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GROWTH AND YIELD RESPONSE OF AEROBIC RICE TO NUTRIENTS APPLICATION IN KPK, PAKISTAN

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ABSTRACT

Studies were carried out for two years to determine the effect of different levels of major (NPK) and trace (Zn, B) nutrient elements on the growth and yield of direct seeded rice on farmer's field in village Dhallah, Dera Ismail Khan (KPK) Pakistan. The experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. The net plot size was 2.5 x 5m ($12.5m^{-2}$) with 10 rows. IR-6 was used as test variety of rice. The combination of fertilizer levels comprised of eight treatments. The fertilizer rates included T_1 = 100% recommended fertilizer dose (RFD) without micronutrients, T_2 = 100% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} , T_3 = 100% RFD + 5.0 Kg Zn ha^{-1} , T_4 = 100% RFD + 7.5 Kg Zn ha^{-1} , T_5 = 100% RFD + 0.5 Kg B ha^{-1} , T_6 = 100% RFD + 1.0 Kg B ha^{-1} , T_7 = 75% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} and T_8 = 50% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} . Application of various doses of macro along with minor nutrient fertilizers significantly influenced the final plant height (cm), productive tillers m^{-2}, panicle length (cm), number of grains $panicle^{-1}$, 1000-grain weight (gm), biomass (t ha^{-1})and paddy yield (t ha^{-1}). The data showed that the paddy yield was significantly higher in the plot of T_2 than that of all other treatments.

Key words: Rice, Direct-seeding, NPK, Zn,B, Paddy yield, Economic return.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the three principal cereals cultivated and eaten in Pakistan. It has the highest digestible energy (96.3%) among cereal grains and it is rated as the second most important crop after wheat in Pakistan. It is cultivated on an area of 2.57 million hectares with total production of 6.16 million tones and average paddy yield at farmer's field is 2396 Kg ha^{-1} (GOP, 2012).The soils found in the area are inherently poor, deficient in organic matter and important nutrients. Nitrogen, Phosphorus, Potassium, Zinc and Boron are essential nutrient elements for increased yield of rice but in this area, they are limiting. Soil infertility in this part of the country is therefore an overriding constraint to rice production. Ma *et al.* (2007) reported that rice is an important staple food and cash crop feeding more than three billion people in the world.

Among the various factors which can help increase the productivity per unit area, fertilizer being a precious input needs to be thoroughly studied to find out its best combination of nutrients which may be both economical and adequate to enhance the productivity of rice. Niamatullah *et al.* (2010) stated that rice is one of the most important cereal crops of the world in terms of food, area and production.

The balanced and adequate NPK in combination with Zn and B use may have direct effect on quality of kernel, ripening and final paddy yield. The indiscriminate use of fertilizer may lower the yield and deteriorate the kernel quality.

Nitrogen plays an important role in photosynthesis, protein and enzymatic process. The application of N leads to more rapid leaf area development and prolongs the life of leaves after flowering and increases over all net assimilation rate, thus contributing to increase paddy yield. In case of sever N deficiency, plants become stunted, yellow in appearance, leaves will turn brown and die.

Phosphorus helps in energy transfer reactions in plant and root growth. It prevents lodging and increases disease resistance in crops. Its deficiency restricts both top and root growth. In cereals, tillering is affected and seed formation is depressed due to P deficiency.

Potassium function appears to be catalytic in nature. It increases paddy yield, improves grain quality and decisively involved in the water economy and influence plant growth in a synergistic way. The symptoms of insufficient potassium is weakening of straw in cereals which produces lodging, susceptible to frost damage, fungal attack and later on do chlorosis and necrosis.

Zinc salts and complexes can also enter directly through the leaves of plants. It takes part in the formation of chlorophyll with the combination of Fe and Mn. It is also involved in the formation of seed, starch, auxin and grain maturation. Plants suffering from Zn deficiency often show chlorosis in the inter vienal areas of the leaf which are pale green, yellow or even white.

Boron is not a component of an enzyme and influences fast growing meristematic tissues, germination and growth of pollen, starch synthesis and protein synthesis. It also helps in water uptake and seed formation. Boron deficiency first retarded growth, leaves are misshapen, wrinkled and are of a darkish blue green colour, flowers and seed formation is restricted or inhibited.

The present study therefore was undertaken to see the effect of different levels of NPK in combination with Zn and B on the growth, yield and economic returns of rice under aerobic conditions.

MATERIALS AND METHODS

Studies reported here, were conducted on farmer's field in village Dhallah, Dera Ismail Khan (KPK) where field experiments were executed in loamy soil during the years, 2011 and 2012 to determine the effect of different levels of NPK and Zn, B on the growth and yield of direct seeded rice. The experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. The net plot size was 2.5 x 5m ($12.5m^{-2}$) with 10 rows. IR-6 was used as test variety because it is the predominantly cultivated rice variety in D.I.Khan area. All the agronomic operations except those under study were kept normal and uniform for all the treatments. The combination of fertilizer rates comprised of eight treatments. The fertilizer rates included T_1 = 100% recommended fertilizer dose (RFD) without micronutrients, T_2 = 100% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} , T_3 = 100% RFD + 5.0 Kg Zn ha^{-1} , T_4 = 100% RFD + 7.5 Kg Zn ha^{-1} , T_5 = 100% RFD + 0.5 Kg B ha^{-1} , T_6 = 100% RFD + 1.0 Kg B ha^{-1} , T_7 = 75% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} and T_8 = 50% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} The RFD referred to NPK @ 150-120-100 Kg ha^{-1} . All P, K, B and 1/3 N were applied at the time of final land preparation while Zn and 1/3 N were applied 30 days after sowing. The remaining 1/3 N was applied after 45 days of planting. Irrigation was applied whenever required and last irrigation was applied one week before harvesting.

Data were recorded on final plant height (cm), productive tillers m^{-2}, panicle length (cm), number of grains $panicle^{-1}$, 1000-grain weight (gm), biomass (t ha^{-1}) and paddy yield (t ha^{-1}) were recorded at maturity and statistical analysis of 2 year average data was carried out using STATISTIX software and the differences among the treatments' means were compared by the least significant differences (LSD) test at 5% probability level (Steel *et al*., 1997).

Table 1. Effects of different levels of macro-micronutrients on paddy yield under aerobic production system.

Treatment	Plant height (cm)	Tillers m^{-2}	Panicle length (cm)	Grains $panicle^{-1}$	1000-grain weight (g)	Biological yield (t ha^{-1})	Paddy yield (t ha^{-1})
T_1	121.00 a	303.33 e	24.97 ab	116.20 d	20.13 de	6.50 c	4.75 c
T_2	116.00 cd	375.67 a	24.83 ab	119.23 c	24.07 b	8.86 a	6.82 a
T_3	113.33 cd	346.00 bc	25.30 ab	123.03 a	25.20 ab	7.45 b	5.67 b
T_4	122.33 a	382.00 a	25.80 a	121.13 b	25.90 a	7.91 b	5.85 b
T_5	115.00 cd	339.33 c	24.07 b	116.93 d	21.07 d	6.73 c	4.83 c
T_6	116.67 bc	355.33 b	25.60 a	119.93 bc	22.57 c	6.83 c	5.09 c
T_7	117.00 b	318.00 d	22.57 c	115.83 d	19.03 e	5.35 d	3.71 d
T_8	112.67 d	294.67 e	24.13 b	117.07 d	21.20 d	4.34 e	3.39 d
LSD	3.6228	9.5460	1.4047	1.7841	1.2596	0.6040	0.4004

RESULTS AND DISCUSSION

Plant height for each treatment was recorded with the help of measuring tape. The data showed that plant height of rice was significantly affected with the application of various doses of major (NPK) in combination with trace (Zn,B) nutrients under aerobic culture in both the years. The plots of 100% RFD + 7.5 Kg Zn ha^{-1} and 100% recommended fertilizer dose (RFD) only produced tallest plants i-e 122.33 cm and 121.00 cm respectively which are statistically at par with each other. The minimum height (112.67 cm) was recorded in control. These results are in agreement with Tisdale *et al.* (1997) who observed that root growth and plant height of crop was significantly affected with the application of macro-micronutrients.

Tillering is the spirited yield component as more number of tillers ensured the better crop stand which leads toward improved crop yield. The data indicated that the application of NPK in combination with Zn and B had

significant affect on number of tillers m^{-2} of rice crop. Maximum tillers (382.00 and 375.67) were produced by the treatments of (T_4) 100% RFD + 7.5 Kg Zn ha^{-1} and (T_2) 100% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} respectively and also statistically at par, whereas, the minimum value of tillers (294.67) was recorded in control plot during both the cropping seasons. These results are in coincide with Nataraja *et al.* (2006) who reported that adequate application of NPK fertilizer, normal growth of crop could not be obtained due to little or no application of micronutrients. High fertilizer responsive varieties express their full yield potential when trace elements are applied along with NPK fertilizers.

Panicle length is considered as a yield contributing factor because larger panicle have more grains as compared to shorter panicle which ultimately leads toward better grain yield. Different doses of major (NPK) and trace (Zn,B) nutrients had significant affect on panicle length (cm) of rice crop. Maximum panicle lengths (25.80 and 25.60 cm) were recorded in the treatments of (T_4) where 100% RFD + 7.5 Kg Zn ha^{-1} and (T_6) 100% RFD + 1.0 Kg B ha^{-1} was applied respectively in both the seasons and also statistically at par with each other, while minimum panicle length (22.57 cm) was attained in the plot where 75% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} was applied. These results match with those of Tisdale *et al.* (1997) who concluded that the application of macro and micronutrients to rice crop had significantly affected growth and panicle length (cm).

Number of grains panicle-1 stands an important yield contributing parameter. The data pertaining that the number of grains $panicle^{-1}$ was significantly affected by the different levels of macro-micronutrient fertilizers. Among all the treatments, the application of fertilizer @100% RFD + 5.0 Kg Zn ha^{-1} seems to be essential to get an appropriate grain $panicle^{-1}$ (123.03) and showed better performance at grain formation stage. Minimum number of grains $panicle^{-1}$ (115.83) was observed in the treatment of 75% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1}. These results match with those of Renukadevi *et al.* (2003) who concluded that boron nutrition increased the number of filled grains.

Thousand grain weight is an important agronomic trait which have positive correlation with grain yield. More the 1000-grain weight ultimately enhanced grain yield will be obtained. The data regarding 1000 grain weight (g) are presented in Table-1. The data suggested that the thousand seed weight was substantially influenced by various doses of NPK and Zn, B fertilizers. Among all the treatments, T_4 (100% RFD + 7.5 Kg Zn ha^{-1}) resulted more 1000 grain weight (25.90 g) and minimum weight (19.03 g) was produced in T_7 (75% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1}) . These results are in conformity with the findings of Renukadevi *et al.* (2003) who stated that boron nutrition increased the number of grains and 1000-seed weight.

Table 2. Economics of fertilizer application for paddy yield under aerobic conditions.

Treatment	Fertilizer cost (Rs)	Yield (t ha^{-1})	Produce value (Rs)	Net Profit (Rs)	Net Return over T_8
T_1	21200/-	4.75	57000/-	35800/-	6790/-
T_2	22270/-	6.82	81840/-	59570/-	30560/-
T_3	21640/-	5.67	68040/-	46400/-	17390/-
T_4	21860/-	5.85	70200/-	48340/-	19330/-
T_5	21515/-	4.83	57960/-	36445/-	7435/-
T_6	21830/-	5.09	61080/-	39250/-	10240/-
T_7	16970/-	3.71	44520/-	27550/-	-1460/-
T_8	11670/-	3.39	40680/-	29010/-	_

Value of Paddy @Rs.12.00 per kg viz. Rs.985/82kg; Cost of N Rs.32.00 per kg viz. Urea @Rs.1600/bag
Cost of P Rs.80.00 per kg viz. DAP @Rs.4000/bag; Cost of K Rs.68.00 per kg viz. SOP @Rs.3400/bag
Cost of Zn Rs.88.00 per kg viz. $ZnSO_4$; Cost of B Rs.630.00 per kg viz. Borax

Biological yield is the total biomass produced by crop from a unit area. Biological yield of rice was significantly affected by the application of major (NPK) and trace (Zn,B) nutrients. Maximum biological yield (8.86 t ha^{-1}) was produced from 100% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} application. Minimum biomass (4.34 t ha^{-1}) was yielded by 50% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1} application. These results are in contradiction with those of reported by Pattigrew (2008) who claimed that to achieve the highest yield of rice, the use of macro (NPK) in combination with minor (Zn,B) nutrients will be more profitable. Uddin *et al.* (2008) also obtained 50% yield of crop increased by the application of boron. Gitte *et al.* (2005) was in the view that the combined application of Zn and B exhibited increases over the control in straw yield, 100-seed weight and seed yield.

Paddy yield is one of the most important parameter and the ultimate output of rice crop. Significant variations were observed in paddy yield due to the application of macro-micronutrients in different levels. The rice plot gave highest paddy yield (6.82 t ha^{-1}) in which NPKZnB was applied @ 150-120-100-5.0-1.0 Kg ha^{-1} and minimum paddy yield (3.39 t ha^{-1}) was produced from control treatment which is statistically at par with T_7 (3.71 t ha^{-1}) . These results are in coincide with Chaudry *et al.* (2007) who reported that boron application along with basal dose of NPK significantly increased the crop yield and Nathan *et al.* (2005) who also in the same direction that Zinc fertilization increased rice yield by 12-18% as compared with the un-fertilized plot. Reddy and Shaik (2000) conducted experiments on various fertilizers and reported that 100% recommended fertilizer dose +500 kg gypsum ha-1 + 0.2% borax gave the highest net returns and cost benefit ratio as a result of increased yield due to boron application.

Adediran *et al.* (2004) who observed that the application of adequate micronutrient fertility increased crop yields and enhanced soil macro and micronutrient status and similar findings were also reported by Taiwo *et al.* (2001) who recorded that they can give 67% more yield over control.

ECONOMIC ANALYSIS

The maximum net return (Rs.30560/-) was recorded with (T_2) by the application of 100% RFD + 5.0 Kg Zn + 1.0 Kg B ha^{-1}. It was followed by T4 and T3 showed (Rs.19330/- and 17390/-) respectively than all other treatments. The use of trace (Zn,B) and major (NPK) nutrients was more economical as compare to application of NPK alone and control. The results suggest that the integrated use of major and minor nutrients may be promoted for obtaining maximum yields as well as highest net profit.

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