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DETERMINING THE NUTRITIONAL REQUIREMENTS OF RICE GENOTYPE JAJAI 25/A EVOLVED AT NIA, TANDO JAM, PAKISTAN

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Abstract

Field studies on rice genotype Jajai 25/A were carried out to investigate the effect of different nitrogen and phosphorus levels on its growth during kharif 2006 and 2007 at experimental farm NIA, Tando Jam, Pakistan. Three levels of nitrogen i.e., 60, 90 and 120 kg ha^{-1} and 7 levels of phosphorus i.e. 15, 23, 30, 40, 45, 60 and 90 kg P_2O_5 ha^{-1} alongwith control were employed to see their effect on its yield and yield components. The results revealed that the number of productive tillers per hill, number of grains per panicle, 100-grain weight and paddy yield showed increasing trend up to 90 kg N and 60 kg P_2O_5 ha^{-1}, while the plant height and straw yield showed the increasing trend up to 120 kg N and 90 kg P_2O_5 ha^{-1}. The highest average paddy yield (4780 kg ha^{-1}), number of grains per panicle (122.3), 100-grain weight (2.16 g) and productive tillers per hill (26.6) were recorded at 90 kg N and 60 kg P_2O_5 ha^{-1}, while the tallest plant (109.9 cm) and straw yield (5657 kg ha^{-1}) were obtained at 120 kg N and 90 kg P_2O_5 ha^{-1}. It would suggest that 90 kg N and 60 kg P_2O_5 ha^{-1} could be the optimum dose for this genotype under the agro-climatic condition of Tandojam, Pakistan.

Introduction

Rice *(Oryza sativa* L.) is an important food crop in the world. It is the staple food in South-East-Asia and at present more than half of the world population depends on this crop. Rice is also one of the most important cereals in Pakistan and occupies second position in cultivation after wheat. In Pakistan, it is grown on an area of 2.51 million hectares, with an annual production of 5.56 million tons giving an average yield of 2211 kg ha^{-1} (Anon., 2007-2008), which is far below than the other rice producing countries of the world. There are a number of factors contributing to this yield gap, including poor fertility of our soils. In fact there is no other alternative, than to use more and balance plant nutrition for high productivity (Ahmad, 1992).

Since the fertilizer is an expensive input, determination of its economical and appropriate dose to enhance crop productivity is imperative to fetch the maximum profit for the growers. At present, the world is facing the shortage of major fertilizers especially nitrogenous and phosphatic fertilizers. Even when their supply is satisfactory, importance of increasing use efficiency cannot be underestimated. The optimum use of fertilizer nutrient, particularly nitrogen plays an important role in boosting the yields (Mandal *et al.*, 1999). It is a fact that improper use of nitrogenous and phosphatic fertilizers, instead of giving yield advantage, may reduce the same (Bajwa & Rehman, 1998). Different varieties may have varying responses to N and P fertilizers depending on their agronomic traits. The application of nitrogen and phosphorous fertilizer either in excess or less than optimum rate affects both yield and quality to a remarkable extent (Manzoor *et al.*, 2006). Hence proper management of crop nutrition is of immense importance. Rice grain yield was recorded highest in case the N application ranged between 90-250 kg ha^{-1} (Bali *et al.*, 1995). The present study was, therefore, designed to find out the most suitable and appropriate combination of nutrients to enhance the productivity of rice under the agro-climatic condition of Sindh.

Materials and Methods

These studies were carried out during kharif season of two consecutive years (2006 and 2007) at NIA, experimental farm Tando Jam to study the nutritional requirements of rice genotype Jajai 25/A. The experimental site was silty clay in texture, non-saline in nature (ECe, 1.3 and 1.0 dS m^{-1}), low in organic matter (7.2 and 6.1 g kg^{-1}), Kjeldahl N (0.055 and 0.042%) and Olsen's P (6.7 and 6.3 mg kg^{-1}) at 0-15 and 15-30 cm. Urea, triple super phosphate (TSP) and sulfate of potash (SOP) were used as nitrogen, phosphorus and potassium sources, respectively. Three levels of nitrogen i.e., 60, 90 and 120 kg ha^{-1} and 7 levels of phosphorous (15, 23, 30, 40, 45, 60 and 90 kg P_2O_5 ha^{-1}) formed the treatment variables, whereas potash was applied at constant rate of 25 kg ha^{-1} in each treatment except control where no fertilizer was used. The experiment was laid out according to randomized complete block design with four replications. The unit plot size was 3 x 4 meter. The required quantity of TSP and SOP were applied at transplanting, whereas urea was applied in three equal splits (1/3 at transplanting, [1/3 at 50% tillering (8-12 tillers/hill) and remaining 1/3 at panicle initiation]. Rice genotype "Jajai 25/A" evolved at NIA, Tando Jam was transplanted as two plants per hill at inter-row and inter plant distance of 20 x 20 cm.. The requisite agronomic and plant protection measures were adopted uniformly for all the treatments throughout the growing period of crop. The crop was sampled at maturity, separated into straw and grains and dried in an oven at 70°C to a constant weight. A uniform sub portion of the dried material was ground in Willey's mill and required quantities of the ground material were digested in HNO_3: $HClO_4$ mixture prepared in 5:1 ratio. The digested material was analyzed for total P by metavanadate yellow colour method as described by Jackson 1962. For N determination the material was digested by modified Kjeldahl's method in which N is converted in NH_4^+ form by digestion with H_2SO_4. The NH_3 is distilled into boric acid and determined by titration with standard H_2SO_4 (Jackson, 1962). The soil samples were subjected to analysis for pH, EC, (Jackson, 1973). The mechanical analysis for soil separates to determine the texture was made using mechanical shaker and hydrometer, according to the method described by Bouyoucos (1962).

The results obtained were subjected to statistical analysis using standard method of analysis (Steel & Torrie, 1986) and treatment means were compared by employing Duncan's multiple range test at 5% level of probability (Duncan, 1955).

Results and Discussion

Plant height and productive tillers hill^{-1}: The data showed that the plant height varied significantly with the fertilizer treatments (Table 1). The maximum plant height of 109.8 cm was recorded where 120 kg N and 90 kg P_2O_5 ha^{-1} were applied, which was statistically at par with that obtained by 90 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}. However, the minimum plant height of 87.5 cm was observed in control. Singh & Sharma (1987) reported that application of 180 kg N ha^{-1} resulted in higher plant height of rice. Manzoor *et al*., (2006) reported the maximum plant height (145.56 cm) with application of 225 kg N ha^{-1}in rice variety Basmati 2000. Similar results were also reported by Kausar *et al*., (1993). The increase in plant height with increased N application might primarily be due to enhanced vegetative growth by increasing nitrogen supply to the plant (Manzoor *et al.*, 2006).

Table 1. Effect of N & P on agronomic parameters of rice genotype Jajai 25/A.

Treatments	Plant height (cm)			Tillers $hill^{-1}$		
(N & P kg ha^{-1})	2006	2007	Mean	2006	2007	Mean
Control	85.3 g	89.7 d	87.5 f	16.1 e	16.0 e	16.0 f
60-15	92.6 f	92.3 d	92.3 e	22.8 cd	19.2 d	20.9 e
60-30	100.9 de	101.3 c	101.1 d	24.5 abc	21.3 cd	22.9 cde
60-45	103.1 cde	101.7 c	102.4 d	23.7 bc	22.7 bc	23.2 cd
90-23	99.5 e	100.3 c	99.9 d	20.4 d	22.3 bc	21.4 de
90-45	103.3 cde	102.8 bc	103.1 cd	23.3 bc	24.3 ab	23.8 bc
90-60	105.5 bc	111.3 a	108.4 ab	27.1 a	26.0 a	26.6 a
120-40	104.7 bcd	107.7 ab	106.2 bc	25.8 ab	24.0 abc	24.9 abc
120-60	107.9 ab	109.5 a	108.7 ab	24.7 abc	26.3 a	25.5 ab
120-90	109.6 a	110.0 a	109.8 a	25.0 abc	26.7 a	25.8 ab
lsd	4.034	5.755	5.344	2.82	2.785	2.009

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 2. Effect of N & P on agronomic parameters of rice genotype Jajai 25/A.

Treatments	100 grain weight (g)			No. of grains $Panicle^{-1}$		
(N & P kg ha^{-1})	2006	2007	Mean	2006	2007	Mean
Control	1.25 d	1.27 f	1.26 e	74.8 f	74.8 h	74.8 f
60-15	1.56 c	1.58 e	1.57 d	103.3 e	94.7 g	99.0 e
60-30	1.50 c	1.66 d	1.58 d	112.7 d	100.0 fg	106.3 d
60-45	1.95 b	1.88 c	1.92 c	113.1 cd	103.3 ef	108.2 d
90-23	1.88 b	1.94 bc	1.92 c	119.0 abcd	108.0 de	113.5 c
90-45	2.05 ab	2.00 b	2.02 b	124.8 a	112.0 cd	118.4ab
90-60	2.15 a	2.18 a	2.16 a	122.9 ab	121.7 a	122.3 a
120-40	2.03 ab	1.93 bc	1.98 bc	119.7 abc	115.3 bc	117.5 bc
120-60	1.91 b	1.95 bc	1.93 c	119.7 abc	119.0 ab	119.4 ab
120-90	1.88 b	1.96 b	1.92 c	117.4 bcd	118.0 ab	117.7 abc
lsd	0.1715	0.07671	0.09053	6.993	5.818	4.634

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Number of productive tillers per hill was significantly influenced by different nitrogen and phosphorus treatments (Table 1). Rice plants yielded more number of productive tillers per hill (26.6) when 90 kg N and 60 kg P_2O_5 ha^{-1} were applied, all these values remained statistically at par with 120 kg N and 90 kg P_2O_5 ha^{-1},. Least productive tillers (16.1) were recorded in control. Enhanced tillering by increased nitrogen and phosphorus application might be attributed to more nitrogen supply to plant at active tillering stage. These results are in conformity with those of Manzoor *et al*., (2006).

100-grain weight and grain $panicle^{-1}$: Data regarding 100-grain weight presented in Table 2 revealed that grain weight was significantly affected by the application of different levels of nutrients. Fertilization of the crop treatments resulted in significantly higher grain weight than unfertilized crop. The maximum 100-grain weight (2.16 g) was recorded in plots where N and P_2O_5 were applied at 90 kg and 60 kg ha^{-1}. Control gave minimum 100-grain weight at 1.26 g. Similar results were reported earlier by Bali *et al*., (1995) and also by Singh & Sharma (1987). Increase in grain weight at high nitrogen and phosphorus rates might be primarily due to increase in chlorophyll concentration in levels which led to higher photosynthetic rate and ultimately plenty of photosynthates available during grain development (Kausar *et al*., 1993).

Maximum number of grains per panicle (122.3) was recorded at 90 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} and it did not differ statistically up to 120 kg N ha^{-1} and 90 kg P ha^{-1}. The lowest value of this parameter (74.8) was recorded in control. Marazi (1993) also reported similar findings. The more number of grains per panicle in higher N and P rates were probably due to better N and P status of plant during panicle growth period (Manzoor *et al*., 2006).

Paddy and straw yield: The paddy yield data (Table 3) revealed a positive response to N and P fertilizer treatment. The pooled data of paddy yield revealed that rice crop responded significantly to nitrogen and phosphorous fertilizers application. The highest paddy yield (4780 $kgha^{-1}$) was recorded where N and P were applied at 90 and 60 kg ha^{-1}, which was statistically at par with 120 kg N and 90 kg P_2O_5 ha^{-1}. The lowest paddy yield (2463 kg-ha^{-1}) was recorded in control. Phosphorus fertilization increased average grain yield (1Mg ha^{-1}) by 20% (Georage *et al.*, 2001). The higher paddy yield at higher nitrogen and phosphorous rates were also reported by other workers (Khan *et al*., 2008). The reason might be that phosphorous contributed substantially to the root development as a result of which nutrient and water absorption was increased, thus resulting in increased paddy yield. A significant decline in paddy yield at 120 kg N and 40 kg P_2O_5 ha^{-1} level might be due to imbalance ratios which reduced the number of grains per panicle and 100-grain weight at this N and P levels.

Rice straw yield was significantly enhanced with the addition of N and P fertilizer (Table 3). The highest straw yield 5657 kg ha^{-1} was recorded where 120 N and 90 kg P_2O_5 ha^{-1} was used which was statistically identical to that produced by 90 N and 60 kg P_2O_5 but different from rest of the fertilizer treatments. The better growth and higher straw yield with increasing N and P levels can be attributed to the most important functions of the N, in enhancing the vegetative growth (Ma *et al*., 2004). Phosphorus seems to have an additive effect on crop growth provided it is supplied in a balanced proportion to that of applied N (Brink, 2001).

Nitrogen and phosphorous uptake (kg ha^{-1}): The nutrient uptake by rice plants was increased significantly with increasing N and P levels (Table 4). The highest N uptake in rice crop was escalated from 23.3 to 114.7 kg ha^{-1} when N was applied from 0 to 120 kg ha^{-1}. The highest total N uptake (114.6 kg ha^{-1}) was recorded with the application of 120 kg N ha^{-1}, whereas the lowest N uptake (23.3 kg ha^{-1}) recorded in the control. These results are similar to those recorded by Mandal *et al*., (1999) who reported that appropriate proportion of nutrients in soil facilitates their uptake by the plants. Successive increase in N at each level showed a tendency to increase N uptake in plants (Hossain *et al*., 2005). Consecutive increments in P fertilization at each N dose significantly improved the efficiency of N usage, which reflects strong synergism between both elements. Khan *et al.*, (2008) observed that nitrogen uptake by rice was escalated from 46.1 to 125.1 kg ha^{-1} when N application rate was increased from 0 to 150 kg ha^{-1}.

Total Phosphorus uptake was influenced significantly by the levels of P application (Table 4). Phosphorus uptake increased linearly with the corresponding increase in P application rates. The highest total P uptake of 15.5 kg ha^{-1} was recorded with 90 kg P_2O_5 ha^{-1}, which was statistically at par with 60 kg P_2O_5 ha^{-1} and the lowest was noticed (2.6 kg ha^{-1}) in the control. Similar results were found by Hossain *et al*., (2005) who observed that the application of 25 mg P_2O_5 kg^{-1} in soil significantly increased phosphorous uptake by wheat crop. Khan *et al*., (2009) observed that the highest phosphorus uptake of 17.9 kg was recorded with 135 kg P_2O_5 ha^{-1} and the lowest (4.2 kg) in the control in wheat. Khan *et al.*, (2008) also observed highest P uptake of 12.3 kg ha^{-1} with 120 kg P_2O_5 ha^{-1} and the lowest (4.9 kg) in control in rice. Phosphorus fertilization increased P uptake (4.1 kg ha^{-1}) by 53% (Georage *et al*., 2001).

Table 3. Effect of different fertilizer levels and ratios on the yield of rice genotype Jajai 25/A.

Treatments (N & P kg ha^{-1})	Yield kg ha^{-1}					
	Paddy			Straw		
	2006	2007	Mean	2006	2007	Mean
Control	2287 d	2639 f	2463 f	2719 e	3750 d	3235 f
60-15	3837 c	3833 e	3835 e	3578 d	4567 c	4072 e
60-30	3784 c	4278 d	4031 de	3958 c	5622 b	4790 d
60-45	3972 bc	4694 bc	4333 b	4089 c	5561 b	4825 d
90-23	3928 bc	4444 cd	4186 d	4367 b	5203 b	4785 d
90-45	3904 bc	4722 bc	4313 b	4419 b	5556 b	4986 c
90-60	4393 a	5167 a	4780 a	4956 a	5867 ab	5411 ab
120-40	3654 c	4694 bc	4174 d	4953 a	6239 a	5596 ab
120-60	3713 c	4722 bc	4217 cd	4917 a	6355 a	5636 a
120-90	4264 a	4805 b	4534 ab	4953 a	6361 a	5657 a
Lsd	325.3	309.8	330.6	177.0	487.1	343.7

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 4. Total nitrogen uptake as influenced by different N & P application.

Treatments (N & P kg ha^{-1})	Total N uptake (kg ha^{-1})			Total P uptake (kg ha^{-1})		
	Grain + Straw		Mean	Grain + Straw		Mean
	2006	2007		2006	2007	
Control	25.2 g	21.3 h	23.3 f	2.6 g	2.7 e	2.6 h
60-15	49.3 f	44.4 g	46.9 e	6.0 f	6.7 d	6.4 g
60-30	59.2 e	52.3 fg	55.8 e	8.8 d	8.9 c	8.8 e
60-45	73.5 d	64.4 f	68.9 d	10.6 c	9.0 c	9.8 d
90-23	76.9 d	66.2 ef	71.6 d	7.5 e	7.7 d	7.6 f
90-45	86.2 c	81.9 de	84.1 c	12.3 b	10.7 b	11.5 c
90-60	97.7 b	90.8 cd	94.3 b	14.1 a	16.6 a	15.4 a
120-40	89.1 bc	100.1 bc	94.6 b	10.8 c	11.6 b	11.2 c
120-60	90.7 bc	110.1 ab	100.4 b	12.2 b	15.9 a	14.0 b
120-90	108.6 a	120.7 a	114.7 a	15.0 a	16.0 a	15.5 a
lsd	8.896	16.37	9.084	0.9943	1.612	0.9336

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Nitrogen and phosphorous recovery (%): Nitrogen recovery was significantly affected by different levels of nitrogen (Table 5). The highest total N recovery of 75.0 was recorded where N and P were applied at 90 and 60 kg ha^{-1}, which was statistically identical to that produced by 120 N and 90 kg P_2O_5. These findings are in close conformity with those reported by Hossain *et al*., (2005). Recoveries of fertilizer N however, decreased with the subsequent increase in N application rates. The lowest values of N recovery 38.9 % was recorded with 60 kg N and 15 kg P_2O_5 ha^{-1}. The highest P recovery recorded was 24.7% at 15 kg P_2O_5 ha^{-1} (Table 5), while the lowest value of 14.3% was recorded with 90 kg P_2O_5 ha^{-1}. Similar findings have been reported by Brink *et al*., (2001) and Mahabari *et al*., (1996).

Conclusion

The rice genotype (cv. Jajai 25/A) performed efficiently with increasing N and P_2O_5 levels. The maximum yield was produced by 90 kg N and 60 kg P_2O_5 ha^{-1} hence, it can be considered as the most economical dose for this genotype when grown on silty clay soil.

Table 5. Nutrient recoveries as influenced by different N & P application.

Treatments (N & P kg ha^{-1})	Total N Recovery (%)			Total P Recovery (%)		
	Grain + Straw		Mean	Grain + Straw		Mean
	2006	2007		2006	2007	
Control	0.0 e	0.0 e	0.0 f	0.0 f	0.0 e	0.0 e
60-15	40.3 d	37.5 d	38.9 e	23.1 a	26.6 a	24.7 a
60-30	56.7 c	50.0 cd	53.4 d	20.7 bc	20.7 bc	20.7 bc
60-45	80.5 a	69.6 ab	75.0 a	17.8 d	14.0 d	15.9 d
90-23	57.5 c	44.8 cd	51.2 d	21.4 ab	21.8 b	21.5 b
90-45	67.8 b	59.5 abc	63.7 bc	21.6 ab	17.6 cd	19.6 bc
90-60	80.6 a	69.4 ab	75.0 a	19.3 bc	23.2 ab	21.2 b
120-40	53.3 c	57.5 bc	55.4 cd	20.6 bc	22.1 b	21.3 b
120-60	54.6 c	66.5 ab	60.5 cd	16.1 d	22.0 b	19.0 c
120-90	69.5 b	75.7 a	72.6 ab	13.8 e	14.7 d	14.3 d
Mean	9.189	16.26	9.622	2.271	3.68	2.112

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

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