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Panicle Structure, Kernel Quality and Yield of Fine Rice as Influenced by NPK Rates and Split Nitrogen application

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ABSTRACT

Field experiments were conducted at Agronomic Research Farm, University of Agriculture, Faisalabad to determine the effect of different NPK rates and N-application technique on panicle structure, kernel quality and yield of rice "Basmati-385". Application of NPK @ 130-67-67 kg ha^{-1} produced the maximum grain yield (4.35 t ha^{-1}) as against the minimum (3.85 t ha^{-1}) @ 60-0-0 kg ha^{-1} while occurrence of sterility, abortive, opaque and chalky kernels in primary and secondary branches were significantly reduced. Application of nitrogen in three equal splits at transplanting, tillering and panicle initiation stages resulted in highest grain yield (4.25 t ha^{-1}) due to longer panicle and more spikelets per panicle against the minimum (3.7 t ha^{-1}) for all N as basal dose. Quality parameters such as occurrence of normal kernels and chalkiness were considerably improved due to improved panicle structure.

Key Words: Panicle structure; Malnutrition; Sterility; Abortiveness; Split nitrogen application; Kernel quality

INTRODUCTION

Rice (*Oryza sativa* L.) crop is adversely affected by malnutrition, poor panicle structure, spikelet sterility, ill ripening of kernel and kernel chalkiness. These problems are attributed to the disturbance in the normal functioning of the vital physiological processes like photosynthesis, translocation of carbohydrate and regular nutritional supply. Appropriate NPK level and their proper management have been reported to have a direct bearing on panicle structure and kernel quality (Karim *et al.*, 1992). Applying N in splits as per need of the crop can considerably increase the N-use efficiency of crop (Sharif, 1994) and improve the quality and productivity of rice. The present study was designed to evaluate the effect of different NPK rates and split application of nitrogen on development of panicle structure, kernel quality and yield of fine rice "Basmati-385" under the agro-ecological conditions of Faisalabad.

MATERIALS AND METHODS

The experiment was conducted during Kharif 1995 and 1996 at Agronomic Research Area, University of Agriculture, Faisalabad. The experimental soil was sandy clay loam having pH 7.8, organic matter 0.21%, total nitrogen 0.051%, available P 5.0 ppm and K 178 ppm. The treatments consisted of three NPK levels (60-0-0, 130-67-67, 180-90-90 kg ha^{-1}) as main plots and 3 N application techniques (all N as basal, 1/2 N at transplanting + 1/2 N at early tillering, 1/3 N at transplanting + 1/3 N at early tillering + 1/3 N at panicle initiation stage in subplots). The layout design was split plot with four replications. The net plot size measured 2m x 3m. Phosphorus and potash were applied as basal, while N was applied in splits as per treatment. Twenty five days old seedlings were transplanted in the puddled field on July 5 at 20 cm x 20 cm spacings. All other agronomic operations were kept normal and uniform. Twenty hills were selected randomly from every experimental unit to count the panicle bearing tillers per hill. For recording observations on panicle length, primary and secondary branches, spikelet primary and secondary branches per panicle, percentage of sterile (unfertilized flower), abortive (the flower that gets fertilized but does not attain full size as it stops growing during early stage of kernel development), opaque (kernel that attains full size but do not become translucent due to lack of carbohydrates), chalkiness, normal kernels (kernels that attain full size, turn translucent and show normal compaction of starch), 30 panicles were selected at random from every plot and standard procedures as described by Nagato and Chaudhry (1969) were employed. Data collected were analysed statistically by using Fisher's analysis of variance technique and LSD test at 0.05 P was employed to compare the treatment means (Steel & Torrie, 1984).

RESULTS AND DISCUSSION

Panicle bearing tillers m^{-2}. Different NPK levels and N-application techniques had significant effect on the number of panicle bearing tillers m^{-2} (Table I). Crop fertilized @ 130-67-67 kg NPK ha^{-1} (F_2) produced the maximum number of panicle bearing tillers m^{-2} against the minimum for F_1 (60-0-0 kg ha^{-1}). Data conclusively indicated that application of balanced NPK level (F_2) that is the recommended level proved to be more effective in producing more panicle bearing tillers m^{-2} under the given conditions. Application of N in three equal splits (1/3 at transplanting + 1/3 at early tillering + 1/3 at panicle initiation) produced more number of panicle bearing tillers m^{-2} than N_1 and N_2 which was attributed to more sustained supply of N during the entire growth period of the crop and thereby resulting in more panicle bearing tillers m^{-2}. Similar results have been reported by Sariam and Surjit (1990).

Panicle length (cm). Both the NPK levels and N-application techniques affected significantly the panicle length (Table I). Greater panicle length in F_3 (180-90-90 kg ha^{-1}) might be attributed to adequate supply of NPK especially N both during the vegetative growth stage and at panicle emergence. These results are in conformity with those of Singh (1992) who stated that length of panicle was increased with successive increase in nitrogen rate. Similarly, greater panicle length in N_3 (1/3 at transplanting + 1/3 at early tillering + 1/3 at panicle initiation) might again be due to sufficient availability of nitrogen at panicle emergence stage. Karuna and Reddy (1992) documented that yield attributes like panicle length and number of filled spikelets were significantly higher when N was applied in three splits.

No. of primary and secondary branches panicle^{-1}. Both the NPK levels and N-application techniques significantly influenced the number of primary and secondary branches per panicle. Significantly more number of primary and secondary branches was recorded in F_3 (180-90-90 kg NPK ha^{-1}) which, however, did not differ from F_2 (130-67-67 kg ha^{-1}) with the minimum in F_1 (60-0-0 kg ha^{-1}). Nitrogen application in three equal splits (1/3 at transplanting + 1/3 at early tillering + 1/3 at panicle initiation) resulted in more number of primary and secondary branches than N_1 but did not differ from N_2 (1/2 N at transplanting + 1/2 N at early tillering). More number of primary (Lion, 1987) and secondary branches (Matsushima, 1969) in F_3 and N_3 might be ascribed to appropriate nutritional supply at primary and secondary rachis branch differentiation phase and optimum number of spikelets in these treatments.

Spikelets in primary and secondary branches. Different NPK rates did not influence the spikelets on primary and secondary branches. By contrast, split application of N significantly influenced the spikelets on secondary branches.

More number of spikelets in F_3 (180-90-90 kg ha^{-1}) and N_3 (1/3 at transplanting + 1/3 N at early tillering + 1/3 at panicle initiation) might be due to sustained supply of N which probably enhanced the physiological activities of plant and thereby resulting in more synthesis and translocation of carbohydrates during spikelets formation and spikelets differentiation stages.

Sterility, abortiveness and opaqueness panicle^{-1}. Occurrence of sterility and abortiveness were significantly influenced both by NPK levels and N-application techniques. Opaque kernels in primary branches was significantly affected. However, occurrence of opaque kernels in secondary branches was not influenced by NPK levels. NPK level F_2 (130-67-67 kg ha^{-1}) resulted in the maximum reduction in occurrence of sterile, abortive and opaque kernels in primary and secondary branches which was attributable to sufficient availability of plant nutrient at early, middle and later development stages facilitating the continuous translocation of carbohydrates to the panicles and reducing these kernel abnormalities. Similar observations have been recorded by Khan and Chaudhry (1995).

Higher sterility and opaqueness in N_3 was due to longer panicles, more spikelet panicle^{-1} which resulted in

Table I. Effect of different NPK levels and N-application techniques on panicle structure, kernel quality and yield of Basmati-385 (Two year average data)

	(P)	(Pl)	(PB)	(SB)	(Sp)	(Ss)	(Stp)	(Sts)	(Apb)	(Abs)	(Op)	(Ops)	(Cp)	(Cs)	(Np)	(Ns)	(Gy)
NPK rates (kg ha^{-1})																	
F_1 (60-0-0)	9.2b	33.5b	12.4b	40.8	74.0	142.3	13.4a	17.9a	4.3b	6.4b	9.3a	9.2	44.6a	40.8a	73.4b	66.2	3.58b
F_2 (130-67-67)	12.0a	34.2a	13.2ab	42.3	75.2	152.7	10.9b	14.4b	4.0b	8.2ab	7.6b	7.9	29.3b	25.4b	76.1a	69.6	4.35a
F_3 (180-90-90)	11.9a	34.5a	12.9a	45.2	77.6	153.7	11.5b	16.2ab	5.8a	9.5a	9.2a	8.8	32.1b	28.6b	73.8b	65.8	4.19a
CD (0.05)	1.14	0.37	0.46	3.12	NS	NS	1.65	1.99	1.13	2.37	1.03	NS	3.31	3.66	1.98	NS	0.22
N-application techniques																	
N_1:All N at transplanting	10.7a	33.6b	12.5b	39.7c	73.5b	139.1b	11.2b	15.8ab	5.2a	8.5a	7.9b	8.3b	37.4a	34.1a	73.1	64.9b	3.78b
N_2:1/2 N at transplanting + 1/2 N at tillering	10.9a	33.9b	12.9ab	43.4b	74.8b	148.5b	10.6b	14.8b	5.2a	9.4a	9.0a	8.1b	35.0b	30.2b	74.9	67.2b	4.09a
N_3:1/3 N at transplanting + 1/3 N at tillering + 1/3 N at panicle initiation	11.4b	34.7a	13.2a	45.9a	78.4a	161.2a	14.0a	17.8a	3.7b	6.3b	9.4a	9.6a	33.6b	30.5b	75.3	69.5a	4.25a
CD (0.05)	0.62	0.43	0.43	2.31	2.14	9.71	1.71	2.07	0.88	1.26	1.05	0.84	2.53	3.24	NS	2.60	0.20

P=Panicle bearing tillers (No.); Pl=Panicle length(cm); PB, SB=Primary and secondary branches (No.); Gy=Grain yield t ha^{-1}; Sp, Ss=Spikelets and primary and secondary branches; Stp, Abp, Op, Cp, Np= Sterile, abortive, opaque, chalky and normal kernel (%) in primary branches panicle^{-1}; Sts, Abs, Ops, Cs, Ns= Sterile, abortive, opaque, chalky and normal kernel(%) in secondary branches panicle^{-1}

severe competition among the spikelets. The minimum abortiveness in N_3 was ascribed to higher sterility in this treatment which ameliorated the severe competition among the growing kernels for carbohydrates. These results are in line with Khan (1991) who stated that hard competition at fertility stage caused high spikelet sterility and left the remaining spikelets at a better position to survive at abortive stage and vice versa.

Occurrence of chalky kernels in primary and secondary branches. NPK levels and N-application in splits significantly affected the occurrence of chalky kernels. Significantly the minimum chalky kernels were obtained in F_2 (130-67-67 kg ha^{-1}) which did not differ from F_3 (180-90-90 kg ha^{-1}). The minimum chalkiness recorded in F_2 was also due to sufficient supply of plant nutrients. The reduced rate of chalkiness in N_3 was due to improvement in photosynthetic rates as reported by Hoshikwa (1993).

Normal kernels in primary and secondary branches. NPK levels significantly influenced the normal kernel in primary branches. By contrast, in secondary branches, the differences among different NPK treatments could not reach the level of significance. The occurrence of more normal kernels in F_2 (130-67-67 kg ha^{-1}) and N_3 (three splits) might be due to the same reason as explained in the preceding parameters i.e. adequate and sustained supply of nutrients produced more carbohydrates for growing kernels which caused a considerable reduction in abnormal kernels.

Grain yield (t ha^{-1}). Grain yield was significantly influenced by NPK levels. Application of N in splits also exerted a remarkable influence on grain yield. Higher grain yield in F_2 (130-67-67 kg ha^{-1}) was due to better kernel development, less deterioration in panicle structure and positive effect of yield components.

Application of NPK @ 130-67-67 kg ha^{-1} with N application in three equal splits proved to be the best for obtaining optimum panicle structure with maximum normal kernels along with considerable reduction in sterility, opaqueness and chalkiness.

Higher level of NPK with all N at transplanting although increased panicle length, primary and secondary branches, primary and secondary spikelets to a considerable extent but resulted in significant reduction in normal kernels due to higher kernel abnormalities and poor panicle structure development. Improvement in paddy yield, panicle structure and kernel quality with split application of nitrogen has also been reported by Karuna and Reddy (1992) and Sharif (1994).

CONCLUSION

The results led to the conclusions that rice cultivar Basmati-385 should preferably be fertilized @ 130-67-67 kg ha^{-1} with nitrogen application in three equal splits each at transplanting, tillering and panicle initiation stage as it not only improves the panicle structure and kernel quality but also increases grain yield ha^{-1} to a considerable extent.

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