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EFFECT OF INCREASED PLANT DENSITY AND FERTILIZER DOSE ON THE YIELD OF RICE VARIETY IR-6

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Abstract: An experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6 was conducted at the farm of Faculty of Agriculture, Gomal University Dera Ismail Khan. Increased plant density significantly increase number of panicles per square meter, sterility and straw yield while increased fertilizer dose of NPK increase plant height, sterility, normal kernels, and 1000 grain weight. Interaction of increased plant density and fertilizer dose was found to be non significant except sterility percentage and straw yield. However efforts are required for increasing yield per unit area of rice.

Keywords: Fertilizer dose, NPK levels, paddy yield, plant density, plant population, rice variety IR-6, spacing.

INTRODUCTION

Rice is most important and delicious food crop of the world. Efforts are required to increase low yield of rice per unit area in Pakistan to meet food requirements of over growing population of the world. Among the various factors, plant population and fertilizers dose can increase yield of rice in Pakistan to the yield level of other countries of the world. Chang and Su [1977] studied the effect of nitrogen and spacing on two rice cultivars. According to them in both cultivars number of tillers/hill at 50 days after transplanting increased with increasing rate of applied N and decrease with decrease in spacing, while plant height, increased as rate of N increased and spacing decreased. Length and weight of panicles, number of panicles per hill and grains per panicle increased with increased rate of N and increased spacing. Grain yield increased spacing, with a greater response to N than to spacing. Fragade and Oje [1977] conducted a field trail in which rice cv. (a) IR-8, (b) SML 140/10 and (c) MAS 2401 was transplanted at spacing of 10x10, 20x20, 25x25 or 7.5 x30cm and was given 0, 75 or 150 kg N ha^{-1} in 3 equal split applications. Paddy yield of (a) and (b) increased from 2.1 and 1.55 t ha^{-1} with no applied N to 5.15 and 2.99 ton, respectively, at 150 kg N, whereas those of (c) increased from 2.04 t ha^{-1} with no N to 3.04 at 75 kg N and then decreased to 2.40 t ha^{-1} at 150 kg N. Spacing at 10x10 cm gave the highest paddy yields of 4.15 t ha^{-1} in (a) and 2.57 t ha^{-1} in (b) whereas 25x25 cm gave the highest yield of 2.93 t ha^{-1} in (c), because of excessive lodging at close spacing. Chandrakar and Khan [1981] reported that optimum grain yields of medium and late cv. were obtained at 15x10 or 20x10 cm spacing with 50kg N, 40kg P_2O_5 and 20kg K_2O ha^{-1}.

Early cv. yielded highest at 10x10 cm spacing with 40 kg N, 30 kg P_2O and 15 kg K_2O ha^{-1}. Lozano and Abruna [1981] observed that yields of rough rice increased from 3.83 to 8.21 t ha^{-1} when N rates were increased from 0-112kg ha^{-1} applied in 2 equal split dressing at sowing and 45 days later. Yields were not increased further by heavier N applications. Moreno *et al.* [1985] conducted an experiment on rice cv. CICA-8 with P and K fertilizer application. The highest yield 7.70 t ha^{-1} was obtained with 50 kg P_2O_5 ha^{-1} + 25 kg K_2O and lowest yield 6.45 t ha^{-1} with 25 kg P_2O_5 + 25 kg K_2O ha^{-1}. The effect on plant height, number of panicle m^2 and 1000 grain weight were recorded. Reddy *et al.* [1986] concluded the P requirement of kharif rice cv. Swarna MTU 7633 etc. and P increased yield only at 26.2 kg P ha^{-1} and straw yield were not affected by P. Singh and Sharma [1987] found that nitrogen fertilizer application increased plant height, the number of productive tillers per hill and panicle length. Nitrogen @ 180 kg ha^{-1} increased grain yield from 1.3-1.4 to 3.4-3.6 t ha^{-1} and straw yield from 2.3–2.4 to 5.9 t ha^{-1}. Nitrogen application increased grain and straw nitrogen content. Keeping in view the above facts, the present study was carried-out to determine the effect of plant spacing from 20x20 cm to 20x10 cm with double recommended fertilizer dose on the growth and yield of rice variety IR-6 under the irrigated condition of Dera Ismail Khan.
Recently, Bajpai and Joshi [1992] found that 120 kg P ha^{-1} and the Kahhar soil type gave the highest grain and straw yield. Kushwaha *et al.* [1992] observed that rice cv. Ratna and Kranti with application of 60 kg N, 60 kg N+40 kg P, 60 kg N+40 kg P+15 kg K, and 60 kg N+40 kg P+15 kg K+ 25 kg $ZnSO_4$ ha^{-1} gave average grain yield of 3.16, 3.60, 3.79, 3.98 and 2.88 t ha^{-1} respectively. The net income and cost of cultivation were highest with NPK+Zn application. Balasubra-maniyan and Palaniappan [1992] found that grain yield and optimum plant population was obtained with 150 kg N ha^{-1} +50 kg K_2O ha^{-1} and uptake of NPK in the grain were highest with 150kg N+50kg K_2O ha^{-1}. Dixit and Patro [1994] in a field experiment on sandy loam during summer season found that 120 kg N+60 kg P+60 kg K + 25 kg $ZnSO_4$ gave more grain yield. Rogelio *et al.* [1997] conducted an experiment using three fertilizer groups and identified comparative analysis of balance fertilization strategy (BFS) as compared to conventional method and concluded that BFS gave maximum yield of rice. Khalid *et al*. [2003] studied the effect of different levels of NPK (0-0-0, 120-0-0,120-60-0, 12-0-60, 120-60-60, 120-90-0, 120-0-90 and 120-90-90) on the yield and quality of rice cv. IR-6. Data show that plant height, tiller per hill and paddy yield were affected significantly by different levels of NPK as compared to control.

MATERIALS AND METHODS

The proposed investigations were carried out to study the effect of increased plant population with increased fertilizer dose on yield and quality of rice IR-6. The experiment was conducted at the Farm of Faculty

of Agriculture, Gomal University, Dera Ismail Khan, Pakistan during the year, 1987. This site is located at latitude 31º 26´ N and longitude 71º 6´ E. The average minimum temperature was 25 ºC and average maximum temperature 37 ºC with day length of 11-12 hrs. It occurs in arid climate zone of Pakistan. Meteorological data for the growing season of crop during 1987 is presented in Table 1. It was laid out in a Randomized Complete Block Design having three replications with a net plot size of 12m x 6m. It was comprised of four treatments as following.

Table 1: Meteorological data for the growing season of crop during 1987.

Months	Av. Minimum Temp. °C	Av. Maximum Temp. °C	Relative Humidity (%)	Rainfall (mm)
June	25.03	39.46	47.40	10.00
July	27.16	38.12	69.30	27.00
August	29.00	39.00	51.22	00.00
September	26.80	36.80	49.22	00.00
October	17.70	31.90	50.00	00.00

Source:- Arid Zone Research Sub Station Pakistan Agriculture Research Council, Dera Ismail Khan.

PLANT TO PLANT SPACING

S1 = 20 x 20 cm (Row x plant spacing)
S2 = 20 x 10 cm (Row x plant spacing)

FERTILIZER DOSE

		N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
F1	=	120	90	60
F2	=	240	180	120

Treatments	**= Plant Spacing**	**+ Fertilizer Dose**		
S1 F1	= 20 x20 cm	+ 120 N	90 P_2O_5	60 K_2O
S2 F1	= 20 x10 cm	+ 120 N	90 P_2O_5	60 K_2O
S1 F2	= 20 x20 cm	+ 240 N	180 P_2O_5	120 K_2O
S2 F2	= 20 x10 cm	+ 240 N	180 P_2O_5	120 K_2O

All the phosphorous as single super phosphate and potassium as potassium sulfate along with half does of nitrogen as urea were applied by broad cast before transplanting and remaining half does of nitrogen was applied after one month. One month old seedling were transplanted in standing water one seedling per hill. Normal cultural practices were given to all the treatments equally. Ten plants in each treatment were randomly selected for measurement of plant height, tillers per hill, normal kernel percentage, 1000-grain weight. To observe the occurrence of sterility, abortiveness and opaqueness in a panicle, a “Rice Kernel Quality Analyzer” and a seed working board were used. The kernels were then differentiated into various categories after getting ten randomly selected panicles from each treatment and sketching them using the standard

method [Nagato and Chaudhry 1969]. The data were analyzed statistically using analysis of variance technique [Steel and Torrie 1980] and Duncan's multiple range test [Duncan 1955] was used to see the significance of treatments means at 5% probability level.

RESULTS AND DISCISSION

EFFECT OF PLANT SPACING

Results presented in Tables 2 and 3 show that the plant height, normal kernel, paddy yield and harvesting index were not significantly influenced by the plant spacing while number of tiller, panicles per square meter, sterility percentage, 1000 grain weight and straw yield were affected significantly. Increased plant density increase panicle, sterility and straw yield, however decrease tiller formation and 1000 grain weight. The increase panicle and straw yield has positive impact on paddy yield but decrease tiller and 1000 grain weight has negative impact on paddy yield. Over impact of yield component remain non significant. The result is contradictory to one reported by Para-sher [1976]. They reported that in 1968 rice cv.IR-8 grown in rows 7.5-30 cm apart with between- plant spacing of 7.5-15cm or in paired rows 7.5 apart with inter-row strips 22.5 or 37.5 cm apart gave the highest paddy yields of 6.46 ton per hectare (t ha^{-1}) at 7.5 cm and the lowest yields of 3.8 t ha^{-1} at 30x15 cm, which indicate that increased plant density cause to increase yield. Fragade and Oje [1977] conducted a field trail in which rice cv. (a) IR-8, (b) SML 140/10 and (c) MAS 2401 was transplanted at spacing of 10x10, 20x20, 25x25 or 7.5x30cm and was given 0, 75 or 150 kg N ha^{-1} in 3 equal split applications. Paddy yield of (a) and (b) increased from 2.1 and 1.55 t/ha with no applied N to 5.15 and 2.99 ton, respectively, at 150 kg N, whereas those of (c) increased from 2.04 t with no N to 3.04 at 75 kg N and then decreased to 2.40 t ha^{-1} at 150 kg N. Spacing at 10x10 cm gave the highest paddy yields of 4.15 t ha^{-1} in (a) and 2.57 t ha^{-1} in (b) whereas 25x25 cm gave the highest yield of 2.93 t ha^{-1} in (c), because of excessive lodging at close spacing. Chandrakar and Khan [1981] reported that optimum grain yields of medium and late cv. were obtained at 15x10 or 20x10 cm spacing with 50 kg N, 40 kg P_2O_5 and 20 kg K_2O ha^{-1}. Early cv. yielded highest at 10x10 cm spacing with 40 kg N, 30 kg P_2O_5 and 15 kg K_2O ha^{-1}. The reasons of contradiction may be soil condition, agronomic practices, different levels of NPK, technique of sowing and cultivar. These results are in partially agreement with Chang and Su [1977].

EFFECT OF FERTILIZER DOSE

The data of Tables 2 and 3 also show that the variety also showed significant response to increased fertilizer dose on plant height, sterility percentage, normal kernel and 1000 grain weight, but number of tillers per hill, number of panicles per square meter, grain yield and harvesting

index showed non significant response to applied fertilizer doses. These results are some what contrary to findings of some researchers such as Chang and Su [1977] who studied the effect of nitrogen and spacing on two rice cultivars. According to them in both cultivars number of tillers per hill at 50 days after transplanting increased with increasing rate of applied N and decreased with decrease in spacing, while plant height, increased as rate of N increased and spacing decreased. Length and weight of panicles, number of panicles per hill and grains per panicle increased with increased rate of N and increased spacing. Grain yield increased spacing, with a greater response to N than to spacing. Lozano and Abruna [1981] observed that yields of rough rice increased from 3.83 to 8.21 t ha^{-1} when N rates were increased from 0-112kg ha^{-1} applied in 2 equal split dressing at sowing and 45 days later. Yields were not increased further by heavier N applications. Khalid *et al.* [2003] reported highest plant height in treatment where increased P and K were applied to rice variety IR-6.

Table 2: Effect of plant population and fertilizer dose on growth and yield components of rice variety IR-6.

Parameters	Fertilizer levels			
	Spacing (cm)	F1	F2	Mean
Plant height	20	81.46	87.53	84.49
	10	82.36	84.63	83.49
	Mean	81.91 b	86.06 a	
Number of tillers	20	13.30	13.80	13.5 a
per hill	10	12.00	12.80	12.4 b
	Mean	12.60	13.30	
Number of	20	365.00	414.00	389.5 b
panicle m^{-2}	10	481.00	502.00	491.5 a
	Mean	423.00	458.00	
Sterility %	20	5.00 c	11.40 b	8.65 b
	10	11.07 b	14.90 a	12.98 a
	Mean	8.49 b	13.15 a	
Normal Kernel %	20	80.12	84.35	82.23
	10	80.14	84.01	82.08
	Mean	80.13 b	84.18 a	
1000 grain	20	20.46	23.16	21.81 a
weight	10	17.46	20.06	18.76 b
	Mean	18.46 b	21.61 a	
Paddy yield t ha^{-1}	20	3.88	4.38	4.13
	10	4.37	4.17	4.27
	Mean	4.12	4.27	
Straw yield t ha^{-1}	20	10.91	13.18	12.04
	10	16.65 a	16.07ab	16.36 a
	Mean	13.78	14.62	
Harvesting index	20	35.30	33.15	34.22
	10	26.32	27.77	27.04
	Mean	30.81	30.46	

1 Means not sharing a letter differ significantly at 5% level in a row.

Interaction between plant density and fertilizer dose was found non significant except sterility percentage and straw yield. Moreno *et al.* [1985] conducted an experiment on rice cv. CICA-8 with P and K fertilizer application. The highest yield 7.70 t ha^{-1} was obtained with 50kg P_2O_5 ha^{-1} + 25 kg K_2O and lowest yield 6.45 t ha^{-1} with 25 kg P_2O_5 + 25 kg K_2O ha^{-1}.

Kushwaha *et al*. [1992] observed that rice cv. Ratna and Kranti with application of 60 kg N, 60 kg N+40 kg P, 60 kg N+40 kg P+15 kg K, and 60 kg N+40 kg P+15 kg K+ 25 kg $ZnSO_4$ ha^{-1} gave average grain yield of 3.16, 3.60, 3.79, 3.98 and 2.88 t ha^{-1} respectively. The net income and cost of cultivation were highest with NPK+Zn application. Balasubramaniyan and Palaniappan [1992] found that grain yield and optimum plant population was obtained with 150 kg N ha^{-1} +50 kg K_2O ha^{-1} and uptake of NPK in the grain were highest with 150 kg N+50 kg K_2O ha^{-}. Dixit and Patro [1994] in a field experiment on sandy loam during summer season found that 120 kg N+60 kg P+60 kg K + 25 kg $ZnSO_4$ gave more grain yield. Rogelio *et al.* [1997] conducted an experiment using three fertilizer groups and identified comparative analysis of balance fertilization strategy (BFS) as compared to conventional method and concluded that BFS gave maximum yield of rice. Khalid *et al*. [2003] studied the effect of different levels of NPK (0-0-0, 120-0-0,120-60-0, 12-0-60, 120-60-60, 120-90-0, 120-0-90 and 120-90-90) on the yield and quality of rice cv. IR-6. Data show that plant height, tiller per hill and paddy yield were affected significantly by different level of NPK as compared to control. The findings were compared with control without plant population, application of BFS and different levels of N. The comparison of findings with other studies show that low yield was obtained in the present experiment and effect of proportionate input could not be achieved due to climate and soil condition of experimental site.

Table 3: Analysis of Variance (ANOVA) summaries F and P values of yield components.

	Plant Height (cm)	Tiller per hill	Panicles m^{-2}	Sterility	Normal kernel
Fertilizers	16.6*	1.5 NS	3.4 NS	31.0 *	12.5 *
Spacing	0.5 NS	39.7 *	29.4 *	26.6 *	0.6 NS
Interaction	0.2 NS	3.3 NS	0.6 NS	10.9 *	0.2 NS
	1000-grain weight	Peddy yield	Straw yield	Harvesting Index	
Fertilizer	103.1 *	0.1 NS	3.7 NS	0.1 NS	
Spacing	135.3 *	0.1 NS	96.1 *	5.0 NS	
Interaction	0.3 NS	0.7 NS	10.5 *	0.1 NS	

* F value of yield component significant at P value (F. Tab.) of 5.99.

The other reason for not achieving objective is the past recommendation of fertilizer application before irrigation. The research and data was collected during training without trained labor of planting seedling on required plant spacing on 20x10 cm and without availability of sufficient resources. The increased plant density and increased NPK fertilizers has significant effect on the plant height, number of tiller per hill, number of panicles per square meter, sterility (%), normal kernel (%), 1000 grain weight and straw yield. Whereas Lopez *et al.* [1985] concluded that application of 156 kg N, 99 kg P and 93 K ha^{-1} gave the highest grain yield but the application of 143 kg N, 90 kg P and 93 kg K ha^{-1} gave the greatest economic return with good harvesting index. The objective of present study for increasing yield with application of increased plant

population and fertilizer dose on paddy yield could be achieved with use of micro nutrients, BFS and improve agro- practices. Still efforts are required to find out methods to achieve potential yield of rice for growing needs to feed of population of the world.

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