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Growth and Yield of Rice (*Oryza sativa* L.) are Influenced by Different Levels of Nitrogen, Phosphorus and Biofertilizers

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Abstract

A field experiment was conducted during the rainy (*Kharif*) seasons of 2013 to 2015 at Agriculture Research Station (Irrigation crops), Anand Agricultural University, Thasra.The farm is located in hot semi-arid eco-region with medium deep black soils and geographically situated at 22.40^0 latitude, 73.12^0 longitude and 32.4 m above the mean sea-level.To study the response of different levels of Nitrogen (N), Phosphorus (P) and Biofertilizers on Rice (*Oryza sativa* L.) under middle Gujarat Agro climatic zone III, 12 treatment combinations consisting three levels of Nitrogen, two levels of Phosphorus and two levels of Biofertilizer were tried in factorial randomized block design with four replications. The three-year experimental results revealed that different treatments for nitrogen levels were found significant for most of the growth and yield contributing characters, while for phosphorus and bio-fertilizer found non-significant. In pooled data the N level N_3 (120 kg N ha^{-1}) gave significantly higher grain yield of 5508 kg ha^{-1}and was found significantly superior over N level of 80 kg (N_1). The result revealed that the potential production and profit from the rice crop could be secured by applying120 kg Nitrogen ha^{-1} only to get higher yield in middle Gujarat Agro climatic zone III.

Key Words: Rice, Growth, Yield, Nitrogen, Phosphorus and Biofertilizer

Introduction

Rice is grown in over hundred countries and is the primary food for half of the people in the world. World population is expected to be 8.5 billion by 2025 and to maintain the self-sufficiency in rice an increase of 2% -3% per year in rice production had to be maintained within the limited available land (Vallino *et al*., 2009). Due to continuous use of chemical fertilizers in rice production, soil health related problems are emerging. While integration of organic sources to sustain the productivity is necessary, it is difficult to meet the crop-nutrient requirements with bulky organic manure alone and there is a need for integrated application of different sources of nutrients including biofertilizers for sustaining the desired crop productivity (Gogoi *et al*., 2010). The efficiency of fertilizer use for nitrogen is lower than 50%, for phosphorus lower than 10% and for potassium 40%. This low efficiency of fertilizer use is also associated with other losses by immobilization, volatilization, denitrification, leaching, and clay adsorption (Ruiz *et al*., 2012). Therefore, the use of biofertilizer along with chemical fertilizers to maintain soil health as well as soil fertility and productivity is a need of the time. Biofertilizer is needed to increase the yield and thereby provide eco-friendly solution by adding organic matter in soil. The availability and efficiency of these mineral elements depend on the organic matter content and the biological activity of soils. In this context, the biofertilizers, products based on microorganisms, are an alternative for plant nutrition as these microorganisms enhance nutrients availability by biological activity, which reduces the amount of chemical fertilizers applied (Arévalo, 2009).

Materials and Methods

Experimental site

A field experiment on the response of different levels of Nitrogen (N), Phosphorus (P) and Biofertilizers on Rice (*Oryza sativa* L.) under middle Gujarat conditions was conducted during the *kharif* 2013 to 2015 at Agriculture Research Station (Irrigation crops), Anand Agricultural University, Thasra. The farm is located in hot semi-arid eco-region with medium deep black soils and geographically situated at 22.40^0 latitude, 73.12^0 longitude and 32.4 m above the mean sea-level. A composite representative soil sample was collected from the site of experimentation and analysed for physico-chemical properties. The soils of experimental site were slightly clay loam and alkaline (*p*H value 7.6 with 1:2.5 soil and water ration). It consists of 0.33% organic carbon (Jacksons *et al.,* 1973), 0.049% total Nitrogen (Jacksons *et al.,* 1973), 34.50 $kgha^{-1}$ available P_2O_5 (Olsen *et al.,* 1954) and 189 $kgha^{-1}$available K_2O (Jacksons *et al.,* 1973). The soil was low in organic matter and nitrogen content and medium in available phosphorus and available K_2O. The average rainfall (900 mm) and average minimum and maximum temperature (20.30^0 C and 33.66^0 C) were recorded, respectively in the years 2013, 2014 and 2015. The experiment was laid out in factorial randomized block design (FRBD) with four replications on GAR 13 variety. The treatment consisted of three levels of Nitrogen N (N_1: 80 kg ha^{-1}, N_2:100 kg ha^{-1} and N_3: 120 kg ha^{-1}), two levels of Phosphorus (P_0: 0 kg ha^{-1}, P_1: 25 kg ha^{-1}) and two levels of Bio-fertilizers B {B_0: Control and B_1: Azospyrillum + PSB (Root dipping 3-5 ml/liter Water)} and 12 treatment combinations in each replication.

The field was ploughed, irrigated, puddled and made ready for sowing. Twenty-five to thirty days old seedlings of rice variety GAR 13 established on 16th July, 2013, 20th July, 2014 and 17th July, 2015 on well puddled soil. The seedlings were collected from the seed bed and transplanting was done at 1-2 seedlings per hill. The crop was treated with three levels of nitrogen fertilizer *viz*., 80, 100 and 120 kg N ha^{-1}, two levels of phosphorus fertilizer *viz.,* 0 and 25 kg P_2O_5 $ha^{-1}$and two levels of biofertilizer *viz.,* control and Azospirillum + PSB root dipping 10-15 minute in 3-5 ml/Liter water at the time of transplanting. Full dose of $ZnSO_4$ (25 kg/ha) was applied as basal dose. While nitrogen and phosphorus were applied treatment wise 50% N and 100% P_2O_5 as basal and remaining nitrogen was applied in two splits, 25% N at tillering (30 DAP) and 25% N at panicle initiation (60 DAP) as top dressing and the treatments were superimposed in the same plot every year to study the cumulative treatment effect. The unit plot size was gross and net 6.00 m x 4.40 m, 5.20 m x 3.60 m respectively. Planting configuration was 20 cm x 15 cm where plot and block were separated by 0.50 m and 1.00 m respectively. Irrigation, weeding and other agronomic practices were done as per recommendations.

Data Collection

Data on different growth parameters, yield components and yield were recorded. For determination of yield attributes five hills were selected and plant height, panicles/m^2, panicle weight, panicle length and test weight were measured while grain yield and straw yield were measured after harvesting in each plot. The crop was harvested from an area of 5.2 m x 3.6 m (18.72 m^2) leaving four rows and five dibbles to avoid border effect. The harvested yield was converted into kg/ha at 12-14% moisture content.

Results and Discussion

Growth

Growth of rice variety was measured by plant height, panicle/m^2, panicle length and panicle weight as affected by various levels of nitrogen, phosphorus and biofertilizer. Data presented in **(Table 1)** showed that nitrogen levels exerted significant effect on plant height and panicles/m^2 while panicle length and panicle weight were not affected nsignificant. While the effect of phosphorous levels were found non-significant on yield attributes, biofertilizer levels registered significant effect on panicle length (cm) and panicle weight. Effect of nitrogen at N_3 level (120 kg N ha^{-1}) found to be significantly highest in plant height (114 cm) and panicle/m^2 (287) over the rest of treatments (Ebaid *et al.,* 2000). Lowest plant height, panicle/m^2, panicle length and panicle weight recorded in nitrogen at N_1 level while nitrogen level N_2 effect was at par with Nitrogen N_3 level in plant height and panicles/m^2. Growth promoting effect of N on plant can be explained on the basis of the fact that N supply increases the number and size of meristematic cells which leads to formation of new shoots (Lawlor, 2002). Furthermore, N application is known to increase the levels of cytokinin which affects cell wall extensibility (Arnold *et al*., 2006). It is therefore, logical to speculate that N was involved directly or indirectly in the enlargement and division of new cells and production of tissues which in turn were responsible for increase in growth characteristics particularly tiller numbers and plant height of the rice variety.

Table 1: Growth attributes influenced by various treatments (Pooled 2013 to 2015)

Treatment	Plant height (cm)	Panicle/m^2	Panicle length (cm)	Panicle wt.(g)
Nitrogen (N) kg/ha				
N_1:80	109	272	23.79	3.78
N_2:100	111	283	24.05	3.77
N_3:120	114	287	24.28	3.85
S.Em±	0.99	3.22	0.21	0.04
CD 0.5%	2.86	9.27	NS	NS
Phosphorus (P) kg/ha				
P_0:00	111	279	23.90	3.79
P_1:25	112	282	24.18	3.81
S.Em±	0.81	2.63	0.18	0.03
CD 0.5%	NS	NS	NS	NS
Biofertilizer (B)				
B_0:00	110	278	23.72	3.73
B_1:*	112	283	24.36	3.88
S.Em±	0.81	2.63	0.18	0.03
CD 0.5%	NS	NS	0.50	0.09
C.V. %	6.19	7.95	6.18	6.91
Y1	116	276	25.03	3.57
Y2	109	281	23.65	4.21
Y3	108	286	23.43	3.62
S.Em±	0.99	2.27	0.22	0.04
CD 0.5%	2.81	6.41	0.63	0.11
C.V. %	6.20	5.60	6.48	7.02

* B_1: Azospyrillum + PSB (Root dipping)

Yield

Effect of Nitrogen

The data in **Table 2** indicated that 1000 grain weight, grain yield and straw yield were significantly affected due to various levels of nitrogen application. Nitrogen at N_3level (120 kg N ha^{-1}) recorded significantly higher 1000 grain weight (18.89 g), grain yield (5508 kg ha^{-1}) and straw yield (7349 kgha^{-1}) than the rest of nitrogen levels. It was at par with nitrogen level N_2 (100 kg N ha^{-1}) while lowest 1000 grain weight (18.09

g), grain yield (5095 kg ha^{-1}) and straw yield (6703 kg ha^{-1}) recorded under the nitrogen level N_1 80 kg N ha^{-1}. Application of 120 kg N ha^{-1} increases grain yield and straw yield (**Figure 1**). This result is in agreement with the findings of (Sivasabari *et al.,* 2021). The increment of grain yield in this study at higher nitrogen levels might be due efficient absorption of nitrogen and other elements which raise the production and translocation of dry matter from source to sink (Ebaid *et al*., 2000; Morteza *et al*., 2011).

Effect of Phosphorus

Impact of Phosphorus on grain yield, straw yield and 1000 grain weight were not significantly affected by various levels of phosphorus **(Table 2**). The higher 1000 grain weight (18.66 g), grain yield (5368 kgha^{-1}) and straw yield (7138 kgha^{-1} was found when the crop fertilized with 25 kg P_2O_5 and lowest value recorded from P_0 level (**Figure 1**). In case of 1000 grain weight, the variation is very low among the levels as it is known to be a genetically controlled character. Similar results were reported by other scientists (Ahmed *et al*., 2005; Maske *et al*., 1997). The results are in conformity with that of Natarajan *et al.,* (2017).

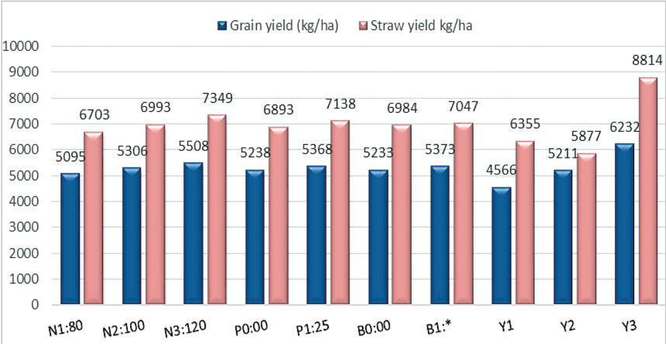

Figure 1: Effect of different treatments on grain and straw

Table 2: Yield attributes influenced by various treatments (Pooled 2013 to 2015)

Treatment	1000 grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Nitrogen (N) kg/ha			
N_1:80	18.09	5095	6703
N_2:100	18.56	5306	6993
N_3:120	18.89	5508	7349
S. Em±	0.16	63	95
CD 0.5%	0.45	183	274
Phosphorus (P) kg/ha			
P_0:00	18.36	5238	6893
P_1:25	18.66	5368	7138
S.Em±	0.13	52	78
CD 0.5%	NS	NS	NS
Biofertilizer (B)			
B_0:00	18.28	5233	6984
B_1:*	18.74	5373	7047
S.Em±	0.13	52	78
CD 0.5%	0.37	NS	NS
C.V. %	5.86	8.28	9.93
Y1	18.55	4566	6355
Y2	18.69	5211	5877
Y3	18.29	6232	8814
S.Em±	0.14	67	92
CD 0.5%	NS	188	261
C.V. %	5.23	8.70	9.13

* B_1: Azospyrillum + PSB (Root dipping)

Table 3: Economics of various treatment

Treament	Grain yield kg/ha	Straw yield kg/ha	Gross income Rs/ha	Total expenditure Rs/ha	Net income Rs/ha	BCR
N1:80	5095	6703	83128	49880	33248	1.67
N2:100	5306	6993	86583	50183	36400	1.73
N3:120	5508	7349	89969	50487	39482	1.78
P0:00	5238	6893	85463	48664	36799	1.76
P1:25	5368	7138	87658	50021	37637	1.75
B0:00	5233	6984	85479	48664	36815	1.76
B1:*	5372	7047	87628	48964	38663	1.79

*- Azospyrillum + PSB (Root dipping), BCR- Benefit cost ratio, Selling price: Paddy 15.00 Rs/ kg (Three year average), Paddy Straw 1.00 Rs / kg, Input cost: Urea Rs. 350/50 kg, DAP Rs. 1250/50 kg, $ZnSo_4$ 750 Rs / 25 kg, Biofertilizer, 150 Rs / Litre

Effect of Biofertilizer

Effect of biofertilizer was found significant on 1000 grain weight (18.74 g) while it was non-significant on grain yield and straw yield. The highest grain yield (5373 kgha^{-1}) and straw yield (7047 kgha^{-1}) were obtained from biofertilizer B_1 level (**Figure 1**).

Economics

The cost of cultivation and net return of rice was influenced to a great extent by different treatments. The economics of different treatments presented in **(Table 3)** indicated that the highest net income of Rs. 39482 was obtained with the treatment N_3 [120 kg N ha$_{-1}$] followed by treatment B_1 (Azospyrillum + PSB root dipping) with net income of Rs. 38663.

Conclusion

Based on the study conducted during three years, it may be concluded that the potential production and profit from the rice crop (GAR 13) could be secured by fertilization of the crop with 120 kg Nitrogen ha^{-1} only to get higher yield in middle Gujarat Agro-climatic zone III.

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