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Effect of Nutrient Levels and Split Application of Nitrogen on Growth and Seed Yield of Maize (*Zea mays L.*) Hybrid-Hema at Various Stages of Plant Growth

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A field experiment was conducted at National Seed Project, Bangalore, to study the effect of nutrient levels *viz*.,100 per cent RDF as a straight fertilizer, 100 per cent RDF in the form of DAP and MOP, 125 per cent N and P, 150 per cent N and P in combination with three levels of time of nitrogen application (40% N @ Basal + 60% N @ tasseling), (40% N @ Basal + 30% N @ 8 leaf stage + 30% N @ tasseling) and (40% N @ Basal + 30% N @ 8 leaf stage + 25% N @ tasseling + 5% N @ seed filling stage) on crop growth and seed yield of maize hybrid Hema. Among the fertilizer levels, application of 125 per cent N and P (187.5:93.75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1}) gave significantly higher growth parameters like plant height, number of leaves and number of green leaves at harvest and yield parameters like number of cobs per plant, cob weight, cob length, cob diameter, seed yield per plant, seed yield per plot, bulk seed yield and graded seed yield compared to all other fertilizer levels. Among the time of applications the application of N at four splits (40% @ Basal + 30 % @ 8 leaf stage + 25% @ tasseling + 5% @ seed filling stage) (N_3) showed significant increase in plant height, number of leaves, number of green leaves at harvest, number of cobs per plant, cob weight, cob length, cob diameter, seed yield per plant, seed yield per plot, bulk seed yield and graded seed yield. This clearly indicates that maize responds to application of nitrogen even at seed filling stage thereby the seed yield can be enhanced by 15-16 % in seed production plots.

Key words: Maize, Fertilizers, Time of application, Growth, Yield

Maize (*Zea mays* L.) is known as “Miracle crop” in view of its several uses. It is being grown both for seed and fodder purpose. It is also gaining importance as a commercial or industrial crop; wherein a large number of byproducts are being manufactured out of its grain. Maize grain contains about 72 per cent starch, 10 per cent protein, 4.8 per cent oil, 5.8 per cent fiber, 3.0 per cent sugar and 1.7 per cent ash. It is a source of raw material for industry, as it is being extensively used for the preparation of corn starch, corn oil, dextrose, corn syrup, corn flakes, cosmetics, wax, alcohol and tanning material for leather industry. Maize being a C4 plant has the higher potential for synthesis of carbohydrate. Dr. Norman E. Borlaug believed that maize had the highest yield potential among cereals. In the last two decades, there was a revolution in rice and wheat and the next few decades will be known as maize era (IRST., 2010). In hybrid maize seed production, plant nutrients like nitrogen, phosphorus, potassium and zinc are known to be potential to enhance seed crop productivity. By modifying morphological and physiological characteristics, it may enhance source to sink relationship ultimately, realizing higher yield of quality hybrid seeds. With increasing use of macronutrients like nitrogen, phosphorus and potassium, increased uptake of micronutrients by crops can be well conceived. Therefore, macro and micronutrients may become limiting factors in boosting up crop production (Gupta and Ram, 1968). In view of higher responsive capacity of maize to micro and macronutrients, an experiment was conducted. Top dressing of nitrogen was spread over till seed filling stage in seed production plots to study crop absorbance beyond the recommended period.

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Materials and Methods

A field experiment was conducted during *kharif,* 2012 at National Seed Project, University of Agricultural Sciences, GKVK, Bengaluru. The Freshly harvested parental line (NAI-137 and MAI-105) seeds of single cross maize hybrid-Hema (NAH-1137) were sown in the ratio of 6:2. The experiment was laid out in factorial RCBD with three replications to study the effect of nutrient levels *viz*.,100 per cent RDF as a straight fertilizer (150:75:40 kg NPK ha^{-1} + $ZnSO_4$ 10 kg ha^{-1}), 100 per cent RDF in the form of DAP and MOP (150:75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1}), 125 per cent N and P with recommended K (187.5:93.75:40 kg NPK ha^{-1} + $ZnSO_4$ 10 kgha^{-1}), 150 per cent N and P recommended K (225:112.5:40 kg NPK ha^{-1} + $ZnSO_4$ 10 kg ha^{-1}) in combination with three levels of time of nitrogen application (40% N @ basal + 60% N @ tasseling), (40% N @ basal +

30% N @ 8 leaf stage + 30% N @ tasseling) and (40% N @ basal + 30% N @ 8 leaf stage + 25% N @ tasseling + 5% N @ seed filling stage) on crop growth and seed yield of maize hybrid Hema. All the growth and yield parameters were recorded.

Results and Discussion

Effect of nutrient levels on growth and yield of maize hybrid-Hema

Application of 125 per cent recommended N and P (187.5:93.75:40 kg NPK ha^{-1}) with $ZnSO_4$ 10 kg ha^{-1} (T_3) gave significantly higher plant height at 60 and 90 DAS (166.65 and 178.32 cm, respectively), number of leaves at 60 and 90 DAS (15.13 and 16.24, respectively) and number of green leaves at harvest (4.13) (Table 1).

Table 1. Effect of nutrient levels and time of nitrogen application on growth attributing characters of maize hybrid-Hema

Treatments	Plant height (cm)		Number of leaves		Number of green leaves at harvest
	60 DAS	90 DAS	60 DAS	90 DAS	
Fertilizer Levels (T)					
T_1: RDF as straight fertilizer (Control) (150:75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	156.03	166.48	14.44	15.67	3.62
T_2: RDF in the form of DAP and MOP (150:75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	152.44	164.00	13.07	14.29	3.16
T_3: 125% N and P (187.5:93.75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	166.65	178.32	15.13	16.24	4.13
T_4: 150% N and P (225:112.5:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	158.30	167.06	14.82	15.84	4.09
S Em±	3.26	2.89	0.30	0.26	0.19
CD (P=0.05)	9.57	8.48	0.87	0.76	0.55
Time of application (N)					
N_1: 40% N @ Basal + 60% N @ tasseling	151.15	163.38	13.25	14.33	2.72
N_2: 40% N @ Basal + 30% N @ 8 leaf stage + 30% N @ tasseling	156.74	166.62	14.38	15.49	3.88
N_3: 40% N @ Basal + 30% N @ 8 leaf stage + 25%N @ tasseling + 5% N @ seed filling Stage	167.18	176.88	15.47	16.72	4.65
S Em±	2.83	2.51	0.26	0.23	0.16
CD (P=0.05)	8.29	7.35	0.75	0.66	0.47
Fertilizer levels and time of application (T X N)					
T_1N_1	151.83	164.10	13.93	15.20	2.40
T_1N_2	154.07	165.73	14.20	15.27	3.87
T_1N_3	162.20	169.60	15.20	16.53	4.60
T_2N_1	144.90	162.07	10.67	12.00	1.33
T_2N_2	153.80	163.29	14.20	15.20	3.73
T_2N_3	158.63	166.63	14.33	15.67	4.40
T_3N_1	154.29	163.87	14.33	15.33	3.40
T_3N_2	160.60	170.97	14.87	15.93	4.00
T_3N_3	185.07	200.13	16.20	17.47	5.00
T_4N_1	153.57	163.50	14.07	14.77	3.73
T_4N_2	158.50	166.50	14.27	15.57	3.93
T_4N_3	162.83	171.17	16.13	17.20	4.60
S. Em±	5.65	5.01	0.51	0.45	0.32
CD (P=0.05)	16.57	14.70	1.50	1.32	0.95
CV (%)	6.18	5.14	6.17	5.03	14.91

Application of 125 per cent recommended N and P (187.5:93.75:40 kg NPK ha^{-1}) with $ZnSO_4$ 10 kg ha^{-1} (T_3) gave significantly higher yield parameters like number of cobs per plant (2.71), cob weight (149.44 g), cob length (16.27 cm), cob diameter (13.99 cm), number of seeds per row (31.47), number of seeds per cob (390.29), seed yield per plant (133.9 g), seed yield per plot (6.31 kg), bulk seed yield (2805 kg ha^{-1}), graded seed yield (2565 kg ha^{-1}), shelling (75.82%) and seed recovery (91.36 %) (Table 2) compared to all other fertilizer levels. Increase in seed yield due increase in yield components was reported by Khot and Umarani (1992), Yadav and Singh (2000) and Paramasivan *et al*. (2011).

Effect of time of nitrogen application on growth and yield of maize hybrid-Hema

Application of N at four splits (40% @ basal + 30 % @ 8 leaf stage + 25% @ tasseling + 5% @ seed filling stage) (N_3) showed significant increase in plant height at 60 and 90 DAS (167.18 and 176.88 cm, respectively), number of leaves at 60 and 90 DAS (15.47 and 16.72, respectively) and number of green leaves at harvest (4.62) (Table 1).

The same treatment (N_3) *i.e.* application of N at

Table 2. Effect of nutrient levels and time of nitrogen application on yield parameters and seed yield of maize hybrid-Hema

Treatments	Number of cobs per plant	Cob weight (gm)	Cob length (cm)	Cob diameter (cm)	Number of seeds per row	Number of rows per cob	Number of seeds per cob
Fertilizer Levels (T)							
T_1: RDF as straight fertilizer (Control) (150:75:40 NPK kg ha^{-1} + $ZnSO_4$10 kg ha^{-1})	2.17	141.63	15.76	13.42	29.16	13.12	354.78
T_2: RDF in the form of DAP and MOP (150:75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	1.93	131.61	14.62	12.39	26.82	12.82	343.28
T_3: 125% N and P (187.5:93.75:40 NPK kg ha^{-1} + $ZnSO_4$10 kg ha^{-1})	2.71	149.44	16.27	13.99	31.47	13.49	390.29
T_4: 150% N and P (225:112.5:40 NPK kg ha^{-1} + $ZnSO_4$10 kg ha^{-1})	2.47	144.51	15.92	13.73	29.69	13.36	366.53
S Em±	0.11	2.44	0.29	0.24	0.79	0.30	8.24
CD (P=0.05)	0.32	7.16	0.84	0.70	2.31	NS	24.17
Time of application (N)							
N_1: 40% N @ Basal + 60% N @ tasseling	2.07	135.06	14.63	12.36	27.47	12.50	347.76
N_2: 40% N @ Basal + 30% N @ 8 leaf stage + 30% N @ tasseling	2.26	141.05	15.87	13.63	29.13	13.15	352.48
N_3: 40% N @ Basal + 30% N @ 8 leaf stage + 25%N @ tasseling + 5% N @ seed filling Stage	2.63	149.29	16.43	14.17	31.25	13.94	390.92
S Em±	0.09	2.11	0.25	0.21	0.68	0.26	7.14
CD (P=0.05)	0.28	6.20	0.73	0.61	2.00	0.77	20.93
Fertilizer levels and time of application (T X N)							
T_1N_1	2.27	139.67	15.20	12.90	28.80	12.27	347.13
T_1N_2	2.03	141.53	15.77	13.47	28.87	13.07	351.60
T_1N_3	2.20	143.70	16.30	13.90	29.80	14.03	365.60
T_2N_1	1.67	117.10	12.23	10.10	22.67	12.00	334.83
T_2N_2	2.13	138.00	15.47	13.33	28.33	12.93	344.40
T_2N_3	2.00	139.73	16.17	13.73	29.47	13.53	350.60
T_3N_1	2.33	141.67	15.73	13.23	29.33	12.93	356.13
T_3N_2	2.47	142.67	16.13	14.17	29.73	13.40	357.93
T_3N_3	3.33	164.00	16.93	14.57	35.33	14.13	456.80
T_4N_1	2.00	141.80	15.33	13.20	29.07	12.80	352.93
T_4N_2	2.40	142.00	16.10	13.53	29.60	13.20	356.00
T_4N_3	3.00	149.73	16.33	14.47	30.40	14.07	390.67
S. Em±	0.19	4.23	0.50	0.42	1.36	0.52	14.28
CD (P=0.05)	0.55	12.41	1.46	1.22	4.00	1.53	41.87
CV (%)	14.05	5.17	5.51	5.39	8.07	6.85	6.80

four splits gave significantly higher yield parameters like number of cobs per plant (2.63), cob weight (149.29 g), cob length (16.43 cm), cob diameter (14.17 cm), number of seeds per row (31.25), number of seeds per cob (390.92), seed yield per plant (131.3 g), seed yield per plot (6.43 kg), bulk seed yield (2858 kg ha^{-1}), graded seed yield (2583 kg ha^{-1}), shelling (75.03%) and seed recovery (90.38 %) (Table-2) compared to other stages of application. These findings are in conformity with the results obtained by Thakur and Vinod Sharma (1999) and Wasaya *et al.* (2012).

Interaction effect of nutrient levels and time of nitrogen application on growth and yield of maize hybrid-Hema

Application of 125 per cent recommended N and P (187.5:93.75:40 kg NPK ha^{-1}) + $ZnSO_4$10 kg ha^{-1} (T_3) along with nitrogen application at four stages (40% @ Basal + 30 % @ 8 leaf stage + 25% @ tasseling + 5% @ seed filling stage) (N_3) had recorded the highest field emergence (96.44%), plant height at 60 and 90 DAS (185.07 and 200.13 cm, respectively), number of leaves at 60 and 90 DAS (16.20 and 17.47, respectively) and number of green leaves at harvest (5.00) (Table 1) compared to all other treatment combinations.

Application of 125 per cent recommended N and P (187.5:93.75:40 kg NPK ha^{-1}) + $ZnSO_4$10 kg ha^{-1} (T_3) along with nitrogen application at four stages (40% @ Basal + 30 % @ 8 leaf stage + 25% @ tasseling + 5% @ seed filling stage) (N_3) had recorded the highest number of cobs per plant (3.33), cob weight (164.00 g), cob length (16.93 cm), cob diameter (14.57 cm), number of seeds per row (35.33), number of seeds per cob (456.80), seed yield per plant (141.5 g), seed yield per plot (6.53 kg), bulk seed yield (2902 kg ha^{-1}), graded seed yield (2678 kg ha^{-1}), shelling (82.74%) and seed

Table 2. continued...

Treatments	Seed yield per plant (g)	Seed yield per plot (kg)	Bulk seed yield (kg ha^{-1})	Graded seed yield (kg ha^{-1})	Shelling (%)	Seed recovery (%)
Fertilizer Levels (T)						
T_1: RDF as straight fertilizer (Control) (150:75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	122.9	5.68	2526	2212	72.33	87.41
T_2: RDF in the form of DAP and MOP (150:75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	116.0	5.55	2466	2187	71.99	88.70
T_3: 125% N and P (187.5:93.75:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	133.9	6.31	2805	2565	75.82	91.36
T_4: 150% N and P (225:112.5:40 NPK kg ha^{-1} + $ZnSO_4$ 10 kg ha^{-1})	127.9	5.80	2576	2358	74.46	91.56
S Em±	2.65	0.10	46.04	51.23	1.02	1.17
CD (P=0.05)	7.78	0.30	135.04	150.26	2.99	2.71
Time of application (N)						
N_1: 40% N @ Basal + 60% N @ tasseling	117.7	5.51	2447	2202	72.04	89.94
N_2: 40% N @ Basal + 30% N @ 8 leaf stage + 30% N @ tasseling	126.6	5.57	2474	2206	72.39	88.95
N_3: 40% N @ Basal + 30% N @ 8 leaf stage + 25%N @ tasseling + 5% N @ seed filling Stage	131.3	6.43	2858	2583	75.03	90.38
S Em±	2.30	0.09	39.88	44.37	0.88	1.01
CD (P=0.05)	6.73	0.26	116.95	130.13	2.59	2.35
Fertilizer levels and time of application (T X N)						
T_1N_1	120.1	5.26	2338	2037	72.23	87.05
T_1N_2	122.6	5.42	2407	2075	72.33	86.08
T_1N_3	125.9	6.38	2834	2524	72.42	89.11
T_2N_1	100.7	5.10	2265	2007	71.46	88.59
T_2N_2	122.2	5.20	2312	2051	72.29	88.73
T_2N_3	125.0	6.34	2820	2502	72.23	88.78
T_3N_1	129.7	5.99	2662	2385	72.23	89.58
T_3N_2	130.5	6.41	2849	2633	72.49	92.27
T_3N_3	141.5	6.53	2902	2678	82.74	94.53
T_4N_1	120.3	5.68	2524	2380	72.21	94.24
T_4N_2	130.9	5.24	2328	2066	72.44	88.73
T_4N_3	132.7	6.47	2876	2629	74.74	91.41
S. Em±	4.59	0.18	79.75	88.74	1.76	2.03
CD (P=0.05)	13.47	0.53	233.90	260.26	5.17	4.70
CV (%)	6.35	5.33	5.33	6.60	4.17	3.91

recovery (94.53 %) (Table 2). These results were in line with the findings of Jakhar *et al*., (2011) and Thakur and Vinod Sharma., (1999).

Thus, based on the results it is concluded that for maximizing growth and seed yield the maize hybrid-Hema (NAH-1137) crop is to be provided with 125 per cent recommended N and P with nitrogen application at four splits (40% @ basal + 30 % @ 8 leaf stage + 25% @ tasseling + 5% @ seed filling stage) along with recommended K (40 kg ha^{-1}) under irrigated condition.

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