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Performance of rice (*Oryza sativa*) varieties to applied nitrogen under irrigated condition

RAJESH KUMAR ARYA*, R.K. TIWARI, R. M. MISHRA, MANOJ KUMAR CHOUDHARI AND K.N. NAMDEO[1]**

Department of Environmental Biology, Awadhesh Pratap Singh University, Rewa (M.P.) 486 001

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ABSTRACT

A field experiment was carried out during rainy seasons of 2016 and 2017 at the Private Agriculture-Research Farm, Rewa (M.P.) to study the performance of rice (Oryza sativa) varieties to applied nitrogen under irrigated condition. Amongst the rice varieties, PS-5 recorded significantly higher tillers (433/m^2), effective tillers (243/m^2), panicle length (26.43 cm), panicle weight (3.64 g), total grains (132.7 panicle-^{1}), filled grains (114.8 panicle^{-1}) and 1000-seed weight (22.19 g). Thus, the maximum grain yield was 33.94 q ha^{-1} and net income upto Rs.45219 ha-^{1} with 2.60 B:C ratio. The variety IR-36 stood the second best in all these parameters. The highest level of 120 kg N ha^{-1} resulted in maximum grain yield (31.90 q ha-^{1}), net income (Rs.40590 ha^{-1}) with2.41 B:C ratio. The variety x N-level interactions was also found to be significant. Accordingly, PS-5 grown with 120 kg N ha^{-1} further augmented the grain yield (40.4 q ha^{-1}) and net income (Rs.57360 ha^{-1}) with 2.98 B:C ratio.

Key words: Rice varieties, nitrogen, irrigated conditions

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important food crop of India and belongs to the family Poaceae. In Madhya Pradesh, rice is grown in 15.59 lac ha area with the production of 14.62 lac tonnes and productivity of 989 kg/ha. It's productivity can be raised by adopting new varieties. Among the major nutrients, nitrogen application is essential to obtain the higher yields from rice. Nitrogen affects production through a number of mechanisms, viz. at cellular level. N increases the cell number and cell volume whereas at the leaf level it increases the photosynthetic rate and efficiency. Fertilizer N also increases proteins, the plant's metabolic component, as shown by increased nitrogen percentage in the plant tissues at higher N supply (Singh and Kumar, 2014). Nitrogen is an essential plant nutrient being a component of amino acid, nucleic acid, nucleotides, chlorophyll and enzymes which promotes rapid plant growth and improves grain yield and grain quality through higher tillering, leaf area development, grain formation, grain filling, and protein synthesis (Tiwari *et al.,* 2015). Varieties play an important role in enhancing the production as well as improve the quality of the grains like other crops. Rice varieties are also influenced by genotypic, phenotypic, environmental and physiological interactions. Day-by-day different varieties are being developed with desirable characters to suit under a particular environmental and agro-climatic conditions. Performance of different cultivars under different agro-climatic conditions with variation in the yield has been reported by several researchers using different N-levels. This was due to enhanced stature of yield attributes, forming larger sink size coupled with efficient translocation of photosynthesis to the sink. Nitrogen is responsible for more leaf area and dry matter production due to higher rate of photosynthesis. In fact leaf is the principal site of plant metabolism and the changes in nutrients supply are reflected in the composition of leaf. Leaf and chlorophyll content are the important parameters for photosynthesis of any crop variety which ultimately affect the crop productivity. In recent years, the development of hybrid rice varieties have shown better yield potential than the existing varieties mainly due to presence of larger sink. Nutrient management of improved rice differs considerably from the conventional varieties. It is, therefore, essential to evaluate the location-specific nutrient management to restore the nutrient balance in soil and to sustain the crop productivity.

*Corresponding author's email:rajeshkumararya53@gmail.com
**Email-rktkvkrewa@rediffmail.com, College of Agriculture, Rewa
[1]Email-drknnamdeo@gmail.com, College of Agriculture, Rewa (M.P.)

MATERIALS AND METHODS

The experiment was carried out during rainy seasons of 2016 and 2017 at the Private Agriculture-Research Farm, Rewa (M.P.). The soil of the experimental field was silty clay-loam having pH 7.3-7.4, electrical conductivity 0.30-0.35 dS m^{-1}, organic carbon 6.75-6.82 g kg^{-1}, available N 226-231 kg ha^{-1}, available P_2O_5 18.0-21.9 kg ha^{-1}, available K_2O 374-389 kg ha^{-1}, and available S 12.8-13.4 kg ha-^{1},. The total rainfall received during the cropping season (June to October) was 760 and 1499 mm in 2016 and 2017, respectively. The treatments comprised three levels of nitrogen (40, 80 and 120 kg ha^{-1}) in the main plots and six varieties (R-36, IR-64, Bandana, PS-3, PS-5 and Dantesvari) in the sub-plots. Thus the eighteen treatment combinations were laid out in the split-plot design keeping three replications. Twenty five days old seedlings were transplanted in rows 20 cm apart between 10-20 July in both the years. An uniform dose of 60 kg P_2O_5 and 20 kg K_2O ha^{-1} was applied as basal through SSP and MOP in all the treatments. The pertinent levels of nitrogen were applied as basal and in splits through urea. The crop was grown as per recommended package of practices. The rice varieties were harvested during 5 to 20 October in both the years. The growth characters were recorded at 30, 60 and 90 DAT yield attributes and yield were recorded at harvest.

RESULTS AND DISCUSSION

Growth parameters

The data (Table 1) reveal that amongst the varieties, Bandana resulted in significantly tallest plants (118.75 cm), lowest tillers (327/m^2) and effective tillers (223/m^2) at 90 DAT stage. On the other hand, PS-3 recorded the dwarfest plants (77.46 cm) at 90 DAT stage. PS-5 recorded the maximum tillers (433/m^2) and effective tillers (243/m^2). The IR-36 variety attained he second position with respect to all these parameters. Thus, at 90 DAT stage, the plant height was 91.37 cm, tillers 416/m^2 and effective tillers 235/m^2. The variations in the plant height and tillers formation among the different rice varieties have also been reported by many workers (Prafull Kumar *et al.,* 2015; Kumar *et al.,* 2015 and Nayak *et al.,* 2016).

Table 1: Growth parameters of rice as influenced by varieties and N-levels

Treatments	Plant height (cm)			Number of tillers/m^2			Effective tillers/m^2
	30	60	90 DAT	30	60	90 DAT	
Varieties							
IR-36	36.19	69.46	91.37	283	393	416	235
IR-64	33.40	56.36	82.96	235	339	253	206
Bandana	37.17	78.57	118.75	203	303	327	223
PS-3	33.80	57.05	77.46	226	334	259	228
PS-5	32.60	65.03	88.69	287	424	433	243
Dantesvari	33.72	55.82	82.07	236	347	384	185
CD (P=0.05)	2.22	8.00	10.55	23.20	43.48	38.00	3.23
N-levels (kg/ha)							
40	33.20	56.94	82.14	215	305	329	214
80	34.82	64.98	90.19	245	362	371	219
120	35.79	68.60	95.27	258	409	446	227
CD (P=0.05)	1.81	6.52	8.61	18.95	35.514	31.00	2.64

The applied nitrogen upto N_{120} enhanced the plant height upto 95.27 cm as against only 82.14 cm due to N_{40} at 90 DAT stage. Similarly numbers of tillers were 446/m^2 and effective tillers 227/m^2 under N_{120}, whereas under N_{40}, the tillers and effective tillers were 329 and 214/m^2, respectively. The maximum increase in growth parameters due to highest level of nitrogen may be on account of the fact that among the commonly applied major nutrients, nitrogen is the key element in rice production, which is structural components of protein molecules, amino acids, chlorophyll and other constituents. Its adequate supply promoted higher photosynthesis activity and vigorous vegetative growth. The plant height is predominantly affected by nitrogen levels which might be due to the fact that the nitrogen is essential for building of protoplasm and protein which induce cell division and initial meristematic activity. A higher nitrogen supply favoured the conversion of carbohydrates in to protein. In fact, nitrogen encouraged the plant foliage and boosted plant growth, because it is an integral part of chlorophyll, all proteins, enzymes and structural materials. Nitrogen functions as a stover of energy. It is also responsible for the dark-green colour of the leaves, vigorous growth, branching or tillering, leaf production and enlargement of leaf surface. The tremendous increase in growth parameters due to increased supply of nitrogen to rice has also been reported by many workers (Sharma, 2015; Vinod Kumar *et al.,* 2015; Tiwari *et al.,* 2015; Pandey and Namdeo, 2016; Tiwari, 2016 and Sudhakara *et al.,* 2017).

Yield-attributing parameters

The variety PS-5 recorded the maximum panicle length (26.43 cm), panicle weight (3.64 g), number of total grains (132.7/panicle), filled grains (114.8/panicle) and 1000-seed weight 2(2.19 g). This was followed by IR-36 and Bandana varieties. On the other hand, IR-64 and Dantesvari produced all these yield-attributes significantly lowest i.e. 21.56-21.70 cm panicle length, 2.25-2.45 g panicle weight, 101.3-103.3 grains/panicle, 74.5-77.0 filled grains and 19.18-19.35 test weight. The other varieties recorded the intermediate values of all these parameters. The higher yield attributes in PS-5, IR-36 and Bandana may be attributed to maximum increase in growth parameters and dry matter accumulation over other varieties which resulted in increased translocation (partitioning) of photosynthates towards the reproductive organics (sink). The varietal differences in yield-attributes of rice have been confirmed by the findings of researchers (Prafull Kumar *et al.,* 2015; Kumar *et al.,* 2015 and Nayak *et al.,* 2016). The increasing levels of nitrogen upto N_{120} resulted in maximum increase in yield-attributes i.e. 3.11g panicles weight, 23.84 cm panicle length, 127.1 total grains panicle^{-1}, 104.5 filled grains panicle^{-1}, 21.67 g 1000-seed weight. This was closely followed by N_{80}. On the other hand, the lowest N-level recorded the lowest panicle length (21.98 cm), panicle weight (2.29 g), total grains (107.8/panicle), filled grains 77.0 panicle^{-1} and test weight 18.81 g. It is a well known fact that the plants well supplied with nitrogen photosynthesize and accumulate more photosynthates for translocation towards reproductive organs.

Table 2: Yield-attributes, yield and economics of rice as influenced by varieties and N-levels

Treatments	Length of panicle (cm)	Weight of panicle (g)	Total grains/ panicle	Filled grains/ panicle	1000-seed weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Net income (Rs/ha)	B:C ratio
Varieties										
IR-36	23.37	2.73	120.1	107.0	21.93	31.18	49.71	35.47	39139	2.38
IR-64	21.70	2.45	103.3	77.0	19.18	24.06	56.23	32.24	25557	1.91
Bandana	22.08	2.81	126.5	78.0	18.81	25.51	46.33	36.74	27634	1.98
PS-3	22.19	2.54	116.3	85.4	20.44	25.18	46.16	37.68	26950	1.95
PS-5	26.43	3.64	132.7	114.8	22.19	33.94	55.19	43.78	45219	2.60
Dantesvari	21.56	2.25	101.3	74.7	19.35	26.84	56.04	34.59	31105	2.10
CD (P=0.05)	1.53	1.30	20.6	22.4	1.78	5.19	6.55	4.57		
N-levels (kg/ha)										
40	21.98	2.29	107.8	77.0	18.81	23.80	46.09	35.24	24727	1.90
80	23.17	2.79	117.8	96.9	20.48	27.75	51.85	36.78	32486	2.15
120	23.84	3.11	127.1	104.5	21.67	31.90	56.89	38.23	40590	2.41
CD (P=0.05)	1.24	1.05	15.7	18.3	1.38	4.24	5.34	3.73	----	----

Productivity of rice

The grain yield of PS-5 variety of rice was found to be significantly higher (33.94 q ha^{-1}) over all the remaining varieties except IR-36 (31.18 q ha^{-1}) being the second best (Table 2). This may be owing to higher yield-attributing parameters attained by PS-5 and IR-36 varieties over others. The remaining four varieties produced the equally lowest grain (24.06 to 26.84 q ha^{-1}). In fact, the grain yield is the resultant of coordinated interplay of growth and development characters. Thus, the productivity parameters are based on the cumulative effect of the genetic ability and production efficiency of the varieties, their fertility management and the agro-climatic conditions where these varieties are grown. The productivity of straw by different varieties was slightly different to that of seed. The varieties IR-64, PS-5 and Dantesvari produced equally higher straw (55.19 to 56.23 q ha^{-1}) than other varieties (46.16 to 49.71 q ha^{-1}). The yield of any crop depends on its capacity to accumulate photosynthates per unit time and its ability to mobilize the photosynthates towards the sink. In this respect, the varieties,PS-5 and IR-36 took a lead over IR-64, Bandana, PS-3 and Dantesvari varieties. The genotypic variability amongst the rice varieties towards their productivity parameters have also been reported by several research workers (Prafull Kumar *et al.,* 2015; Kumar *et al.,* 2015 and Nayak *et al.,* 2016). The highest levels of nitrogen (N_{120}) produced significantly higher grain (31.90 q/ha) as well as straw (56.89 q ha^{-1}), closely followed by N_{80} (27.75 and 51.85 ha^{-1}, respectively). The significantly lowest grain yield (23.80 q ha^{-1}) and straw yield (46.09 q ha^{-1}) of rice was obtained under lowest N_{40} nitrogen application. The grain and straw yield was found exactly in accordance with the vegetative growth and yield-attributing parameters under different levels of nitrogen. Thus, it is apparent that the plants adequately supplied with nitrogen might have synthesized more photosynthates which were translocated and stored in seed thus resulting higher seed yield. These findings corroborate with those of Tiwari *et al.* (2015), Pandey and Namdeo (2016), Sharma (2015), Tiwari (2016) and Sudhakara *et al.* (2017).

The harvest index was significantly higher (43.78%) in case of PS-5 variety as compared to rest of the varieties (34.59 to 37.68%). IR-64 recorded the lowest harvest index (32.24%). So many differences in HI among the varieties from different origins reveal the fact that there was a greater variation in the partitioning of assimilates from shoot to grain. Accordingly, the greater partitioning of assimilates from shoot to grain might have been in PS-5 variety, followed by PS-3 (37.68%) and Bandana (36.74%) and then IR-36 (35.47% HI). The harvest index (HI) was significantly higher (38.23%) due to 120 kg N ha^{-1} as compared to the lowest N level (35.24%). This indicates the fact that the significant rise in HI might be because of the increased grain production as compared to that of straw. Improvement in the HI might have been the main factor for increase in grain yield of overalls during green revolution through greater partitioning of assimilates from shoot to grain (Loss *et al.,* 1989).

Economics

Amongst the varieties, PS-5 gave the maximum net income upto Rs.45219 ha^{-1} with 2.60 B:C ratio. The variety IR-36 stood the second best (Rs.39139 ha^{-1} with 2.38 B:C ratio). Dantesvari was the third best (Rs.31105 ha^{-1} with 2.10 B:C ratio). The equally lower net income was secured from IR-64, PS-3 and Dantesvari. The variation in economical gain from different varieties was exactly in accordance with their grain and straw yields which fetched increased market value. With the increasing levels of nitrogen there was a corresponding increase in the grain yield which resulted in increasing monetary returns. Accordingly the application of 120 kg N/ha produced the highest grain yield and hence gave maximum net profit of Rs.40590 ha^{-1} with 2.40 B:C ratio. On the other hand, N_{40} gave the lowest income of Rs.24727/ha with 1.90 B:C ratio.

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