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Effect of Potassium and Nickel on Yield and Yield components in Maize under Heat Stress

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ABSTRACT

Field experiment was conducted during *rabi* 2017-18 and 2018-19 at Agricultural College, Bapatla to study the 'Effect of potassium and nickel on yield and yield components in maize under heat stress'. The experiment was laid out in split plot design with twenty four treatments. Three dates of sowing *viz.,* December 20 (M_1), January 10 (M_2) and January 30 (M_3) as main plots and eight subplot treatments as 100% RDK (control) (S_1), 125% RDK (S_2),1 kg Ni ha^{-1} as nickel chloride (S_3), 2 kg Ni ha^{-1} (S_4), 100% RDK+1 kg Ni ha^{-1} (S_5), 100% RDK+2 kg Ni ha^{-1} (S_6), 125% RDK+1 kg Ni ha^{-1} (S_7) and 125% RDK+2 kg Ni ha^{-1} (S_8). The results revealed that heat stress imposed by dates of sowing and nutrient treatments significantly influenced the yield and yield components during two seasons in maize. During both the years, among the dates of sowing the most delayed sown crop, M_3 reduced the number of rows per cob (16.08 % and 14.56 %), kernel per row (23.31 % and 20.88 %), test weight (21.74 % and 22.49 %) and kernel yield (50.23 % and 48.75 %) respectively compared to timely sown crop, M_1. Among the subplots all treatments except S_3 and S_4 recorded a significant increment with the highest percentage of rows per cob (23.77 % and 23.93 %) kernel per row (13.63% and 13.30%), test weight (27.90 % and 23.69 %) and kernel yield (29.98 % and 28.36 %) respectively in S_8 over S_1. Potassium and nickel application reduces the impact of heat stress to some extent so that the reduction in the yield and yield components was minimized.

Keywords: *Maize, Potassium and Nickel, Yield and Yield Components.*

Under changing climatic conditions extreme temperatures become more intense and frequent as the number of hot days and nights were increased compared to cold days and nights. This results in a mean increase of maximum and minimum temperatures creating heat stress, which shows greater impact on plant growth, development and productivity affecting the primary and secondary metabolic pathways (Wahid, 2007).

Maize is the third most important cereal belongs to the family poaceae. It is a highly efficient plant with maximum genetic potential under suitable environmental conditions. But it is very susceptible to extreme environmental conditions especially drought and heat. Heat stress had a great impact on maize yield as it leads to increased anthesis silking interval, abortion of kernels and poor kernel filling.

Delayed sowing due to various reasons results in a situation where the crop has to face extreme environmental conditions particularly highly temperatures. In Andhra Pradesh, maize crop is mostly grown as *rabi* crop after the harvest of wetland paddy. Hence the crop is subjected to high temperature stress leading to yield losses.

Potassium the major nutrient is well known for its role in plant stress management as it helps to strengthen the plant due to its role in photosynthesis, turgor maintenance, assimilate transport, stomatal regulation as well as activation and stabilization of many enzymes (Mengal and Kirkby, 1987).

Dixon *et al*. 1975 reported that nickel is essential for higher plants. It is a key component of the enzymes involved in nitrogen metabolism and biological nitrogen fixation. Its metabolism is very critical for certain enzyme activities other than urease, such as glyoxalases (family I), methyl-CoM reductase, peptide deformylases, some superoxide dismutases and hydrogenases, in maintaining proper cellular redox state and various other biochemical, physiological and growth responses (Kutman *et al*., 2013).

As in the native environment little work was done on heat stress in maize with mineral nutrition, keeping in view of these a study was taken up on effect of different levels of potassium and nickel on yield and yield components in maize under heat stress.

MATERIAL AND METHODS

The study was conducted at Agricultural College Farm, Bapatla located at 15.54^0 N and 80.25^0 E, situated in the Agro Climatic Zone III. It was laid out in split plot design with three replications, three dates of sowing *viz.,* December 20 (M_1), January 10 (M_2) and January 30 (M_3) as main plots and eight subplot treatments as 100% RDK (control) (S_1), 125% RDK (S_2),1 kg Ni ha^{-1} as nickel chloride (S_3), 2 kg Ni ha^{-1} (S_4), 100% RDK+1 kg Ni ha^{-1} (S_5), 100% RDK+2 kg Ni ha^{-1} (S_6), 125% RDK+1 kg Ni ha^{-1} (S_7) and 125% RDK+2 kg Ni ha^{-1} (S_8).

Five uniform sized adjacent plants per each plot (excluding boarder rows) were selected and tagged (non destructive) for recording the data. At harvest cobs from the plants were collected dried and the yield and yield components were calculated.

RESULTS AND DISCUSSION

Number of cobs per plant

Data on number of cobs per plant were presented in Table 1. During both the seasons, number of cobs per plant were not influenced significantly by the dates of sowing, potassium and nickel application, as it was a genetically controlled trait.

Rows per cob

Number of rows per cob as influenced by dates of sowing and nutrient treatments were presented in Table 1.

During both the years, heat stress induced by dates of sowing significantly reduced the number of rows per cob. Maximum number of rows per cob was recorded in timely sown crop, M_1 (15.85 and 16.14) and minimum in the most delayed crop, M_3 (13.30 and 13.79) respectively. The mean reduction ranged from 1.02 to 2.55 during 2017-18 and 0.94 to 2.35 during 2018-19.

Among the nutrient treatments, all except S_3 and S_4, recorded a great enhancement in number of rows per cob compared to S_1 by 0.58 to 3.25 during 2017-18 and 0.68 to 3.35 during 2018-19. The highest number of rows per cob was obtained in S_8 (16.92 and 17.35) and the lowest in S_3 (12.44 and 12.80) during 2017-18 and 2018-19 respectively.

Kernel per row

Data on kernel per row was presented in Table 2. Dates of sowing influenced the number of kernel per row greatly. The highest number of kernel per row were obtained in M_1 (48.00 and 49.19) and the lowest in M_3 (36.81 and 38.92) during 2017-18 and 2018-19 respectively. Heat stress lead to a decrement of 3.52 to 11.19 kernel per row during 2017-18 and 3.18 to 10.27 kernel per row during 2018-19.

Table 1. Effect of potassium and nickel on Cobs per plant and Rows per cob in maize under heat stress

Treatments	Cobs per plant								Rows per cob							
	2017-18				2018-19				2017-18				2018-19			
	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean
S_1: 100% RDK	1.180	1.170	1.130	1.160	1.210	1.200	1.180	1.200	14.750	13.800	12.460	13.670	15.170	14.170	12.670	14.000
S_2: 125% RDK	1.180	1.170	1.130	1.160	1.220	1.200	1.180	1.200	15.360	14.310	13.080	14.250	15.680	14.860	13.500	14.680
S_3: 1 kg Ni ha^{-1}	1.160	1.150	1.140	1.150	1.180	1.170	1.150	1.170	13.370	12.690	11.250	12.440	13.730	12.870	11.800	12.800
S_4: 2 kg Ni ha^{-1}	1.160	1.150	1.140	1.150	1.200	1.200	1.170	1.190	14.000	13.050	11.620	12.890	14.500	13.520	12.000	13.340
S_5: $S_1 + S_3$	1.180	1.170	1.130	1.160	1.220	1.200	1.170	1.200	16.110	15.410	13.780	15.100	16.530	15.670	14.050	15.420
S_6: $S_1 + S_4$	1.180	1.180	1.140	1.170	1.230	1.220	1.190	1.210	17.290	15.750	14.000	15.680	17.000	16.130	15.080	16.070
S_7: $S_2 + S_3$	1.180	1.180	1.150	1.170	1.230	1.210	1.190	1.210	17.810	16.710	14.560	16.360	17.900	16.820	15.380	16.700
S_8: $S_2 + S_4$	1.190	1.180	1.170	1.180	1.230	1.230	1.200	1.220	18.130	16.950	15.680	16.920	18.600	17.580	15.870	17.350
Mean	1.180	1.170	1.140		1.220	1.200	1.180		15.850	14.830	13.300		16.140	15.200	13.790	

	2017-18			2018-19			2017-18			2018-19		
	Main plots	Sub plots	Interaction	Main plots	Sub plots	Interaction	Main plots	Sub plots	Interaction	Main plots	Sub plots	Interaction
SEM±	0.02	0.02	0.03	0.02	0.02	0.03	0.26	0.2	0.34	0.23	0.24	0.41
CD @ 0.05	NS	NS	NS	NS	NS	NS	1.01	0.56	NS	0.91	0.68	NS
CV%	10.13	4.85		9.57	5.33		8.64	4.04		7.52	4.77	

Table 2. Effect of potassium and nickel on Kernel per row and Test weight (g) in maize under heat stress

Treatments	Kernel per row								Test weight (g)							
	2017-18				2018-19				2017-18				2018-19			
	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean
S_1: 100% RDK	46.75	43.14	35.13	41.67	47.88	44.30	36.83	43.00	29.12	26.46	21.53	25.70	30.15	28.26	24.54	27.65
S_2: 125% RDK	47.39	44.49	36.67	42.85	48.42	45.70	38.54	44.22	30.67	28.58	24.55	27.93	32.55	29.74	25.16	29.15
S_3: 1 kg Ni ha^{-1}	43.58	39.61	30.81	38.00	45.49	41.98	34.00	40.49	25.43	23.83	20.28	23.18	28.45	26.10	21.71	25.42
S_4: 2 kg Ni ha^{-1}	45.49	40.25	32.52	39.42	46.84	42.92	35.58	41.78	26.49	24.75	20.76	24.00	29.87	27.04	23.19	26.70
S_5: $S_1 + S_3$	49.33	45.29	37.61	44.08	50.23	47.04	39.66	45.64	32.72	29.58	25.36	29.22	34.17	31.08	26.13	30.46
S_6: $S_1 + S_4$	49.68	46.49	39.31	45.16	50.33	47.62	40.86	46.27	33.97	30.68	26.54	30.40	35.24	32.20	27.72	31.72
S_7: $S_2 + S_3$	50.44	48.04	40.24	46.24	51.59	48.59	42.51	47.56	34.52	32.58	27.82	31.64	36.74	33.64	28.43	32.94
S_8: $S_2 + S_4$	51.29	48.54	42.22	47.35	52.76	49.97	43.42	48.72	36.58	33.57	28.46	32.87	38.60	34.87	29.13	34.20
Mean	48.00	44.48	36.81		49.19	46.01	38.92		31.19	28.75	24.41		33.22	30.37	25.75	

	2017-18			2018-19			2017-18			2018-19		
	Main plots	Sub plots	Interaction	Main plots	Sub plots	Interaction	Main plots	Sub plots	Interaction	Main plots	Sub plots	Interaction
SEM±	0.47	0.39	0.68	0.68	0.44	0.76	0.61	0.43	0.71	0.56	0.44	0.76
CD @ 0.05	1.86	1.12	NS	2.67	1.26	NS	2.41	1.22	NS	2.2	1.25	NS
CV%	9.35	7.23		7.45	7.29		10.69	8.54		9.22	8.4	

Table 3. Effect of potassium and nickel on Yield (kg ha^{-1}) in maize under heat stress

Treatments	2017-18				2018-19			
	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean	M_1 (Dec 20)	M_2 (Jan10)	M_3 (Jan30)	Mean
S_1: 100% RDK	8228.79	6537.01	3865.85	6210.55	8370.51	6775.48	4151.45	6432.48
S_2: 125% RDK	8708.49	6948.59	4196.41	6617.83	8895.46	7168.66	4426.84	6830.32
S_3: 1 kg Ni ha^{-1}	7718.86	5724.74	3007.83	5483.81	7889.15	6047.18	3206.54	5714.29
S_4: 2 kg Ni ha^{-1}	7972.68	6145.44	3358.28	5825.47	8183.21	6426.86	3539.66	6049.91
S_5: $S_1 + S_3$	9180.73	7479.52	4461.79	7040.68	9285.61	7734.05	4694.85	7238.17
S_6: $S_1 + S_4$	9278.85	7868.03	4989.38	7378.76	9415.08	8107.02	5198.79	7573.63
S_7: $S_2 + S_3$	9442.56	8253.48	5451.66	7715.9	9654.63	8534.89	5529.23	7906.25
S_8: $S_2 + S_4$	9808.45	8733.36	5675.24	8072.35	9893.2	8934.5	5942.82	8256.84
Mean	8792.43	7211.27	4375.81		8948.36	7466.08	4586.27	

	2017-18			2018-19		
	Main plots	Sub plots	Interaction	Main plots	Sub plots	Interaction
SEM±	147.24	121.99	211.29	187.08	122.83	212.74
CD @ 0.05	578.13	348.16	NS	734.55	350.55	NS
CV%	10.62	5.39		13.09	5.26	

All the treatments except S_3 and S_4 lead to an increment of kernel per row by 1.18 to 5.68 during 2017-18 and 1.22 to 5.72 during 2018-19. Maximum number of kernel per row were recorded in S_8 (47.35 and 48.72) and the minimum in S_3 (38.00 and 40.49) during 2017-18 and 2018-19 respectively.

Test weight (g)

Test weight as influenced by dates of sowing, potassium and nickel application was presented in Table 2. During both the years, heat stress imposed by delay in sowing dates significantly reduced the test weight by 2.44 to 6.78 g and 2.85 to 7.47 g respectively. The highest test weight was obtained in M_1 (31.19 and 33.22 g) and the lowest in M_3 (24.41 and 25.75 g) respectively.

Among the nutrient treatments all except S_3 and S_4, increased the test weight by 2.23 to 7.17 g during 2017-18 and 1.50 to 6.55 g during 2018-19. Maximum test weight was obtained with S_8 (32.87 and 34.20 g) and minimum with S_3 (23.18 and 25.42 g) during 2017-18 and 2018-19 respectively.

Yield (kg ha^{-1})

Data on yield as influenced by dates of sowing, potassium and nickel application was presented in Table 3. During both the years, enhanced temperatures with delayed sowing decreased the yield by 1581.16 to 4416.62 kg ha^{-1} during 2017-18 and 1482.28 to 4362.09 kg ha^{-1} during 2018-19. Maximum yield was recorded in M_1 (8792.43 and 8948.36 kg ha^{-1}) followed by M_2 (7211.27 and 7466.08 kg ha^{-1}) and minimum in M_3 (4375.81 and 4586.27 kg ha^{-1}) respectively.

Application of potassium and nickel significantly enhanced the yield except in nickel alone application without potassium compared to control (S_1) by 407.28 to 1861.80 kg ha^{-1} during 2017-18 and 397.84 to 1824.36 kg ha^{-1} during 2018-19. The highest yield was obtained with S_8 (8072.35 and 8256.84 kg ha^{-1}) and the lowest in S_3 (5483.81 and 5714.29 kg ha^{-1}) during 2017-18 and 2018-19 respectively.

Heat stress imposed by delay in sowing dates results in increased anthesis silking interval that lead to poor pollination, reduced filling of kernels as evident from reduced rows per cob, reduced kernel per row and test weight ultimately decreased the yield. Singletary *et al*. (1994) reported that high temperature decreased the water potential which inhibits grain filling rate leading to fall of kernel weight by 45 per cent in maize.

Application of potassium and nickel maintains proper water status, reduced anthesis silking interval, increased pollination so that number of rows per cob, kernel per row, test weight enhanced and lead to the reduction of yield reduction percentage under heat stress. Application of 125 per cent potassium gave significantly higher grain (77.45 q ha^{-1}) and stover yield (116.38 q ha^{-1}) in maize (Patil and Basavaraju, 2017). Nickel @ 1 and 2 kg ha^{-1} significantly enhanced the grain and straw yield in wheat compared to control and higher levels of nickel (Singh *et al*., 2011).

CONCLUSION

From the present it can be concluded that application of potassium and nickel in combination (125 % RDK + 2 kg ha^{-1}) enhanced the yield and yield components compared to individual application, by reducing the impact of heat stress on yield reduction to some extent.

LITERATURE CITED

Dixon N E, Gazzola C, Blakeley R L, Zerner B 1975 Jack bean urease (EC 3.5.1.5). A metalloenzyme. A simple biological role for nickel. *Journal of the American Chemical Society*. 97:4131-4133.

Kutman B Y, Kutman U B and Cakmak I 2013 Foliar nickel application alleviates detrimental effects of glyphosate drift on yield and seed quality of wheat. *Journal of Agricultural and Food Chemistry*. 61:8364-8372.

Mengal K and Kirkby E A 1987 Principle of plant Nutrition, 4th Ed., International Potash Institute, Bern, Switzerland. 434-440.

Patil S and Basavaraja P K 2017 Effect of different sources and levels of potassium on yield, nutrient requirement and nutrient use efficiency by maize crop (*Zea mays* L.) in low K soils of eastern dry zone of karnataka, India. *International Journal of Current Microbiology and Applied Sciences*. 6(6):193-199.

Singletary G W, Banisadr R and Keeling P L 1994 Heat stress during grain filling in maize: Effects on carbohydrate storage and metabolism. *Australian Journal of Plant Physiology*. 21: 829"841.

Singh R P, Chandel S K S, Yadav P K and Singh S N 2011 Effect of Ni on nitrogen uptake and yield of wheat (*Triticum aestivum*). *Indian Journal of Science and Research*. 2(4): 61-63.

Wahid A 2007 Physiological implications of metabolite biosynthesis in net assimilation and heat stress tolerance of sugarcane (*Saccharum officinarum*) sprouts. *Journal of Plant Res*earch. 120: 219–228.

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