EFFECTS OF EXOGENOUS NITROGEN LEVELS ON THE YIELD OF RICE GRAIN IN SHEIKHUPURA, PAKISTAN

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ABSTRACT:- A three-year field experiment was conducted at Adaptive Research Farm, Sheikhupura to optimize the nitrogen levels for two coarse cultivars. The coarse rice cultivars are the non-basmati rice cultivars having no fragrance. The experiment was laid out in randomized complete block design in factorial arrangement. The experiment consisted of three nitrogen rates viz. 85, 170 and 255 kg ha^{-1}, and two rice cultivars viz. KSK-133 and KS-282. Both these rice cultivars are widely grown by the farmers in rice-wheat around the experimental site. Every year, the nursery of both the rice cultivars was transplanted during the second week of July. The results indicated that different nitrogen levels had a significant effect on all studied parameters of both rice cultivars during all the years of experimentation. Both cultivars also differed significantly from each other in number of grains per spike, 1000-grain weight and paddy yield during all the years of experimentation. Application of nitrogen at 255 kg ha^{-1} was the most suitable level of nitrogen for both the cultivars. The performance of KSK-133 was better than KS-282 at all levels of N during all the years. In conclusion, to attain higher yields of coarse rice, KSK-133 should be grown and the nitrogen should be applied at 255 kg ha^{-1} under agroecological conditions of Sheikhupura.

Key Words: Nitrogen, Rice, Course Cultivars, Vegetative Growth

INTRODUCTION

The judicious use of fertilizers is critical for commercial production of agricultural crops. Unwise use of fertilizers may increase the cost of production. Over use of nitrogenous fertilizers can cause lodging of crop plants and may enhance the incidence of insect pests and diseases. High nitrogen rates can cause the leaching of fertilizers into underground water reservoirs (Lemair and Gastal, 1997; Pham et al., 2004; Cu et al., 1996), which may pollute the ground water. However, it is well known fact that higher doses of fertilizer (especially nitrogen) boosts the agricultural yields (Cassman et al., 2003). Introduction of fertilizer responsive semi-dwarf crop varieties of wheat and rice during green revolution in 1960's helped improving yields of both crops (Yoshida, 1972). After that era, the use of nitrogenous fertilizers has become common in Pakistan.

Today, nitrogen is the most widely demanded and applied fertilizer for cereals across the globe. It is vital due

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to its multi-dimensional roles in the plant growth and metabolism. Nitrogen is the integral component of chlorophyll, amino acids, energy transfer compounds like ATP and genetic material i.e. DNA and RNA. During the vegetative growth phase, nitrogen is quite necessary as it promotes the plant growth.

Rice is second most important cereal crop in the world and is grown in diverse climatic conditions in many countries of the world. Although, most of the growers in rice growing areas in Pakistan has shifted towards the production of fine aromatic basmati rice, yet many farmers in Punjab and Sindh prefer to grow coarse rice varieties. These coarse rice varieties demand higher doses of fertilizers than traditional fine aromatic basmati rice varieties. Among different yield limiting factors in rice, one is the under optimal use of nitrogenous fertilizers (Xia et al., 2011). Nitrogen applied to rice plants is responsible mainly for vegetative growth, photosynthesis and also contributes towards grain filling through translocation during re-productive phase (Mae, 1997; Bufogle et al., 1997; Norman et al., 1992). It also contributes actively towards accumulation of carbohydrate in culm and leaf sheaths during the pre-heading stage (Swain et al., 2010). Moreover, nitrogen is also involved in sink size at late panicle formation stage. Therefore, proper nitrogen management is a key factor in boosting up the yield of rice. Application of nitrogenous fertilizer at the proper time with a suitable rate according to the soil conditions can cause a significant increase in paddy yield by increasing nitrogen use efficiency of the crop (Ganga Devi et al., 2012; Shakouri et al., 2012). Keeping in view the above facts, a field study was carried out to quantify nitrogen requirements of 2 coarse rice cultivars viz. KS-282 and KSK-133, grown under climatic conditions of Sheikhupura, Pakistan.

MATERIALS AND METHOD

Site Description

The study was undertaken at Adaptive Research Farm, Sheikhupura, (longitude 73.98 °E, latitude 31.7 °N, and altitude 236 masl). The climate of the study site is moist sub-humid with annual precipitation ranging from 250 to 500 mm. Rice-wheat cropping system is adapted by the majority of the farmers in Sheikhupura and neighboring areas. Soil samples were collected from a

Table 1. Meteorological data for Kharif 2012, 2013 and 2014 at Adaptive Research Farm, Sheikhupura

	Temperature (°C)						Rainfall (mm)			Relative Humidity (%)		
	Minimum			Maximum								
	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
July	30.2	20.1	26.7	40.0	35.4	38.3	144.5	123.6	254.7	62.3	64.5	66.0
August	25.0	24.2	26.8	37.0	33.5	36.6	48.0	253.1	28.9	66.2	72.6	69.2
September	21.0	21.0	24.1	32.0	31.6	32.7	269.3	058.2	180.5	69.5	80.2	70.5
October	18.3	19.2	20.7	30.4	30.5	30.4	010.0	020.2	001.0	71.2	82.5	75.2
November	12.5	10.0	10.2	24.6	28.2	25.8	080.5	---	015.5	78.5	84.5	79.5

Source: Meteorological cell, Adaptive Research Farm, Sheikhupura depth of 30 cm, were composited, and were analyzed for various physio-chemical characteristics. Soil of the study site was loamy in nature as categorized by the International textural triangle (Moodie et al., 1959) with relative proportion of 14%, 70% and 16% of sand, silt and clay, respectively. The soil had pH of 8.4 with 0.07% total nitrogen, 10.4 ppm available phosphorous, 204 ppm potassium, 0.8% organic matter and 10.1% total soluble salts for all three years with 1-2% variations. Meteorological data of Kharif-2012, 2013 and 2014, obtained from meteorological observatory set up at Adaptive Research Farm, Sheikhu-pura is presented here in Table 1.

Crop Husbandry

Nursery of both rice cultivar (KS-282 and KSK-133) was sown in the first week of June every year, and it was transplanted in puddled soil during the first week of July. Phosphorus and potassium @ 101 and 62 kg ha^{-1}, respectively as recommended by the Department of Agriculture, Punjab were applied to all experimental units at the time of puddling every year. Diammonium phosphate (DAP) and sulphate of potash (SOP) were used as the sources of phosphorus and potassium respectively for the whole period of study. Moreover, Zn deficiency was compensated with the application of zinc sulphate (33%) @ 5 kg ha^{-1} at the active tillering stage. Rest of the agronomic operations like soil preparation, irrigation and weed management, etc. were kept uniform for all the experimental units every year. Harvesting and threshing were done manually every year from all the experimental units individually.

Experimental Design and Treatments

This experiment was conducted in Randomized Complete Block Design in factorial arrangement. The experiment consisted of three nitrogen levels viz. 85, 170 and 255 kg ha^{-1} and 2 coarse rice varieties viz. KS-282 and KSK-133. Urea and DAP purchased from Fauji Fertilizer Limited Pakistan were used as a source of nitrogen. It was applied in 3 splits at tillering, panicle initiation and flowering stage) in equal doses according to treatment structure to all the experimental units. Each year, the net plot size was 3.78 m × 3.12 m for each experimental unit. Nitrogen supplied by DAP was also taken into account while applying the treatments.

Data Collection and Statistical Analysis

Data regarding different agronomic parameters like plant height at maturity, productive tillers m^{-2}, the number of grain per spike, grain weight index (1000-grain weight) and paddy yield was recorded using the standard procedures. The collected data was analyzed statistically by employing the Fisher's analysis of variance technique. The significance of treatment means was tested using the least significance difference (LSD) test at 5% probability level (Steel et al., 1997).

RESULTS AND DISCUSSION

Plant Height (cm)

Different nitrogen levels significantly affected the plant height of both cultivars during all 3 years of experimentation. However, rice cultivars did not differ significantly for plant height during all the years. The interaction of rice cultivars with nitrogen levels was also significant for plant height during all years of experimentation (Table 2). In general, increased dose of N caused significant increase in plant height. The maximum plant height during all years was recorded with the application of nitrogen @ 255 kg ha^{-1} for cultivar KSK-133 and it was followed by cultivar KS-282 with the same application rate of nitrogen during all years (Table 2). The minimum plant height during all experimental years was recorded in KS-282 with the application of nitrogen @ 85 kg ha^{-1}.

Number of Productive Tillers (m^2)

Different nitrogen levels significantly affected the productive tillers of both cultivars during all 3 years of experimentation. However, rice cultivars did not differ significantly for productive tillers during all the years. The interaction of rice cultivars with nitrogen levels was also significant for productive tillers during all years of experimentation (Table 2). In 2012, nitrogen application at either rate was equally beneficial for improvement in the number of productive tillers in both rice cultivars except nitrogen application @ 85 kg ha^{-1} in KSK-282. In 2013, the highest number of productive tillers were observed in KSK-282 with nitrogen application @ 255 kg ha^{-1}. However, in cultivar KSK-133, nitrogen application @ 170 kg ha^{-1} was best for improvement in number of productive tillers during 2013. In 2014, nitrogen application @ 255 kg ha^{-1} in both cultivar or nitrogen application @ 170 kg ha^{-1} in KSK-133 was equally beneficial for improvement in number of productive tillers (Table 2).

Number of Kernels Per Panicle

Different nitrogen levels significantly affected the kernels per panicle of both cultivars during all 3 years of experimentation. Rice cultivars also differ significantly for kernels per panicle during all the years. The interaction of rice cultivars with nitrogen levels was also significant for kernels per panicle during all years of experimentation (Table 2). The highest number of kernels per panicle were observed in cultivar KSK-133 @ 255 kg ha^{-1} during all experimental years and that was statistically similar with the nitrogen application at the same rate in cultivar KSK-282 in 2012 and 2013. Overall, cultivar KSK-133 produced more kernels per panicle than cultivar KSK-282 during all three experimental years (Table 2).

1000-grain Weight (g)

Different nitrogen levels significantly affected the 1000-grain weight of both cultivars during 2012 and 2014. Rice cultivars also differ significantly for 1000-grain weight during 2013 and 2014. The inter-action of rice cultivars with nitrogen levels was also significant for 1000 grain weight during all years of experimentation (Table 2). In 2012 and 2014, the highest 1000-grain weight was recorded in KSK-133 with nitrogen application at @ 255 kg ha^{-1} and that was statistically similar with KSK-282 with the same level of nitrogen application. In 2013, nitrogen application at either rate in KSK-133 and @ 255 kg ha^{-1} in KSK-282 was equally beneficial for improvement in 1000-grain weight. Among the rice cultivars, the highest

1000-grain weight was recorded in KSK-133 during 2013 and 2014 (Table 2).

Paddy Yield (t ha^{-1})

Different nitrogen levels significantly affected the paddy yield of both cultivars during all 3 years of experimentation. Rice cultivars also differed significantly for paddy yield during all the years. The interaction of rice cultivars with nitrogen levels was also significant for paddy yield during all years of experimentation (Table 2). In all years, the highest paddy yield was recorded in KSK-133 @ 255 kg ha^{-1}. Among the rice cultivars, the performance of KSK-133 was better than KSK-282. The lowest paddy yield was noted in KSK-282 @

Table 2. Effect of different doses of nitrogen on the yield of rice varieties KS-282 and KSK-133 during

	2012			2013			2014		
Plant height (cm)	KS-282	KSK-133	Mean (N)	KS-282	KSK-133	Mean (N)	KS-282	KSK-133	Mean (N)
85-101-62 NPK (kg ha^{-1})	94^{c}	95^{bc}	95^{B}	96^{d}	97^{cd}	97^{C}	96^{c}	97^{bc}	96^{B}
170-101-62 NPK (kg ha^{-1})	96^{abc}	97^{abc}	96^{AB}	98^{bcd}	99^{abc}	99^{B}	97^{bc}	98^{abc}	97^{B}
255-101-62 NPK (kg ha^{-1})	97^{ab}	98^{a}	98^{A}	100^{ab}	101^{a}	101^{A}	98^{ab}	99^{a}	99^{A}
Mean (VRT)	96	96		98	99		98	98	
LSD values ($p \leq 0.05$)	N=1.95;VRT = ns; N × VRT= 2.75			N=1.50; VRT=ns; N × VRT= 2.13			N=1.22;VRT=ns; N × VRT= 1.72		
Number of productive tillers (m^{2})									
85-101-62 NPK (kg ha^{-1})	158^{b}	159^{ab}	158^{B}	163^{c}	164^{c}	164^{c}	157^{d}	158^{cd}	158^{C}
170-101-62 NPK (kg ha^{-1})	159^{ab}	159^{ab}	159^{AB}	166^{bc}	169^{ab}	168^{b}	161^{bc}	162^{ab}	161^{B}
255-101-62 NPK (kg ha^{-1})	160^{ab}	160^{a}	161^{A}	172^{a}	171^{b}	171^{a}	164^{a}	165^{a}	165^{A}
Mean (VRT)	151	59		716	168		16	162	
LSD values ($p \leq 0.05$)	N= 1.84;VRT= ns; N × VRT= 2.61			N= 2.17;VRT=ns; N × VRT= 3.06			N= 2.25;VRT=ns; N × VRT= 3.18		
Number of grains per spike									
85-101-62 NPK (kg ha^{-1})	315^{d}	316^{d}	316^{C}	343^{d}	346^{c}	345^{C}	321^{f}	334^{e}	328^{C}
170-101-62 NPK (kg ha^{-1})	340^{c}	345^{b}	325^{B}	349^{b}	350^{b}	350^{B}	340^{d}	344^{c}	342^{B}
255-101-62 NPK (kg ha^{-1})	362^{a}	364^{a}	363^{A}	352^{ab}	354^{a}	353^{A}	350^{b}	356^{a}	353^{A}
Mean (VRT)	339^{B}	342^{A}		348^{B}	350^{A}		337^{B}	345^{A}	
LSD values ($p \leq 0.05$)	N= 2.57;VRT= 2.10; N × VRT= 3.63			N= 2.10;VRT= 1.72; N × VRT= 2.97			N= 2.53;VRT= 2.06; N × VRT= 3.58		
1000-grain weight (g)									
85-101-62 NPK (kg ha^{-1})	21.2^{c}	21.3^{bc}	21.3^{B}	21.3^{bc}	21.4^{ab}	21.4	21.1^{d}	21.5^{c}	21.3^{B}
170-101-62 NPK (kg ha^{-1})	21.3^{bc}	21.4^{abc}	21.4^{AB}	21.2^{c}	21.5^{a}	21.4	21.7^{bc}	21.8^{abc}	21.8^{A}
255-101-62 NPK (kg ha^{-1})	21.4^{ab}	21.5^{a}	21.5^{A}	21.4^{ab}	21.5^{a}	21.5	21.9^{ab}	22.1^{a}	22.0^{A}
Mean (VRT)	21.3	21.4		21.3^{B}	21.5^{A}		21.6^{B}	21.8^{A}	
LSD values ($p \leq 0.05$)	N= 0.14;VRT=ns; N × VRT= 0.19			N= ns;VRT= 0.09; N × VRT= 0.16			N= 0.24;VRT= 0.20; N × VRT= 0.34		
Paddy yield (t ha^{-1})									
85-101-62 NPK (kg ha^{-1})	5.37^{f}	5.67^{e}	5.52^{C}	5.40^{f}	5.50^{e}	5.45^{C}	5.39^{e}	5.43^{e}	5.41^{C}
170-101-62 NPK (kg ha^{-1})	5.90^{d}	6.33^{c}	6.12^{B}	5.91^{d}	6.12^{c}	6.02^{B}	5.86^{d}	6.08^{c}	5.97^{B}
255-101-62 NPK (kg ha^{-1})	6.38^{b}	6.67^{a}	6.53^{A}	6.45^{b}	6.58^{a}	6.52^{A}	6.20^{b}	6.33^{a}	6.27^{A}
Mean (VRT)	5.88^{B}	6.22^{A}		5.92^{B}	6.07^{A}		5.82^{B}	5.94^{A}	
LSD values ($p \leq 0.05$)	N= 0.04;VRT= 0.03; N × VRT= 0.05			N= 0.03;VRT= 0.02; N × VRT= 0.04			N= 0.04;VRT= 0.03; N × VRT= 0.05		

Means not sharing the same letter for a set of data differ from each other at p≤0.05; N= nitrogen levels, VRT= Rice Varieties; INT= interaction between nitrogen levels and varieties.

85 kg ha^{-1} during all years (Table 2).

Discussion

Nitrogen is one of the yield limiting factors of cereals in the world (Ladha and Reddy, 2003; Samonte et al., 2006). It is actively involved in many different phenomenon in the plant body like photosynthesis, carbohydrate assimilation and grain filling (Mae, 1997). In addition to it, proper utilization of other useful nutrients like phosphorous and potassium is also dependent upon the balanced nitrogen supply to the plant, as it makes plant healthy through proper vegetative growth. In present study, increase in plant height was observed with the increase in the applied nitrogen to the crop plant (Table 2). This might be due to enhancement in the vegetative growth of the plant (Singh and Sharma, 1987; Maqsood, 1998; Meena et al., 2003), which ultimately improved the assimilate translocation thus ensuring better rice yields. Higher levels of nitrogen supply to the rice plant also enhanced the number of productive tillers of both the cultivars (KSK-122 and KS-282). Indeed, nitrogen was applied exactly applied at active tillering stage, which might have boost up the cell division thus resulting in the emergence of more shoots (Singh and Sharma, 1987; Rafey et al., 1989; Munda, 1989; Maqsood, 1998; Nawaz, 2002; Meena et al., 2003). Increased supply of nitrogen also caused a significant increase in number of grains per spike as maximum number of grains per spike in both cultivars was recorded at 255 kg ha^{-1} of N. More grains per spike might be attributed to better source to sink relationship which improved the grain filling cascades. Indeed, higher photo-synthesis rate due to larger leaf area owing to nitrogen application helps translocation of photosynthates to the grains that causes a significant increase in number of grains per spike (Cock and Yoshida, 1973). It was also recorded that increase in the nitrogen supply, significantly increased the 1000-grain weight of both rice cultivars during all three years of study. It might also be due to increased production of photosynthates that translocated to grain and sub-sequently increased the 1000-grain weight of rice. In few other studies, Maqsood (1998) and Nawaz (2002) also reported an enhancement in number of grains per spike and grain weight with the application of higher doses of nitrogenous fertilizer. Maximum paddy yield in case of 255 kg ha^{-1}, looks the results of more number of productive tillers, more number of grains per spike and higher 1000 grain weight in this treatment. The differences in yield parameters and paddy yield among the both rice cultivars might be due to genetic variations among the cultivars. In addition, negligible differences among yield and yield associated parameters during 2012, 2013 and 2014 might be attributable to climatic variations (Table 1). In conclusion, course rice cultivar KSK-133 is better than KS-282. For attaining higher paddy yields under agroecological conditions of Sheikhuspura, cultivar KSK-133 should be grown with nitrogen application @ 255 kg ha^{-1}.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

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1.	Mr. Muhammad Nawaz	Over all management of the paper, data collection
2.	Mr. Anwar Javaid Wahla	Technical input at every step , result and discussion, conclusion
3.	Mr. Muhammad Saleem Kashif	Data entry and analysis, result and discussion, conclusion
4.	Mr. Asim Raza Chadhar	Wrote abstract, methodology, result and discussion.
5.	Mr. Muhammad Anjum Ali	Conceived the idea, technical in put at every step
6.	Mr. Masood Qadir Waqar	Conceived the idea, technical in put at every step

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