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Full Length Research Paper

Studies on the nutritional requirements of candidate rice genotype Bas-15-1

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A field study was conducted at experimental farm of Nuclear Institute of Agriculture (NIA), Tando Jam to evaluate the nutritional requirements of candidate rice genotype Bas-15-1 evolved at Nuclear Institute of Agriculture (NIA), Tando Jam. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications during kharif 2010. Four levels of N (0, 60, 90 and 120 kg ha^{-1}), eight levels of P_2O_5 (0, 15, 23, 30, 40, 45, 60 and 90 kg ha^{-1}) along with 25 kg K_2O ha^{-1} in ten combinations were employed in (4:1, 4:2 and 4:3 N: P ratios). Yield and yield components i.e., grains per panicle, 100-grain weight, productive tillers per plant, value cost ratio (VCR). The results indicated that N and P recoveries significantly enhanced with successive increment of N and P up to 90 kg and 60 kg ha^{-1} respectively. Maximum paddy yield (3.99 tons ha^{-1}) was obtained at 90 kg and 60 kg ha^{-1}, further increasing of N & P could not benefit the paddy yield. Application of 90 kg N and 60 kg P_2O_5 ha^{-1} also produced higher number of grains per panicle (165) along with maximum 100-grain weight (2.38 g), productive tillers per plant (20.1), value cost ratio (5.34) and N recovery (102.2%), while the plant height (128 cm) and N and P uptake (107.3, 14.10 kg ha^{-1}) were maximum at 120 kg N + 90 kg P_2O_5 ha^{-1} Therefore, recommending higher rate (120 kg N + 90 kg P_2O_5 ha^{-1}) is neither judicious nor economical while the application of N in a concentrations of90 kg ha^{-1} and P in a concentration of 60 kg P_2O_5 ha^{-1} are the most economical amounts under the same indigenous conditions.

KEYWORDS: *Oryza sativa* L, agronomic characters, nitrogen, phosphorous fertilizers, uptake, recovery.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops of the world, grown in wide range of climatic zones to nourish the mankind. It is an essential cash crop and one of the main export items of Pakistan. Its accounts 2.7 percent of the value added in agriculture and 0.6 percent of GDP. Rice is cultivated on 2311 thousand hectares, 10.1 percent less than last year's area of 2571 thousand hectares with an average yield of 2398 kg ha^{-1}. Production of the crop is estimated at 5541 thousand tonnes, against the target of 6900 thousand tonnes shows a weak performance of 19.7 percent and to compare last year production which was 6160 thousand tones shows a decrease of 10.0 percent (Anonymous, 2012-2013). This average yield is much lower than most of the rice growing countries of the world.

The ultimate yield of rice crop is controlled by genetic as well as external factors. It is well recognized that the inputs like improved variety, balanced fertilizers, plant protection measures and weed control, all collectively contribute in increasing the yield of crops. However, there is a wide gap in researcher's and farmer's yield in Pakistan, in spite of the fact that use of fertilizer has increased more than double Heffer, (2007). Efforts are being made to narrow the gap between researcher yield and field yield of rice crop. The constraints of rice yield include use of non judicious application of fertilizers and use of low responsive varieties to fertilizers, (Mondal 2011) Blanced fertilizer i.e., use of fertilizer nutrients in right proportion and in adequate

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amount are considers as promising agrotechniques to sustain yield, increase fertilizer use efficiency and to restore soil health balanced use of all nutrients is essential because no agronomic manipulation can produce high efficiency out of an unbalanced nutrient use (Yadav *et al*., 1998).along with other biotic and abiotic factors. Nitrogen is the key element which is used mainly for rice production. But under flooding conditions its efficiency is very low (Zia *et al*., 1988). Besides nitrification, denitrification leaching and immobilization its major losses occur due to NH_3 volitization (Kai *et al.,* 1986). The applied nitrogenous fertilizers therefore, need to be utilized more efficiently by the crop through proper and timely methods of application and judicious crop requirements. Low soil P may also be one of the reasons for low harvests 90% soils of Pakistan suffer from moderate to severe P deficiency (Aslam *et al.,* 2009). Phosphorus fertilization is therefore, very essential for exploiting maximum yield potentials of different crop plants (Rashid *et al.,* 1994). In Pakistan the increasing price of phosphate fertilizer emphasizes the need to find some methodology for improving the efficiency of added fertilizer (Twyford, 1994).

At present, the world is facing the problem of shortage of major fertilizer nutrients especially nitrogen (Manzoor *et al*., 2006). The developing countries like Pakistan are more sensitive to this shortage because the fertilizer production in these countries is expensive and less than its demand (Manzoor *et al*., 2006). Even when the fertilizer supply is satisfactory, it is important to increase its use efficiency. The application of fertilizer either in excess or less than optimum rate affects both yield and quality of rice to a remarkable extent, hence proper management of crop nutrition is of immense importance Manzoor *et al.,* 2006b).

The need of the day is to devise technologies from the existing resources for easy adoption by the farming community to gain maximum sustainable production. The inefficient utilization of these available resources as well as the poor access to the inputs for the farmers need to be addressed (Dixit and Gupta, 2000) as these are main impediments to sustainable agriculture. Consequently, to obtain high yields of rice from this environment, it is apparently important to add nitrogen and phosphorus fertilizers and the application of nitrogen to be split in order to increase fertilizer use efficiency (Ghobrial, 1980). As response to added nitrogen and phosphorus in rice varies with variety, soil types, climate and cropping system Ghobrial, 1982, the present study was undertaken to devise such a nutritional package for new rice genotype Bas-15-1 which may give economical paddy yield on sustainable basis.

MATERIALS AND METHODS

Field studies were conducted during kharif 2010 at the Experimental Farm of the Nuclear Institute of Agriculture, Tando Jam to assess the nutritional requirements of newly evolved candidate rice genotype Bas-15-1. Composite soil samples from experimental site were collected from 0-15 and 15- 30 cm depth before transplanting. All the samples were analyzed for soil texture (Koehler *et al*., 1984), Soil $EC_{(1:5)}$ (Richards, 1954), Organic matter (Nelson and Sommers, 1982), pH (McLean, 1982), AB-DTPA extractable P and K (Olsen and Sommer,1982) and Total nitrogen was determined using Kjeldahl distillation procedure as described by Bremner and Mulvaney (1982). The experimental site was silty clay in texture, non-saline in nature (EC 0.69 and 0.54 dS m^{-1}), pH (7.6 and 7.9) low in O.M (0.75 and 0.78%), having Kjeldahl N (0.039 and 0.041 %), Olsen's P (7.2 and 6.5 mg kg^{-1}) and Exchangeable K (220 and 160 µg g^{-1}). Four levels of N (0, 60, 90 and 120 kg ha^{-1}), eight levels of P_2O_5 (0, 15, 23, 30, 40, 45, 60 and 90 kg ha^{-1}) along with 25 kg K ha^{-1} in ten combinations were employed in (4:1, 4:2 and 4:3 N: P ratios). The experiment was laid out according to randomized complete block design with three replications. The required quantity of N in the form of urea was divided in three equal splits (1/3 at transplanting, [1/3 at 50 percent tillering (6-10 tillers/plant) and remaining 1/3 at panicle initiation] while P_2O_5 in the form of triple super phosphate (TSP) was applied at the time of transplanting according to the quantity required for each treatment.

The nursery of candidate rice variety Bas-15-1 developed by plant Genetics Division of NIA, Tando Jam was used for the evaluation of nutrient requirements prior to its release. Rice was transplanted at inter-row spacing of 20 cm. Plots received identical cultural treatments in terms of ploughing, transplanting method, potassium fertilizers, and insect control. At maturity, the data was recorded for biological and paddy yield after harvesting the crop. The plant samples were then collected randomly from each treatment and separated into straw and paddy. Both of these plant parts were dried at 70 ^{o}C in an oven at a constant weight for determination of nitrogen and phosphorus. A uniform sub-portion of the dried material was ground in Wiley's mill and a known quantity of the ground 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). Total P was also determined by digesting the plant material in HNO_3: $HClO_4$ mixture prepared in 5:1 ratio. The digested material was analysed for total P by metavanadate yellow colour method as described by Jackson (1962).The concentration of N and P so obtained were used for

Table 1: Effect of N and P on Agronomic Parameters of Rice Genotype Bas-15-1

Treatments (N& P kg ha^{-1})	Plant height (cm)	No of productive Tillers $plant^{-1}$	100 grain weight (g)	Grain No. $Panicle^{-1}$
Control	105.2 e	6.9 g	1.70 d	98 d
60-15	110.3 d	10.3 f	1.84 d	116 c
60-30	115.1 c	12.9 e	2.11 bc	124 c
60-45	119.9 b	15.5 d	2.13 abc	144 b
90-23	115.1 c	16.1 cd	1.92 cd	139 b
90-45	121.3 b	16.9 bcd	2.19 ab	151 b
90-60	126.1 a	20.1 a	2.38 a	165 a
120-40	119.2 b	17.2 bc	2.15 abc	152 ab
120-60	126.3 a	18.5 ab	2.19 ab	151 b
120-90	128.4 a	18.9 a	2.21 ab	143 b

Values followed by different letters are significantly different at $P \leq 0.05$ by the DMR Test

calculating NP-uptake and recovery using following formulae (Ali *et al*., 2005).

Nutrients uptake (kg ha^{-1}) = [Yield (kg ha^{-1}) X Concentration of nutrients in plant (%)]/ 100

Nutrients recovery (%) = [Nutrient uptake (fertilized)-Nutrient uptake (control) X 100] / Nutrient applied (kg ha^{-1})

Analysis of variance of the data from each attribute was computed using the MSTAT Computer Program (MSTAT Development Team, 1989).The Duncan's New Multiple Range test at 5% level of probability was used to test the differences among mean values (Steel and Torrie, 1997).

RESULTS AND DISCUSSION

Agronomics traits:

The results showed that plant height, number of productive tillers per plant, 100-grain weight and number of grains per panicle were significantly influenced by different nitrogen and Phosphorous applications (Table 1). Maximum plant height of 128.4 cm was recorded at 120 kg N + 90 kg P_2O_5 ha^{-1} which was statistically identical to 126.1 cm obtained from 90 kg N + 60 kg P_2O_5 ha^{-1}. However minimum plant height (105.2 cm) was recorded in control treatment where no fertilizer was applied. (Manzoor *et al*., 2006) reported that application of 180 kg N per hectare resulted in higher plant height of rice. The increase in plant height by splitting nitrogen in 3 equal doses instead of a single dose might be the result of efficient nitrogen uptake by plant, which ultimately led to improvement in plant growth (Raza *et al*., 2003; Hossain *et al*., 2005)

The data regarding number of productive tillers per plant are given in Table 1 which showed that number of productive tillers per plant increased with each increment of N & P fertilizer levels. The maximum number of productive tillers per plant was produced (20.1) at 90 kg N + 60 kg P_2O_5 which was statistically at par to that obtained by 120 N + 90 P_2O_5 kg ha^{-1}. Enhanced tillering by increased N & P application might be attributed to balance nitrogen and phosphorus supply to plant at active tillering stage. These findings are in close conformity with those reported by Samrathlal *et al.,*2003. The increase in productive tillers with increasing number of N splits might be due to increased nitrogen uptake efficiency and reduction in nitrogen loss by volatilization and leaching. The efficient nitrogen uptake by rice plants resulted in better growth and development (Meena *et al.,* 2003).

The results showed that 100-grain weight was also significantly increased with corresponding increase in N & P levels (Table 1). Relatively heavier grains were produced (2.38 g) at 90 kg N + 60 kg P_2O_5 level. The control treatment produced the lowest grain weight (1.70 g). Similar findings have already been reported by, Hossain *et al*., (2005) who suggested that the N and P in appropriate proportion are vital for formation and development of grains.

The number of grains per panicle was more (165) at 90 kg N + 60 kg P_2O_5 level which was significantly higher than 120 kg N + 90 kg P_2O_5 ha^{-1}, which may be due to better nitrogen and phosphorous ratio of plant during panicle growth period (Khan *et al.,* 2008).These findings corroborate with the results reported by Nawaz, (2002).

Straw and Paddy Yield

Without added nitrogen, rice plants were pale green, short statured and lack of vigour. The growth of plants as expressed by straw yield was significantly and progressively increased with the rise in levels of nitrogen and phosphorus however, beyond 120 kg N

Table 2: Effects of N and P on Yield of Rice Genotype Bas-15-1

Treatments (N& P kg ha^{-1})	Yield (tons ha^{-1})		VCR
	Rice Straw	Paddy	
Control	2.11 g	1.48 h	-
60-15	2.82 f	1.90 g	1.98
60-30	3.81 e	2.56 f	3.96
60-45	4.60 d	3.22 d	5.17
90-23	4.46 d	2.91 e	4.44
90-45	5.32 c	3.68 c	5.32
90-60	5.99 a	3.99 a	5.34
120-40	5.46 bc	3.75 bc	4.80
120-60	5.49 bc	3.76 bc	4.15
120-90	5.63 b	3.85 b	3.01

Values followed by different letters are significantly different at $P \leq 0.05$ by the DMR Test

Table 3: Nutrient Concentration as influenced by different N and P levels

Treatments (N& P kg ha^{-1})	N Concentration (µg g^{-1})		P Concentration	
	Grain	Straw	Grain	Straw
Control	89.3 g	9.05 h	6.38 d	3.85 f
60-15	178.0 f	12.03 g	15.51 c	6.80 e
60-30	192.7 f	17.70 f	15.86 c	7.00 de
60-45	198.7 de	23.18 e	18.65 b	8.54 ab
90-23	205.3 d	25.18 de	16.29 c	7.08 cde
90-45	216.7 c	26.37 cd	22.23 a	8.01 a-e
90-60	225.3 abc	29.03 b	21.94 a	8.35 abc
120-40	221.3 bc	28.18 bc	19.56 b	7.36 b-e
120-60	227.3 ab	29.52 ab	21.72 a	8.30 a-d
120-90	232.0 a	31.85 a	23.38 a	9.04 a

Values followed by different letters are significantly different at $P \leq 0.05$ by the DMR Test

and 90 kg P_2O_5 ha^{-1} the plants became excessively leafy and maturity was delayed for two weeks.

Maximum yield of rice straw of 5.99 tons ha^{-1} was obtained with 90 kg N + 60 kg P_2O_5 ha^{-1} (Table 2) which was significantly higher than the straw yield of 5.63 tons ha^{-1} recorded at 120 kg N + 90 kg P_2O_5 ha^{-1}. The combinations of N and P in 3:2 ratio have significantly increased the paddy yield. Without addition of nitrogen and phosphorus paddy yield 1.48 tons ha^{-1} compared to 3.99 tons ha^{-1} with addition of the optimal levels (90 kg N plus 60 kg P_2O_5 ha^{-1}) and further increasing the rate of N & P could not enhanced paddy yield (Table 2). It might be due to the reason that 90 kg N + 60 kg P_2O_5 ha^{-1} was sufficient under the experimental condition. The high potential for rice production in same environment is evidently restricted by the addition of relatively high rates of nitrogen and phosphorus. Likely response was reported by Khan *et al.,* 2008, Yanni and Hegazy 1990, Awan *et al.,* (2007) The identical increasing trend was observed in VCR. The highest paddy yield at 90 kg N + 60 kg P_2O_5 ha^{-1} may be attributed to healthy plant growth due to efficient N and P uptakes and having higher grain weight, which ultimately resulted in higher paddy yield. Increase in grain yield at 90 kg N ha^{-1}, nitrogen might be primarily due to increase in chlorophyll content of leaves which led to higher photosynthetic rate and ultimately plenty of photosynthates available during grain development (Samrathlal *et al*., 2003.

Nitrogen and Phosphorus Concentrations (µg g^{-1})

The chemical composition of any plant is an important parameter to compare the performance of treatments applied. Nitrogen is very important for plant growth because of constituent of major cell parts and protein production (Meena *et al*., 2003). The N concentration in rice (both straw and grain) varied significantly by the application of N ($P<0.05$). The data presented in (Table 3) indicated that N concentrations in rice straw and grain increased significantly as a function of increase in N levels. Higher N concentrations in grain and straw were 232 and 31.85 (µg g^{-1}), respectively, which were obtained with 120 kg N ha^{-1} as compared to 89.3 in grain and 9.05 in straw (µg g^{-1}) in control. These findings are in close conformity with those reported by

Table 4: Nutrient uptake as influenced by different N and P levels

Treatments (N& P kg ha^{-1})	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**
Control	13.19 h	1.91 h	15.17 h	0.94 h	0.81 f	1.75 h
60-15	33.81 g	3.39 g	37.20 g	2.95 g	1.91 e	4.86 g
60-30	49.36 f	6.70 f	56.06 f	4.06 f	2.65 d	6.71 f
60-45	63.90 d	10.68 e	74.58 d	6.01 d	3.92 c	9.93 d
90-23	59.63 e	11.21 e	70.84 e	4.72 e	3.15 d	7.88 e
90-45	79.76 c	14.01 d	93.77 c	8.19 b	4.44 bc	12.46 b
90-60	89.83 a	17.35 ab	107.20 a	8.74 ab	4.98 ab	13.73 a
120-40	82.89 bc	15.35 c	98.24 b	7.29 c	4.01 c	11.31 c
120-60	85.57 b	16.18 bc	101.70 b	8.17 b	4.53 abc	12.70 b
120-90	89.36 a	17.91 a	107.30 a	9.01 a	5.08 a	14.10 a

Values followed by different letters are significantly different at $P \leq 0.05$ by the DMR Test

(Yanni and Hegazy, 1990) and Awan and Baloch 2005.

Plant P concentrations were also significantly influenced at each level of P fertilizer application (Table 3). The lowest plant P concentration in grain and straw (6.38 and 3.85 µg g^{-1}) recorded in the control (P0) was significantly lower as compared to all other treatments. Highest plant P concentration in grain and straw (23.38 and 9.04 µg g^{-1} respectively) observed with 90 kg P_2O_5 ha^{-1} applied P was significantly different from other treatments. The data further showed that 60 kg of applied P was statistically identical to 90 kg P with respect to plant P concentrations. This higher absorption of the nutrients by plants relates to their higher availability of nutrients for particular treatments Hossain *et al*., (2005) and Awan *et al.,* (2007). Our results also correspond to the findings of Rahim *et al.,* (2010) who reported the increasing trend of P concentrations with the increasing P levels.

Nitrogen and Phosphorous Uptake (kg ha^{-1})

The data regarding nitrogen uptake depicted in Table 4 showed that the maximum uptake of N (107.30 kg ha^{-1}) was in treatment where 120 kg N ha^{-1} was applied and minimum was in control. Nitrogen uptake in straw was found to be highly coincided i.e., increased with increase N in soil. Similar pattern as in straw was also found in grain. Mannan, 2005 reported that N uptake in grain and straw increase with increasing levels of N.
Successive increments in P fertilization at each N dose (Table 4) significantly improved the efficiency of N usage, which reflects strong synergism between both elements. Phosphorus harvests also increased linearly with the corresponding increase in P application rates. The highest P uptake of 14.1 kg ha^{-1} was recorded with 90 kg P_2O_5 ha^{-1} and the lowest (1.75 kg ha^{-1}) in the control treatment. The results are compatible with the findings of Awan *et al.,* 2007 and Haefele & Wopereis, 2005 and Khan *et al.,* 2008 who also reported the optimum proportions of nutrients in soil facilitating their uptake by the plant.

Nitrogen and Phosphorous Recovery (%)

Nitrogen recovery was significantly affected by various combinations of nitrogen. (Table 5) The highest total N recovery of 102.2% was recorded where N and P were applied at 90 and 60 kg ha^{-1} while lowest was recorded (36.72 %) in control. 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 highest P recovery recorded was 26.59% at 23 kg P_2O_5 ha^{-1} (Table 5), while the lowest value of 13.92% was recorded with 90 kg P_2O_5 ha^{-1}. At higher level of P application, its availability in the soil gets in excess of the requirement of crop which results in low recovery of applied phosphorus (Awan *et al.,* 2007). The results are in accordance with the findings of Khan *et al*., 2008.

CONCLUSION

The genotype (Bas-15-1) performed efficiently with increasing N and P_2O_5 levels and their ratios. Maximum paddy yield 3.99 tons ha^{-1} was obtained with 90 kg N + 60 kg P_2O_5 ha^{-1}(3:2), which was significantly higher than the paddy yield of 3.85 tons ha^{-1} recorded at 120 kg N + 90 kg P_2O_5 ha^{-1}(4:3). The combinations of N and P in 3:2 ratio have significantly increased the paddy yield. Without addition of nitrogen and phosphorus paddy yield was 1.48 tons ha^{-1} compared to 3.99 tons ha^{-1} with addition of the optimal levels (3:2) and further increasing the rate of N & P could not enhanced paddy yield hence, 90 kg N + 60 kg P_2O_5 ha^{-}

Table 5: Nutrient recovery as influenced by different N and P levels

Treatments (N& P kg ha^{-1})	N Recovery (%)			P Recovery (%)		
	Grain	Straw	Total	Grain	Straw	Total
Control	-	-	-	-	-	-
60-15	34.27 e	2.45 h	36.72 g	13.37 b	7.12 bcd	20.68 b
60-30	60.17 c	7.98 g	68.16 d	10.38 de	6.12 de	16.50 d
60-45	84.41 a	14.62 b	99.03 a	11.25 cd	6.92 bcd	18.16 cd
90-23	51.53 d	10.33 e	61.86 e	16.41 a	10.19 a	26.59 a
90-45	29.80 f	13.44 b	43.25 f	17.61 a	7.68 bc	25.29 a
90-60	85.09 a	17.15 a	102.20 a	12.99 b	6.96 bcd	19.95 bc
120-40	61.10 bc	11.20 de	72.30 c	16.71 a	8.01 b	24.71 a
120-60	63.41 bc	11.88 cd	75.30 bc	12.65 bc	6.20 cde	18.85 bc
120-90	65.02 b	13.33 bc	78.35 b	9.17 e	4.75 e	13.92 e

Values followed by different letters are significantly different at $P \leq 0.05$ by the DMR Test

[1] (3:2) can be considered as the most optimum dose for this genotype when grown on silty clay textured soil.

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