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Effect of Nitrate of Potassium and Calcium on Grain Filling and Yield of Hybrid Rice

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ABSTRACT

A field experiment was conducted during kharif 2012 and 2013 at Seed Research Farm, Gambharipali to evaluate the effect of nitrate and its counter ions applied as post-flowering foliar spray on performance of 'hybrid rice' (*Oryza sativa* L.). Foliar application of 0.406% Ca $(NO_3)_2$ followed by 0.5% KNO_3 during 50% flowering stages increased the yield attributes resulting higher grain yield. No_3^- and its counter ions both K^+ and Ca^{2+}, gave beneficial effect in grain filling and yield of rice. It was found that No_3^- in combination with Ca^{2+} gave higher grain filling and yield than No_3 with K^+. Foliar spray of Ca $(No_3)_2$ resulted in the highest grain yield (6.54 t/ha), net return (Rs.109112/ha) and benefit cost ratio (2.47). Among the hybrid variety 'Arize-dhani' recorded higher yield than 'Arize-prima '(5.35 t/ha).

1. Introduction

Grain chaffyness is common in hybrid rice. In the rice cultivation, K and Ca application is partially or completely ignored by farmers, which results in the imbalance fertilization that causes grain chaffyness and productivity (Cassman et al. 1996). Encouraging results were obtained with post-flowering foliar application of various nutrients on yield of rice and wheat (Fanyan and Yakovlev 1977). The grain and straw yield of rice was higher with spraying of 0.5% KNO_3 solution at 50% flowering stage of crop (Sarkar and Bandopadhyay 1991). The beneficial effects of NO_3 in delaying synthesis of abscisic acid and promotes cytokinin activity and causes higher chlorophyll retention and thereby higher photosynthesis activity in leaves for supply of photosynthate to grains (Sarkar et al. 2007). Potassium on photosynthesis, carbohydrate redistribution and starch synthesis in storage organs (Imas and Magen 2007) were presumed to be responsible for higher grain yield. Calcium (Ca^{2+}) may substantially increase N and P uptake and this may prove to be helpful in promoting root growth (Friessen et al. 1980). Prevalence of Ca^{2+} cation which is a constituent of cell wall and plays a key role in cellular functions and activity of enzymes (Bush 1995). Presence of Ca^{2+} may result in more rational utilization of soil N and more active assimilation of No_3, N in roots and leaves (Kondratev et al. 1984). Hence the present study was initiated to quantify the beneficial effect of No^{3-} , K^+ and Ca^{2+} on grain filling and yield of hybrid rice.

2. Materials and Methods

The study was conducted during Kharif 2012 and 2013 at Seed Research Farm, Orissa University of Agriculture & Technology, Gambharipali, Odisha, India. The soil of experimental field was sandy clay loam, acidic (pH 5.65), low in organic carbon content (0.47%) and available N, P and K content were 242, 9.2 and 155 kg/ha, respectively. Chemically pure salts of KNO_3, KCl, Ca $(NO_3)_2$, $CaCl_2$ were used for scanning the effect of NO_3 and its counter ions (K^+ and Ca^{2+}). The treatments consisted of foliar application of water, KNO_3 = 5g/l, KCl = 3.69 g/l (Supplying equal amount of K^+ as in KNO_3 treatment), Ca $(No_3)_2$ = 4.06 g/l (Supplying equal amount of No_3^- as in KNO_3 treatment), $CaCl_2$ = 3.63 (Supplying equal amount of Ca^{2+} as in Ca $(NO_3)_2$ treatment).

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These salt solutions were tested in two hybrids (Arize prime, Arize dhani). Total 10 treatments were tried in factorial randomized block design replicated thrice. The FYM was applied @ 5 t/ha with a fertilizer dose 120-60-60 N-P_2O_5-K_2O kg/ha, respectively. All P_2O_5 was applied as basal and N was applied in 3 splits *i.e.* 50% as basal, 25% 45 DAT & 25% 60 DAT while K was applied in two splits, *i.e.* 50% as basal and 50% at 60 DAT. Rice (hybrid) 'Arize prima' and 'Arize dhani' was transplanted on 25th and 27th July of 2012 and 2013 respectively at 20 X 10 cm spacing. Dilute solution of nutrient salts as per treatments were applied @ 800 litres water/ha as foliar spray at 50% flowering stage in afternoon hour. The crop was grown in medium land situation. Plot size 8 X5 m. The plant protection measures were taken as and when required. All other cultural operations were carried out as per recommendation. Rainfall received during the crop growth period was 550 mm (45 rainy days) in 2012 and 662 mm (49 rainy days) in 2013, respectively. Ten panicles were selected randomly to compute the panicle length, panicle weight and number of grains/panicle. Grain and straw yields were recorded on net plot size. Nutrient accumulation by the crop was estimated by multiplying the nutrient concentration with the grain or straw yield. The economics like net returns and benefit cost ratio were worked out by using the prevailing market price of inputs and produce.

3. Results and Discussion

3.1 Yield attributes

The beneficial effects of various nutrients, especially the nitrates, on grain filling are quite evident from the data (Table 1). Foliar application of Ca $(NO_3)_2$ spray during 50% flowering stage resulted significantly more filled grain/panicle (133.28), panicle weight (6.23 g) and 1000 grain weight (29.5 g). The yield attributes by spraying of KNO_3 was at par with Ca $(NO_3)_2$. However, panicle length did not show significant variation. 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 capacity (Sarkar and Pal, 2006). Minimum panicle weight (4.03 g), grains/panicle (108.98) and test weight (27.3 g) was obtained from the plot sprayed with water. Yield attributing characters of hybrid variety 'Arize dhani'is more than that 'Arize-prima'.

3.2 Yield

Spraying of Calcium nitrate and potassium nitrate during 50% flowering gave significantly higher grain yield (Table 1). Foliar spray of 0.406 g/l of Ca $(NO_3)_2$ registered 18.2% higher grain yield over water spray (5.35 t/ha). 'Arize dhani' gave (15.1% higher grain yield than that of 'Arize 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, panicle weight and higher grain yield in rice. In fact spraying of 0.406 mg/l Ca $(No_3)_2$ supplied Ca^{2+} and NO_3 which were effectively absorbed as cation and anion by plants assimilated and translocated more efficiently prima (5.49 t/ha). Spraying at 50% flowering stage might have helped the plants better absorption and consequent cellular functions (Ward and Shroeder 1994) and increasing enzyme activities (Bush 1995) which were reflected in higher values of yield attributes and resulted in higher grain yield. Similarly, in case of foliar spray of KNO_3, besides the beneficial functions of NO_3^- N, prevalence of K^+ enhanced

Table 1. Yield attributes (pooled), yield and harvest index (pooled) as influenced by different salt solution in hybrid rice

Treatment	Panicle length (cm)	Panicle wt. (g)	Grains/ panicle	Test wt. (g)	Grain yield (t/ha)			Straw yield (t/ha)			Harvest index
					2012	2013	Pooled	2012	2013	Pooled	
Water	22.63	4.03	108.98	27.30	5.22	5.49	5.35	6.97	7.46	7.22	42.59
KNO_3	24.37	5.92	127.00	28.89	5.81	6.11	5.96	7.24	7.85	7.55	44.13
KCl	23.66	5.17	116.86	27.93	5.43	5.71	5.57	7.01	7.47	7.24	43.47
$Ca(NO_3)_2$	25.07	6.23	133.28	29.53	6.38	6.71	6.54	7.35	7.91	7.63	46.16
$CaCl_2$	24.05	5.23	118.47	28.24	5.55	5.84	5.69	7.01	7.51	7.26	43.96
SEm	0.13	0.09	2.80	0.26	0.08	0.09	0.09	0.08	0.09	0.08	
CD (P=0.05)	NS	0.26	7.76	0.72	0.23	0.24	0.24	0.22	0.25	0.23	
Varieties											
Arize Dhani	24.49	5.86	142.37	28.80	6.14	6.46	6.30	7.48	7.53	7.50	45.63
Arize Prima	23.42	4.77	99.47	27.96	5.22	5.49	5.35	6.75	7.75	7.25	42.46
SEm	0.06	0.03	2.30	0.04	0.09	0.09	0.09	0.06	0.07	0.07	
CD (P=0.05)	0.19	0.12	7.96	0.13	0.31	0.33	0.32	0.22	0.25	0.23	

Table 2. Nutrient uptake and economics of foliar spray of salt solution in hybrid rice (pooled data)

Treatment	Nutrient uptake (kg/ha)			Salt required (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit: cost
	N	P	K				
Water	71.73	14.45	81.10		44234	88963	2.01
KNO_3	79.86	16.09	90.29	4.00	44215	100197	2.27
KCl	74.61	15.03	84.36	2.90	45077	91360	2.03
$Ca(NO_3)_2$	87.66	17.66	99.11	3.24	44170	109112	2.47
$CaCl_2$	76.30	15.37	86.26	2.90	45650	92707	2.03
SEm	1.15	0.23	1.31				
CD (P=0.05)	3.19	0.64	3.62				
Varieties							
Arize Dhani	84.37	17.00	95.38		45919	102879	2.24
Arize Prima	71.70	14.45	81.07		43419	90050	2.07
SEm	1.24	0.25	1.40				
CD (P=0.05)	4.28	0.86	4.85				

Prevailing market price (Rs/kg) : KNO_3=370, $Ca(NO_3)_2$=280, $CaCl_2$=22, KCl =18, Rice=14.10, Straw=80

photosynthetic activity and facilitated partitioning of photosynthates (Batra 1982), resulting in higher grain yield. When the benefits in grain yield due to individual components of the treatments are splitted in table 3, the figures show positive effects due to spraying of NO_3^- and both the counter ions (K^+ and Ca^{2+}). The highest effect was derived from NO_3 when present with to developing grains for proper filling by increasing leaf nitrogen content, chlorophyll synthesis and by regulating Ca^{2+} (14.89%) as counter ion, which could be taken as 'Viets effect"- stimulation K^+ and Br^- absorption in excised barley roots in presence of Ca^{2+} (Viets 1944). Furthermore, Kondratev et al. (1984) showed that in maize, the prevalence of Ca^{2+} over K^+ resulted in more rational utilization of soil nitrogen and more active assimilation of NO_3 in roots and leaves. Foliar spray of 0.406% $Ca(NO_3)_2$ with equal amount of NO_3 –N basis proved better than 0.5% KNO_3, possibly due to prevalence of Ca^{2+} cation which is a constituent of cell wall and plays a key role in cellular function and activity of enzymes (Bush 1995).

3.3 Nutrient uptake

Significant variations among the nutrient uptake were observed mainly due to the variation in grain and straw yield of the crop (Table 2). The uptake of the nitrogen, phosphorus and potassium was significantly more under Ca $(NO_3)_2$ spray (87.66, 17.66 and 99.11 kg/ha) followed by KNO_3 (79.86, 16.09 and 90.29 kg/ha) over water spray (71.73, 14.45 and 81.10 kg/ha). Nutrient uptake of 'Arize dhani' is more than that of 'Arize prima'.

3.4 Economics

Among the foliar spray treatments, the highest monetary return and benefit: cost ratios (Table 3) were observed with application of 0.406% Ca $(NO_3)_2$, which involved lesser cost for per unit nutrient salt and were most economical among the nitrate salts. The highest net return (Rs 109112 /ha) and benefit: cost (2.47) with foliar spray of 0.406% Ca $(NO_3)_2$ was due to highest yield in this treatment. The lowest net return (Rs 88963 /ha) and benefit: cost (2.01) was obtained from the water spray treatment. The net return (Rs 102879/ha) and benefit: cost (2.24) was higher in variety 'Arize dhani' than that of 'Arize prima'. It was concluded that NO_3– in combination with Ca^{2+}, i.e. $Ca(NO_3)_2$ at 0.406% gave higher yield than NO_3 with K^+. The yield of hybrid rice 'Arize dhani' is more than that of 'Arize prima'.

Table 3. Benefit in grain yield due to individual components of the treatments

Effect due to spraying	Increase in Grain yield (t/ha)	Percent increase over water spray
K+ (KCl-Water)	0.22 (5.54-5.35)	4.01
Ca^{2+} ($CaCl_2$-Water)	0.34 (5.69-5.35)	6.37
NO_3- with K+ (KNO_3-KCl)	0.39 (5.96-5.57)	7.04
NO_3- with Ca^{2+} Ca $(NO_3)_2$-$CaCl_2$	0.85 (6.54-5.69)	14.89

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