the grain of different cultivars might be responsible for raised difference in cooking time. In contrast to this, Pusa Basmati 1121 showed higher elongation ratio (1.69), cooking coefficient (5.25) and more water absorption (3.29) as it required more time for cooking followed by Punjab Basmati 2. Both cultivars were statistically at par with each other. High grain elongation during cooking is generally considered a characteristic property of basmati rice (Kamath *et al*, 2008). In addition to this, protein content in grains is one of the important characters to judge the quality of rice. The cultivars had non-significant effect on protein content. The protein content (6.8%) was recorded in both cultivars. Levels of nitrogen increased the protein content in grains and the differences were significant.

Simultaneously, the scores for sensory evaluation for cooked basmati rice grain are given in Table 3 which indicated that aromatic compound and their intensity was affected by cultivars and different levels of nitrogen. The cultivars showed significant differences with respect to aroma. Grains of Pusa Basmati 1121 showed significant higher aroma score (3.47), cohesiveness (3.49), tenderness (3.43), colour score than Punjab Basmati 2 but there was not much variation in aroma and colour score, cohesiveness of grains at different levels of nitrogen. Therefore, the overall acceptability score (Table 3) was the mean score for all sensory attributes which depicted that there was significant difference among cultivars and different levels of nitrogen. Amongst cultivar Pusa Basmati 1121 (3.51) have significantly higher acceptability than Punjab Basmati 2 (3.43). Amongst nitrogen levels 80 (3 splits; 0, 15, 50 DAS) kg N ha^{-1} and 80 (3 splits; 0, 21, 65 DAS) kg N/ ha

Table 3. Influence of nitrogen levels on quality parameters of DSBR cultivars.

Treatment	Hulled rice recovery (%)	Milled rice recovery (%)	Head rice recovery (%)	L:B ratio	Minimum cooking time	Water absorption ratio	Elongation ratio	Cooking coefficient	Protein	Aroma	Cohesiveness	Tenderness	Colour	Overall acceptability
Cultivars														
Pusa Basmati 1121	76.3	67.6	51.9	4.42	13.26	3.29	1.69	5.25	6.8	3.47	3.49	3.43	3.68	3.57
Punjab Basmati 2	75.4	67.4	51.7	4.32	13.27	3.15	1.63	5.14	6.8	3.36	3.38	3.37	3.62	3.51
CD at 5%	NS	NS	NS	NS	NS	0.63	0.61	0.74	NS	0.38	0.37	0.38	0.44	0.42
Nitrogen levels (kg ha^{-1})														
T_1	74.6	65.2	49.3	4.25	13.28	3.15	1.63	5.15	6.8	3.29	3.31	3.30	3.55	3.43
T_2	75.1	66.5	49.6	4.29	13.25	3.15	1.65	5.15	6.7	3.32	3.34	3.33	3.58	3.46
T_3	75.6	67.4	51.4	4.37	13.28	3.20	1.65	5.20	6.8	3.39	3.41	3.40	3.65	3.54
T_4	76.1	67.6	51.3	4.38	13.25	3.23	1.65	5.20	6.9	3.40	3.43	3.42	3.67	3.55
T_5	76.6	69.0	55.1	4.46	13.25	3.28	1.68	5.23	6.9	3.53	3.56	3.48	3.73	3.62
T_6	77.0	69.2	53.9	4.48	13.28	3.30	1.70	5.25	7.0	3.54	3.56	3.48	3.73	3.62
CD at 5%	0.9	0.8	0.6	NS	NS	0.68	0.39	NS	0.1	0.76	0.77	0.76	0.82	0.78
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

treatments showed maximum overall acceptability score (3.58). However, interaction among different cultivars of basmati rice with levels of nitrogen found to be non-significant.

CONCLUSION

It was concluded from the study that the nutrient uptake of rice in Pusa Basmati 1121 were found to be significantly better than Punjab Basmati 2. It was observed that 60 kg N ha^{-1} performed better over recommended 40 kg N/ha when applied in 3 splits (0, 21 and 65 DAS). The soil status after harvest of the soil revealed that there is non-significant difference in organic carbon, available P and K with varying nitrogen levels whereas the available N status of the soil varied significantly with varying nitrogen levels. Pusa Basmati 1121 was also better in quality than Punjab Basmati 2 as indicated by its higher hulled rice recovery, milled rice recovery, head rice recovery, grain L: B ratio, water absorption, elongation ratio and cooking co-efficient. The sensory evaluation parameters *viz.,* aroma, cohesiveness, tenderness, colour and overall acceptability were significantly better in Pusa Basmati 1121 than Punjab Basmati 2.

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