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Effect of spacing and foliar application of potassium nitrate and calcium nitrate on seed yield in rice

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ABSTRACT: *Five varieties of rice sown at two spacing under normal condition were evaluated for grain yield, seed yield and yield contributing components during* kharif *2010. Seed recovery in two varieties MTU 7029 and BPT 5204 was found 4 per cent higher at spacing 20 x 20 cm over 20 x 15 cm. Therefore, these two varieties were further selected for recording their responses to seed recovery by applying foliar spray of different concentrations of potassium nitrate (0.2%, 0.5% and 1%) and calcium nitrate (0.4% and 0.8%) during* kharif *2011 and 2012 at three stages of plant growth (panicle initiation, flowering stage and milking stage).Foliar spray of 0.4% Ca (NO3)2 resulted in maximum grain yield in MTU 7029 (64.79q/ha) and in BPT 5204 (54.8 q/ha) and seed recovery up to 80 % in MTU 7029 and 74% in BPT 5204. Hence, foliar spray of 0.4% Ca (NO3)2 may be practised to obtain maximum grain yield and seed yield by seed producers.*

Key words: *Calcium nitrate, Correlation, Grain yield, Potassium nitrate, Seed yield,*

Rice is a globally accepted staple food. India produces 106.54 m t in 43.95 m ha (9). Production of rice largely depends on the type of quality seed used in the respective zones. Modern high-yielding rice varieties absorb K in greater quantities than any other essential nutrient. In fields across Asia, total K uptake for a crop yielding 5 t/ha are close to 100kg K/ha (Dobermann and Fairhurst, 2000). Foliar application of K can be beneficial when K uptake via the root zone is limited. Varieties with high yield followed with high seed recovery have greater preference among seed producers both for production and profitability point of view. In seed production, seed recovery is as important component as grain/seed production. Potassium helps in photosynthesis, carbohydrate distribution and starch synthesis in storage organs (Imas and Magen, 2007; White *et al*. 2010 and Philip *et al*. 2012) which in turn helps in higher grain yield. Quality grain yield opens the avenues for better seed recovery. Hence, the present study was initiated to investigate the effect of foliar application of potassium nitrate and calcium nitrate for improving seed production under space planting.

MATERIALS AND METHODS

The field experiment was conducted in randomised block design (R.B.D.) with three replications at the farm of Directorate of Seed Research, Kushmaur, Mau, U.P. during *kharif* season of 2010, 2011 and 2012. During *kharif* 2010, five varieties were transplanted at a distance of 15 cm in trial I and at a distance of 20 cm in trial II. The row to row distance was maintained 20 cm in each trial. Each genotype was sown 16 rows in a bed length of 12m. All agronomical practices were followed to raise good crop. Five competitive plants were selected from each replication of both the trials. Observations on 50% flowering, days to maturity, plant height, ear bearing tillers per plant (EBT), panicle length, number of filled grains per plant, number of unfilled grains per plant, grain weight of filled grains per plant, 1000 grain weight and grain yield in net plot area were recorded. Seed recovery (SR) or seed yield was calculated in per cent by applying the formula:-

$$Seed\,recovery = \frac{(Grain\,yield - under\,sized\,grains + other\,impurities) \times 100}{Grain\,yield}$$

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The statistical analysis was carried out on the mean data of the characters studied. The analysis of correlation coefficient was done following the standard statistical procedure followed by Dewey and Lu (2).

Seed recovery in two varieties MTU 7029 and BPT 5204 was found 4 per cent higher at spacing 20 x 20 cm during *kharif* 2010. Therefore, these two varieties were selected for recording their responses for seed recovery by applying foliar application of different concentrations of potassium nitrate (0.2%, 0.5% and 1%) and calcium nitrate (0.4% and 0.8%) during *kharif* 2011 and 2012 at three stages of plant growth (panicle initiation, flowering stage and milking stage). KNO_3 contained 38.7% K and 61.3% NO_3 whereas Ca $(NO_3)2$ contained 24.4% Ca and 75.6% NO_3 as reported by Kundu and Sarkar (5). The experiment was conducted in three replications in randomised block design (R.B.D.). The observations for number of filled grains per plant and number of unfilled grains per plant were recorded from 10 randomly selected plants in each plot. 1000 grain weight, grain yield per plot and seed recovery data was recorded on net plot size (12m x 2.8m = 33.60 m^2).

RESULTS AND DISCUSSION

From the *per se* performance point of view (Table 1), MTU 7029 was found to be the highest yielding genotype both at 15 cm and 20 cm interplant distance. Grain yield of Sarjoo 52 and Naveen was at par with each other. But seed recovery was found numerically higher in Sarjoo 52 over Naveen at both spacing. This may be due to bolder grain of Sarjoo 52. Naveen possesses long slender grain with lower 1000 grain weight. Maximum seed recovery was recorded in MTU 7029 (78.2%) and BPT 5204 (76.31%) at 20 x 20 cm spacing. This seed recovery was slightly higher (4%) in 20 x 20 cm spacing. Hence, it was concluded that by increasing interplant distance, seed recovery could increase in the varieties MTU 7029 and BPT 5204. These two varieties are genetically high tillering genotypes and due to increase in interplant distance, assimilates accumulate more in the sink region.

Days to 50% flowering showed significant positive correlation with days to maturity and number of panicles per plant (Table 2). It means that late maturing genotypes have advantage of producing more productive tillers. Number of productive tillers per plant and number of filled grains per plant

Table 1
Yield and ancillary data of Trial I (Spacing 20 x 15 cm) and Trial II (Spacing 20 x 20 cm); Net plot area=12m x 2.8m; *Kharif* 2010-11

Character	*Trial*	*Sarju 52*	*Naveen*	*BPT 5204*	*MTU 7029*	*Pratikshya*	*S.E.+*	*C.D.*	*C.V.*
Days to heading	I	76.33	75.33	90.33	91.66	92	0.49	1.55	1.01
	II	77.33	75.5	90.66	94.00	93.33	0.40	1.26	0.81
Days to maturity	I	116.00	116.00	136.00	139.00	139.66	0.32	1.03	0.44
	II	116.66	115.66	136.33	140.00	140.00	0.43	1.36	0.58
Plant height (cm)	I	119.80	151.86	99.46	116.53	110.73	1.67	5.27	2.34
	II	118.00	151.33	96.33	116.4	108.33	2.82	8.91	4.01
No. of panicles/	I	8.40	8.06	13.13	11.13	9.13	0.44	1.38	7.39
plant	II	11.40	8.86	14.80	12.53	13.93	1.33	4.21	8.98
Length of spike	I	22.35	27.36	21.05	23.58	23.47	0.25	0.80	1.79
(cm)	II	23.78	27.63	21.62	24.27	24.30	0.39	1.24	2.72
No. of filled	I	1116.66	1130.86	2021.86	1549.00	1213.78	66.79	210.45	7.78
grains / plant	II	1616.20	1435.6	2512.13	2030.33	1810.06	211.23	665.57	18.96
No. of unfilled	I	129.33	219.13	384	553.2	384.53	42.86	135.05	21.15
grains / plant	II	108.86	229.46	537.26	446.93	620.4	45.95	144.8	20.53
Grain weight of	I	24.35	20.15	28.49	25.88	23.98	1.49	4.69	9.34
filled grains (gm)	II	35.72	25.97	32.23	33.49	35.02	4.48	5.11	10.23
1000 grain	I	21.87	17.78	14.06	16.7	19.76	0.58	1.83	5.34
weight (gm)	II	21.93	18.37	16.2	17.63	20.36	0.31	1.00	2.8
Grain yield /	I	16.16	16.66	17	18.46	18.1	1.61	2.07	4.51
plot (kg)	II	16.46	16.86	17.19	19.04	18.59	1.00	3.17	5.77
Seed yield (%)	I	73.52	69.34	65.92	75.17	75.71	0.19	0.62	0.46
	II	74.79	70.12	68.62	78.2	76.31	0.27	0.85	0.62
Percent gain in grain yield / plot over Trial I		1.8%	1.2%	1.1%	3.1%	2.7%			
Percent gain in seed yield over Trial I		1.7%	1.1%	4.0%	4.0%	0.7%			

Table 2
Correlation coefficient between seed yield and yield contributing characters in rice; Date of transplanting: 22/07/2010

Character	*Trial No.*	*Correlation coefficient*	*Days to maturity*	*Plant height*	*No. of panicles/plant*	*Length of spike*	*No. of filled grains / plant*	*No. of unfilled grains / plant*	*Grain weight of filled grains*	*1000 grain weight*	*Grain yield / plot*	*Seed yield*
Days to 50% flowering	I	G	0.961**	-0.847	**0.821****	-0.652	**0.788****	0.863**	**0.925****	-0.527	**0.812****	0.032
		P	0.957**	-0.842	**0.768****	-0.646	**0.773****	0.845**	**0.711****	-0.505	**0.766****	0.030
	II	G	0.962**	-0.819	**0.779****	-0.629	**0.804****	0.854**	**0.902****	-0.542	**0.720****	-0.004
		P	0.957**	-0.815	**0.762****	-0.626	**0.781****	0.831**	**0.737****	-0.526	**0.717****	0.006
Days to maturity	I	G		-0.728	0.711**	-0.515	0.683**	0.960**	0.778**	-0.516	0.946**	0.232
		P		-0.725	0.685**	-0.513	0.667**	0.945**	0.571**	-0.496	0.905**	0.230
	II	G		-0.702	0.650**	-0.494	0.676**	0.954**	0.900**	-0.500	0.886**	0.225
		P		-0.701	0.639**	-0.492	0.663**	0.933**	0.623**	-0.488	0.878**	0.222
Plant height	I	G			-0.709	0.954**	-0.718	-0.498	-0.082	0.241	-0.513	-0.032
		P			-0.684	0.941**	-0.706	-0.485	-0.830	0.223	-0.493	-0.037
	II	G			-0.702	0.957**	-0.721	-0.447	-0.732	0.210	-0.392	0.041
		P			-0.695	0.953**	-0.712	-0.441	-0.818	0.206	-0.390	0.040
No. of panicles /plant	I	G				-0.614	0.023	0.621	0.972**	-0.884	0.452*	-0.475
		P				-0.581	0.950	0.570	0.658**	-0.783	0.436*	-0.440
	II	G				-0.637	0.908	0.554	0.895**	-0.840	0.291*	-0.523
		P				-0.627	0.980	0.540	0.649**	-0.804	0.283*	-0.502
Length of spike	I	G					-0.648	-0.247	-0.072	0.130	-0.298	-0.012
		P					-0.613	-0.238	-0.761	0.114	-0.285	-0.009
	II	G					-0.652	-0.216	-0.958	0.109	-0.187	0.088
		P					-0.632	-0.209	-0.759	0.096	-0.190	0.087
No. of filled grains / plant	I	G						0.569	**0.957****	-0.846	**0.429****	0.467
		P						0.563	**0.719****	-0.811	**0.400***	0.455
	II	G						0.572	**0.926****	-0.820	**0.319***	0.497
		P						0.569	**0.649****	-0.815	**0.306***	0.486
No. of unfilled grains / plant	I	G							0.532	-0.561	0.980	0.260
		P							0.367	-0.562	0.918	0.250
	II	G							0.651	-0.587	0.940	0.274
		P							0.422	-0.584	0.919	0.264
Grain weight of filled grains	I	G								-0.506	0.472*	0.211
		P								-0.316	0.355*	0.143
	II	G								-0.423	0.509**	0.104
		P								-0.245	0.411*	0.038
1000 grain weight	I	G									-0.370	**0.538****
		P									-0.350	**0.520****
	II	G									-0.299	**0.526****
		P									-0.284	**0.521****
Grain yield / plot	I	G										**0.518****
		P										**0.487***
	II	G										**0.598****
		P										**0.590****

*, ** Significant at 5% and 1% level, respectively G = Genotypic correlation; P = Phenotypic correlation

showed significant positive correlation with grain yield per plant. 1000 grain weight per plant exhibited significant positive correlation with seed yield. Grain yield per plant exhibited significant positive correlation with seed yield. These findings are in close agreement with earlier workers (6 and 10). This shows that genotypes with high magnitude of filled grains per plant and 1000 grain weight would necessarily be the right choice for good seed recovery. Based on this finding, two varieties viz, MTU 7029 and BPT 5204 were given the spray treatment of KNO_3 and Ca $(NO_3)2$ during the *kharif* season of 2011 and 2012 and finding are presented in Table 3 and Table 4.

The effect of foliar spray treatment of 0.2%, 0.5% and 1% KNO_3 at various growth stages of rice was found significant with respect to no-spray in both the varieties MTU 7029 and in BPT 5204 (Table 3 and 4). However, spray of 0.5% KNO_3 was found more effective than other concentrations because there was appreciably more number of filled grains per panicle. Increase in 1000 grain weight was also found in positive direction. Such increase in yield attributes may be owing to altered physiological and reproductive growth of the crop induced by foliar spray of nitrate salts through enhanced activities of enzymes and photosynthetic efficiency(8). This achievement confirms the finding of earlier workers, Kundu and Sarkar (5).

Foliar spray of 0.4% Ca $(NO_3)2$ registered an average of 11.09 per cent increase in 1000 grain weight over no spray in the variety MTU 7029. In case of rice variety BPT 5204, the average increase in 1000 grain

Table 3
Effect of foliar application of KNO_3 and Ca $(NO_3)2$ on seed yield of rice variety MTU 7029
Gross Plot area = 12m x 16 rows x 20 cm; Net Plot area = 12m x 14 rows x 20 cm (33.6 m2)

S.N.	*Treatment*	*1000 grain weight (g)*		*No. of filled grains per plant*		*No. of un-filled grains per plant*		*Grain yield per plot (kg)*		*Seed recovery in per cent*	
		2011-12	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*
1.	KO (No spray)	17.80	18.00	2029.82	2032.14	437.07	439.90	19.20	19.34	78.37	78.20
2.	K1(0.2% KNO_3 spray)	18.17	18.40	2045.17	2048.04	428.30	425.50	20.25	20.64	79.27	79.10
3.	K2 (0.5% KNO_3 spray)	19.10	19.40	2051.07	2057.90	398.87	385.13	21.23	21.66	81.13	80.73
4.	K3 (1% KNO_3 spray)	18.30	19.83	2046.54	2048.08	403.93	399.67	20.45	20.66	79.20	78.83
5.	K4 (0.4% $Ca(NO_3)$ 2 spray	19.60	20.17	2054.37	2058.03	385.47	372.93	21.70	21.77	81.80	80.90
6.	K5 (0.8% $Ca(NO_3)$ 2 spray	18.50	18.93	2048.29	2049.00	390.60	379.27	20.50	20.84	80.20	79.28
SE(M) $^{+}_{-}$		0.013	0.218	0.541	0.669	1.601	3.040	0.09	0.150	0.143	0.355
C.D. at 5%		0.043	0.687	1.710	2.110	5.045	9.580	0.27	0.475	0.450	1.119
C.V. in per cent		0.13%	1.97%	0.05%	0.06%	0.68%	1.32%	0.73	1.25%	0.31%	0.77%

Table 4
Effect of foliar application of KNO_3 and Ca $(NO_3)2$ on seed yield of rice variety BPT 5204
Gross Plot area = 12m x 16 rows x 20 cm; Net Plot area = 12m x 14 rows x 20 cm (33.6 m2)

S.N.	*Treatment*	*1000 grain weight (g)*		*No. of filled grains per plant*		*No. of un-filled grains per plant*		*Grain yield per plot (kg)*		*Seed recovery in per cent*	
		2011-12	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*
1.	KO (No spray)	16.30	16.40	2510.36	2506.95	535.70	515.23	17.20	17.30	68.37	68.43
2.	K1(0.2% KNO_3 spray)	16.80	16.90	2514.40	2517.20	530.22	522.22	17.50	17.60	70.30	70.23
3.	K2 (0.5% KNO_3 spray)	17.40	17.50	2523.70	2527.56	496.26	497.36	18.27	18.37	73.63	73.90
4.	K3 (1% KNO_3 spray)	16.60	16.73	2515.23	2516.31	524.67	523.8	17.40	17.77	74.60	72.77
5.	K4 (0.4% $Ca(NO_3)$ 2 spray	17.57	17.63	2527.83	2512.24	510.20	493.19	18.37	18.43	74.60	74.73
6.	K5 (0.8% $Ca(NO_3)$ 2 spray	16.70	16.77	2501.60	2530.52	498.98	498.5	17.53	17.65	72.60	71.90
SE(M) $^{+}$-		0.102	0.089	3.61	2.875	4.205	1.742	0.036	0.069	0.021	0.73
C.D. at 5%		0.321	0.283	11.37	9.059	12.24	5.489	0.113	0.185	0.061	2.30
C.V. in per cent		1.05%	0.92%	0.25%	0.20%	1.41%	0. 59	0.35%	0.57%	0.05%	1.7%

weight over no spray in both the years, was 7.65 per cent. The increase in 1000 grain weight, number of filled grains per plant, grain yield per plant and seed yield was found higher with the treatment of 0.4% Ca $(NO_3)2$ than 0.5% KNO_3. This was in close agreement with previous workers, Kundu and Sarkar (5). Better response of foliar spray of 0.4% $Ca(NO_3)2$ than 0.5% KNO_3 may possibly be due to prevalence of Ca^{2+} cations which is a constituent of cell wall and plays a key role in cellular functions and activity of enzymes as reported by Bush (1). However, there was a positive response of all concentrations of nitrate salts on 1000 grain weight, number of filled grains per plant, grain yield and seed yield. There was a reduction in number of unfilled grains per plant in each treatment. Spraying at panicle initiation and 50% flowering stage might have helped the plants for better absorption and consequent assimilation of nutrients supplied through foliar application resulting in luxuriant growth and development which led to higher dry matter and consequently improved yield attributes like filled grains, test weight, higher grain weight and seed weight. Our finding is in close agreement with Kundu and Sarkar (5). Ca^{2+} cations plays important role in more rational utilization of soil nitrogen and active assimilation of NO_3^- in roots and leaves. Foliar application of Ca $(NO_3)2$ recorded more nitrogen uptake than KNO_3 and substantially higher concentration of N in grain becomes the cause for higher yield.

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