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PANICLE STRUCTURE, KERNEL QUALITY AND YIELD OF F,:INERICE AS INFLUENCED BY DIFFEREN,t NPK LEVELS AND PER HIL.LSEEDLING DENSITY

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Field studies to evaluate the effect of four NPK levels I.e, 02Q0, 60"0-0, 130-67-67 and 180-90-90 kg ha" and three seedling densities (1, 2 and 3 seedlings per hill) on panicle structure and kernel quality were conducted for two consecutive years during 1995 and 1996. The experirll'ent was laid out in randomized complete block design with split plot arrangement having 4 replications and. a net plot size at 2 x 3 m. Yield and yield components were significantly improved by NPK level of 130-67",67 kg ha . arid 2 seedlings/hillalong with considerable reduction in kernel sterility, opaqueness and chalkine~s due/tbetter development of panicle structure. Application of NPK F_2(130-67-67 kg ha") produced the maximum~grain yield at 4.63 and 4.45 t ha" during 1995 and 1996, respectively against the minimum of 3.21 and 2.63 t ha' in control (0-0-0). Among seedling density treatments, two seedlings per hill resulted in the maximum grain ¥ield of 4.30 and 4.02 t ha" during 1995 and 1996, respectively.

Key words: fine rice, kernel quality, panicle structure, per hill seedling density

INTRODUCTION

Rice *(Oryza sativa L.)* is an important staple food of over half the global population. In Pakistan, it is also a major source of foreign exchanqe eamings. Ou: fine rice commonly known as Basmati is world famous and enjoys monopoly in the intemational market due to its fineness and aroma. But its per hectare yield is markedly lower than the potential yield of the existing varieties. Among several factors responsible for lower yield, poor grain quality and panicle structure, sterility of spikelet, ill-ripening of kernel and kernel chalkiness are of immense importance. Poor panicle structure and abnormal kernels in rice are international problems and need concerted efforts of both the breeders and the aqronornists to improve it. Increasing yield through improvement in panicle structure, ripening and kernel quality would be a significant and valuable scientific accomplishment arid a great service to hurnanity.

Optimum nutrition and appropriate number of seedlings per hill are important factors to improve panicle structure and yield of rice. The number of seedlings per hill influence the tillers per unit area affecting the penetration of sunlight and photosynthesis which ultimately affect the growth and development of crop, and its kernel quality (5reedevi and 5reedharan, 1991). Optimum plant population and appropriate level of NPK have a direct bearing on panicle structure and kernel quality (Karirn *et at"*, 1992). Thus, to improve panicle structure and to get higher yield, optimum number of seedlings/hill and NPK level are essential. The present study was designed ro determine appropriate levels of NPK and optimum number of seedlings per hill that could help ill achieving the suitable panicle structure, better kernel quality and increased paddy yield.

MATERIALS AND METHODS

The. expel irnent was conducted at the Agronomic Research Area, University' of Agriculture, Faisalabad during 1995 and 1996. The soil was sandy clay loam with pH 7.7, organic matter 0.69%, total nitrogen 0.036%, available P'<0s6.3 ppm and K 187 ppm. A recornrnended fine nee venety,Basrnati-Sdf was used as a test crop.

The treatments comprised four NPK levels i.e. 0-0-0 (Fa), 60-0-0 (Fi), 130-67-67 (Fi) and 180-90-90 (F_3) kg ha' 511:_ :3 seedlinq densities viz. 1 (5,),2 (52) and 3 (53) seedlings per hill. The experiment was laid out i' randomized complete block design with split plot arrangement having 4 replications and a net plot size measuring 2 x 4 m. Various NPK levels were rancornized to main plots and seedling densities to subplots. All P and K and one-third N were applied at transplanting. The remaining N was top dressed in two equal splits i.e. at tillering and panicle initiation. The other agronomic practices were kept normal and uniform.

Twenty hills were selected randomly from each experimental unit to count the panicle bearing tillers per *hill.* For recording panicle length, primary', secondary branches, percentage of sterile lunf... flowers), *abortive* (the flowers that get fert'... do not attain *full* size as they stop grow' ... *early* stage of kernel development), *op*... (that attain *full size* but do not bee... translucent due to lack of carbohydrates), cha"ky kernels (kernels *having* white POwdery mass' e~ ... on *dorsal* or *ventral side* or in the central con... *normal* kernels (that attain *full* size, turn translucent and show normal compactness of starch) in primary and secondary branches. T'hfty panicles were selected at random from *every* ptoti. The standard methods *given* by Nagato and Chaudhry (1969) were employed to determine the aforementioned *quantitative* and *qualitative* chara~teristics of rice panicle.

RESULTS AND DISCUSSION

Panic•,e_ng *Tillers:* Panicle bearing t'"ers were signifioantly affected by number of seedlings per hiH *andj~-leve/s during* both the years (Table 1). The ~jfTlum *panicle* bearing tillers *were* produced by ~,. *level* of 130-67-67 kg ha' and a density of 2 seedlings (52)per hi.fl: The increased panicle bearing tillers *in* F_2 and S2 might be due to proper bai,ance *between the* NPK *availability* and tillers produced in $2- Maximum paniele bearing tillers *were* obtained *with* NPK *level* of 130-67-67 kg ha' (Anonymous, 1990), while Desingn *et al.* (1990) *recorded* the *maximum* panicle bearing tillers With optimum number of plants under *lesser* competition.

Pantola-length (cm): *Panicle* length was significantly affected by NPK levels and per hill seedling density (Table 1) during both the years. Panicles of greater length in F3 (180-90~90 kg ha') might be due to adequate Supply of nitrogen during the vegetative growth period of plant partiCUlarly at panicJ;e *emergence. NPK level* F_3, *however,* did not differ statistically from F_2 (130-67-67 kg ha') in 1995. Production of longer panicles with treatment S, (1 seedling/hill) might be due to better competition among the tillers on aCCOuntof small number of panicle bearing tillers hill'. These results conform to those of Rao and Reddy (1993) who reported that increasing number of seedlings per hill decreased the panicle length due to high *interplant* competition.

Primary and Secondary Branches per Panicle: Primary and Secondary branches per panicle *were* influenced significantly by NPK levels and per hill seedling density (Tab/-e1): Among NPK levels, F_2(130-67-67 kg ha") resulted in the max'imum number of *primary* branches, whil-e F3 (180,90-90 kg ha') produced maximum number of secondary bra'lcheSduring both the years of study. As regards seedling density per hill, oneseed/ing produced greater number of primary and secondary branches than 2 *or* 3 seedlings/hill. Higher number of primary branches in F_2 with 1 seedling per hi'll *might* be attributed to *ba/-aRced* nutrient' supply and lesser competition among, the plants at minimum *seedling* density.

Spik-eJets,in- Ptimaryand Seoond_V Branches per Panide:: NPK levels and per *hill* seedling density- influenced s-ignificantly the number of spikef.ets on primary and: secondary branChes during 1995 and 1996 *(Table* 1)..Among *NPK leve/s,* F_3(180-90-90 kg ha"),' *Which* did not differ statistically from F_2 (130-67-67 kg ha"), produced the maximum number of spikelets in primary and secondary branches. One seed~iflgperhi.fl (S_1) produced the panicles with *larger* r,umbe., of spike/ets in primary and secondary branches than 82 and S3' while S, did not differ significantly *from* S2 (2 seedlings/hill). The gre.ater number of spikeJets recorded with F_3 could be ascribed to adequate Supply,of NPK during, panicle and spikeJet differentiation stage. Higher number of spikelets in S, (1 Seedling/hill) *might* be due to *lesser* competition among,the panicle bearing tillers in this treatment. These results are supported by Shah *et al.* (1997) who found that number of spikelets per panicle of rice increaseo with each reduction in seedlings per hill.

Steritifv. Abortiveness and ORaqUeness in Primary and Secondary Branches p.er HiD: Occurrence of *sterile,* abortive and opaque kernels was significantly affected by NPK levels during both the years. However, no differences were recorded in OCcurrence or sterile, *abortive* and opaque kernels in primary and secondary branches per panicle among different seedling densities (Table 2). *More* sterility in F_3(180-90-90 kg ha") was due to *longer* panicles *bearing more* spikelets both on primary and secondary branches which might have resulted in rather hard competition for assimilates a.mongthe spikelets at the time of flowering. Similar reSUlts have been reported by Nagato and Chaudhry (1969). Higher lodging in F (data not *given)* could be another reason *for* increased sterility. Small number of abortive and opaque kernels in primary and secondary branChes in F_2(130-67-67 kg ha 1) might be attributed to more starch synthesis

Table 1. [illegible]

[illegible]	[illegible] 1995	1996	[illegible] 1995	1996	Number of grains per panicle: Primary 1995	1996	Secondary 1995	1996	Number [redacted] 1995	1996	[illegible] 1995	1996	[illegible] (%): PB 1995	PB 1996	SB 1995	SB 1996
[illegible] (kg ha-1)																
F_0 [illegible]	8.1	6.4	33.2	30.9	12.2	10.6	38.4	34.5	76.8	69.2	118.9	114.5	12.3	14.4	16[illegible]	15.1
F_1 [illegible]	10.8	8.9	33.9	3[illegible].8	12.6	[illegible]	42.3	388	75.3	71.1	137[illegible]	[illegible]	11[illegible]	13.6	13.8	14.2
F_2 [illegible]	12.2	11.9	35.8	33.7	13.7	12.3	50.8	43.4	83.1	77.0	170.6	136.6	7.2	11.1	[illegible]2	13.5
F_3 [illegible]	12.3	10.9	36.2	33.6	13.6	12.3	63.2	44[illegible]	83.2	78.8	176.6	147.1	16.7	15.7	16.1	1[illegible]1
CD (0.05)	1.49	1[illegible]8	0.64	0.88	0.72	0.76	408	3.97	[illegible]17	2.9[illegible]	5.53	4[illegible]7	3.68	1[illegible]8	3.76	[illegible]19
[illegible] seedlings																
S_1 (1 seedling)	10.4	8.7	3[illegible].2	33.2	13.7	12.3	46.5	43.6	81[illegible]	76.8	162.4	138.5	12.6	13.8	15[illegible]	15.8
S_2 (2 seedlings)	11.5	10.3	34.6	32.6	12.8	[illegible]	45.6	36[illegible]	8[illegible]	74.2	150[illegible]	128.7	113	14.3	14.8	14.8
S_3 (3 seedlings)	10.6	8.7	34.6	31[illegible]	12.7	[illegible].1	43.[illegible]	37.8	75.7	69.7	140.1	12[illegible]1	118	12.8	15.2	1[illegible]1
CD (0.05)	[illegible].86	0.8[illegible]	0[illegible]8	0.44	0.76	0.66	2.67	2.66	2.68	3.[illegible]	5.87	5.54	NS	NS	NS	NS

Table 2. [illegible] of NPK levels and per hill seedlings on kernel abnormalities, [illegible]

[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NPK level (kg ha^{-1})																		
F_0 (0-0-0)	9.8	7.7	13.9	10.5	24.4	13.5	20.1	13.8	45.5	44.6	43.5	43.2	50.4	60.1	46.1	56.2	3.21	2.65
F_1 (60-0-0)	7.9	6.9	12.8	9.2	15.8	11.5	15.7	12.5	34.9	34.1	34.1	32.8	65.0	67.5	57.41	62.9	4.34	3.48
F_2 (130-67-67)	6.8	5.4	13.3	8.1	13.1	5.7	12.8	7.1	24.7	21.5	23.8	21.4	70.6	76.3	60.1	71.1	4.63	4.45
F_3 (180-90-90)	7.3	6.1	13.4	5.7	16.1	6.3	12.7	6.8	32.1	33.8	33.5	32.9	64.9	73.7	60.1	69.7	4.32	4.44
CD (0.05)	NS	1.84	NS	1.19	6.52	1.71	NS	1.62	6.47	3.46	6.20	4.91	8.38	2.61	7.23	4.36	0.23	0.29
Per hill seedlings																		
S_1 (1 seedling)	7.5	6.2	12.9	8.3	18.1	9.3	15.8	10.1	35.7	35.0	35.0	34.2	62.5	68.9	56.3	65.5	3.83	3.51
S_2 (2 seedlings)	7.9	6.4	12.8	8.6	16.99	8.9	15.3	9.5	33.0	32.2	32.5	30.5	64.1	71.0	57.0	66.3	4.3	4.02
S_3 (3 seedlings)	8.5	6.9	14.3	8.2	16.97	9.5	14.9	10.6	34.1	33.3	33.6	33.1	61.5	68.2	54.5	63.2	4.24	3.73
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.65	NS	NS	NS	NS	0.31	0.32

PB = Primary branches; SB = Secondary branches; NS = Non-significant.

and its better translocation at early and middle stages of kernel development as a result of which the percentage of abortive kernels was decreased.

Occurrence of Chalky Kernels in Primary and Secondary Branches: Various NPK levels influenced significantly the chalkiness in primary and secondary branches in both the years of experimentation (Table 2), Decreased chalkiness in F_2 (130-67-67 kg ha') might again be due to balanced availability of NPK to plants in this treatment resulting in less lodging and reduced competition among the spikelets during the kernel development and starch filling stages of the panicle. Bangweak (1994) reported that the factors affecting the accumulation of photosynthats during spikelet filling could have affected the compactness of starch.

Per hill seedling density did not affect the chalkiness significantly in primary branches during either year of the study. However, it had significant effect on chalky kernels in secondary branches in 1996. One seedling per hill produced more chalkiness as compared to 2 seedlings per hill. However, it did not differ from S3 (3 seedlings/hill) during 1996.

Occurrence of Normal Kernels in Primary and Secondary Branches: NPK levels significantly influenced the occurrence of normal kernels in primary and secondary branches per panicle (Table 2), Per hill seedling density did not affect the normal kernels in primary and secondary branches during 1995 and 1996. However, two seedlings per hill resulted in higher numberdf normal kernels during both the years of study. The higher number of normal kernels in F_2 (130-67-67 kg ha') might be attributed to better NPK supply for normal kernel development. It is thus suggested that NPK applied in appropriate amount along with optimum number of seedlings per hill (S2) helps in enhancing the physiological function of plants such as photosynthesis and translocation resulting in increased normal kernels (Nazemi *et et.,* 1995).

Grain Yield (t ha'): Grain yield was significantly influenced by NPK levels and per hill seedling density during both the years of study (Table 2). Higher grain yield in F_2(130-67-67 kg ha') was ascribed to better kernel development and minimum deterioration in panicle structure. Higher grain yield obtained from two seedlings per hill (S2) appeared to be due to production of higher number of panicle bearing tillers and more normal kernels. These results conform to those of Ramasamy *et al.* (1987) and Anonymous (1994). However, 52 and 53 were statistically at par with each other in both the study years.

Conclusion: Application of NPK @ 130-67-67 kg ha" (F2) to Basmati-385 grown at 2 seedlings per hill (52) g~oved to be the best for obtaining optimum spikelets ~h maximum normal kernels on primary and ~J1dary branches along with considerable reduction IOl teril itv. opaqueness and chalkiness due to better dev elopm ent of panicle structure. Higher NPK level @ 180-90-90 k h 'F) ith df "g a \ 3 Wit rrurumurn see mqs per hili (5,) cause d maximum kernel abnormalities ~ue to poo~ development of panicle structure leadinq to lower grain yield ith nom kernel qualtv

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