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Response of Popcorn (*Zea mays everta*) to Different Fertilizer Levels and Plant Densities in *Kharif* Season"

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ABSTRACT

An experiment entitled "Response of popcorn (*Zea mays everta*) to different fertilizer levels and plant densities in *kharif* season" was conducted during 2012 at Post Graduate Research Farm, College of Agriculture, Kolhapur, to study the effect of fertilizer and plant spacing levels on growth and yield of popcorn. The experiment was laid out in Factorial randomized block design with twelve treatments combinations comprising of three fertilizer levels viz., 75% RDF (90:45:30 Kg NPK ha^{-1}), 100% RDF (120:60:40 Kg NPK ha^{-1}) and 125% RDF (150:75:50 Kg NPK ha^{-1}) and four plant spacing levels viz., 60 x 15 cm^2, 60 x 20 cm^2, 75 x15 cm^2 and 75 x 20 cm^2. The study has revealed that all the growth characters viz., plant height, number of functional leaves, leaf area and dry matter accumulation per plant were found significantly higher with application of 125% RDF (150:75:50 Kg NPK ha^{-1}) over 75% RDF (90:45:30 Kg NPK ha^{-1}) and it was on par with 100% RDF (120:60:40 Kg NPK ha^{-1}) at all the crop growth stages. The number of functional leaves, leaf area and dry matter accumulation per plant were significantly higher with plant spacing of 75 x 20 cm^2 over 60 x 15 cm^2, expect 75 x 15 and 60 x 20 cm^2 spacing levels.

Key words : Fertilizer levels, Plant densities, Popcorn.

Maize is the world's third most important cereal crop after wheat and rice. Besides providing nutrients for human/animals, maize serves as a basic raw material for the production of starch, oil, protein, alcoholic beverages and food sweeteners. Maize has been an important cereal because of its greater productivity, potential and adaptability to wide range of environments. It is a miracle crop because of its high yield potential and is also known as the queen of cereals. Popcorn (*Zea mays everta*) is a special type of corn that was selected by Indians in early western civilizations. Recently specialty corns such as baby corn, sweet corn and popcorn confectionaries and popcorn products especially in amusement parks, moving picture theatres and the like have greatly increased the demand for popcorn products and have made a profitable outlet for those who desire to grow popcorn on a commercial scale.

The demand for the popcorn products in the amusement parks, moving theatres, circus and exhibitions is increasing with the increasing urban population. Also there is an increasing tendency towards specialisation in agriculture where commercial production would become more and more important. Keeping in this view the above facts the present investigation was undertaken to study crop ecology modification of popcorn through fertilizer application and varied plant population.

MATERIAL AND METHODS

A field experiment was conducted in during *kharif* season of 2012 at the Post Graduate Research Farm, College of Agriculture, Kolhapur, Maharashtra on medium black soil with pH 7.52, OC 0.43%, available N (174.64 kg ha^{-1}), available P_2O_5 (24.73 kg ha^{-1}) and available K_2O (240.69 kg ha^{-1}). The experiment was laid out in factorial randomized block design and the treatments were replicated thrice. There are 12 treatment combinations in the study and the treatment consisted of three fertilizer levels viz., 75% RDF (90:45:30 Kg NPK ha^{-1}), 100% RDF (120:60:40 Kg NPK ha^{-1}) and 125% RDF (150:75:50 Kg NPK ha^{-1}) and four plant spacing levels viz., 60 x 15 cm^2, 60 x 20 cm^2, 75 x15 cm^2 and 75 x 20 cm^2. The certified seed of Amber popcorn (composite variety) was sown 28-6-2012 and harvested on 8-10-2012.

The Amber popcorn seeds were treated with Carbendazim (Bavistin) and Azotobacter @ 3 g kg^{-1} seed and 250 g for 10 kg seed, respectively.

The ridges and furrows were opened at 60 and 75 cm spacings as per treatments. The seeds were dibbled at the rate of two seeds per hill on one side of ridge as per treatments i.e. 15 and 20 cm intra row spacings, where the fertilizer was applied. Thinning and gap filling was done at 10 DAS by keeping on seedling hill^{-1}. As per treatments, one third dose of nitrogenous fertilizer and full dose of phosphatic and potassic fertilizers were applied on one side of the ridge by leaving 1/3rd portion from bottom of furrow at sowing. The next one third dose of nitrogen fertilizer was applied in bands as top dressing one month after sowing and remaining one third dose of nitrogen fertilizer was applied at 45 days after sowing. The FYM @ 5 tone ha^{-1} was applied uniformly to all the plots after formation of ridges and furrows. The sources of nitrogen, phosphorus and potash were urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The crop was maintained by adopting the recommended package of practices. The pre emergence application of herbicide, Atrazine @ 1 kg *a.i* ha^{-1} was undertaken next day after sowing, followed by one hand weeding at 30 DAS for weed control. Need based plant protection measures were taken up during crop growth period. The data on plant height, number of functional leaves, leaf area per plant, dry matter accumulation and yield were recorded and analysed as per described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The results on growth parameters *viz*., plant height, functional leaves, leaf area, dry matter accumulation, 50 percent tasseling, and 50 percent silking were significantly influenced by both levels of fertilizer and planting density.

An application of 125% RDF (150:75:50 kg NPK ha^{-1}) produced significantly (Table 1) the highest plant height as compared to 75% RDF (90:45:30 kg NPK ha^{-1}) and was on par with 100% RDF (120:60:40 kg NPK ha^{-1}) at 30, 45, 60, 75 and at harvest. This may be due to its profound influence on the vegetative crop growth resulting in higher plant height. The mean plant height was influenced significantly due to different spacing levels during all the crop growth stages. The spacing of 60 x 15 cm^2 recorded significantly the taller plants than 75 x 20 cm^2 spacing at all the stages of observations, which may be due to competition between plants for utilization of sunlight, moisture, space and nutrients is less in wider planting pattern. The results are in conformity with the findings of Gozubenli and Kinuskan (2010).

The effect of fertilizer levels on mean number of functional leaves per plant was significant (Table 2) at all the stages of crop growth. The fertilizer levels of 125% RDF (150:75:50 kg NPK ha^{-1}) and 100% RDF (120:60:40 kg NPK ha^{-1}) were at par and recorded significantly higher number of functional leaves per plant over 75% RDF (90:45:30 kg NPK ha^{-1}) at the all stages of crop growth. The higher number of functional leaves under higher fertilizer levels may be due to increase in assimilation rate, cell division and metabolic activities in plant. The mean number of functional leaves per plant was significantly influenced due to different spacing levels, at 30, 45, 60, 75 DAS and at harvest. The plant spacing of 75 x 20 cm^2 recorded significantly higher number of functional leaves per plant over 60 x 15 cm^2 during all crop growth stages. The crop planted at 75 x 20, 75 x 15 and 60 x 20 cm^2 were at par with each other at 30, 45, 60, and 75 DAS in respect of number of functional leaves. Which may due to efficient utilization of space and nutrient by popcorn. The present findings corroborates with the findings of Singh *et al.* (2012). in maize.

The mean leaf area per plant was significantly influenced by different fertilizer levels during all the crop growth stages. The application of 125% RDF (150:75:50 kg NPK ha^{-1}) recorded significantly the highest leaf area per plant over 75% RDF (90:45:30 kg NPK ha^{-1}) and was on par with 100% RDF (120:60:40 kg NPK ha^{-1}) at all the crop growth stages. The increased leaf area with higher fertilizer levels (125 and 100% RDF) was because of increased amount of cellular protoplasm along with increased amount of proteins. This resulted in the expansion of cell wall which was manifested in the increased linear and lateral dimensions of leaves of the plant. The differences in leaf area per plant due to different spacing levels were significant at all the crop growth stages. The spacing of 75 x 20 cm^2 recorded significantly the highest leaf area than 60 x 15 cm^2 at all the stages of crop growth. However, plant spacing of 60 x 15 cm^2 recorded the lowest leaf area per plant under study. This may be due to availability of more space, moisture, nutrients and solar radiation at wider

Table 1. Mean plant height (cm) as influenced by different treatments.

Treatments	Days after sowing				
	30	45	60	75	At harvest
Fertilizers levels :					
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	37.46	94.90	164.16	178.73	184.31
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	37.25	93.45	163.75	171.37	179.86
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	32.99	84.72	154.49	169.35	175.14
S.E. ±	0.53	1.32	2.40	2.54	1.72
C.D.at 5%	1.54	3.87	7.05	7.44	5.06
Spacing levels (cm^2) :					
S_1) 60 x 15 (1,11,111 plants ha^{-1})	37.21	93.29	164.98	178.22	184.19
S_2) 60 x 20 (83,333 plants ha^{-1})	35.64	90.59	162.04	175.13	179.71
S_3) 75 x 15 (88,888 plants ha^{-1})	36.82	92.93	163.08	173.01	181.15
S_4) 75 x 20 (66,666 plants ha^{-1})	33.94	87.29	153.10	166.23	174.03
S.E. ±	0.61	1.53	2.77	2.93	1.99
C.D. at 5%	1.78	4.47	8.14	8.59	5.84
Interaction					
S.E. ±	1.05	2.64	4.81	5.08	3.45
C.D.at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	35.90	91.02	160.80	173.15	179.77

Table 2. Mean number of functional leaves per plant as influenced by different treatments.

Treatments	Days after sowing				
	30	45	60	75	At harvest
Fertilizers levels :					
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	7.28	7.78	9.21	10.93	6.64
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	6.95	7.51	8.86	10.43	6.18
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	6.38	6.75	8.14	9.78	5.01
S.E. ±	0.12	0.17	0.16	0.18	0.17
C.D.at 5%	0.34	0.49	0.47	0.52	0.52
Spacing levels (cm^2) :					
S_1) 60 x 15 (1,11,111 plants ha^{-1})	6.36	6.87	8.32	9.58	4.99
S_2) 60 x 20 (83,333 plants ha^{-1})	7.10	7.52	8.80	10.75	6.35
S_3) 75 x 15 (88,888 plants ha^{-1})	6.90	7.33	8.65	10.39	5.84
S_4) 75 x 20 (66,666 plants ha^{-1})	7.13	7.67	9.16	10.81	6.58
S.E. ±	0.13	0.19	0.18	0.20	0.20
C.D. at 5%	0.39	0.57	0.54	0.60	0.60
Interaction					
S.E. ±	0.23	0.33	0.32	0.38	0.35
C.D.at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	6.87	7.35	8.73	10.38	5.94

Table 3. Mean leaf area per plant (dm^2) as influenced by various treatments.

Treatments	Days after sowing				
	30	45	60	75	At harvest
Fertilizers levels :					
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	22.49	50.38	63.13	73.96	56.38
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	22.28	49.82	62.57	72.55	54.96
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	18.02	45.34	55.87	65.86	46.67
S.E. ±	0.52	0.75	0.95	1.03	1.05
C.D.at 5%	1.54	2.19	2.78	3.03	3.07
Spacing levels (cm^2) :					
S_1) 60 x 15 (1,11,111 plants ha^{-1})	18.97	46.41	57.45	66.76	48.81
S_2) 60 x 20 (83,333 plants ha^{-1})	21.85	49.29	61.58	72.15	53.62
S_3) 75 x 15 (88,888 plants ha^{-1})	20.67	48.11	60.86	70.94	52.82
S_4) 75 x 20 (66,666 plants ha^{-1})	22.24	50.25	62.20	73.29	55.82
S.E. ±	0.61	0.86	1.10	1.20	1.21
C.D. at 5%	1.78	2.53	3.21	3.50	3.54
Interaction					
S.E. ±	1.05	1.49	1.90	2.07	2.09
C.D.at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	20.93	48.51	60.52	70.79	52.67

Table 4. Mean dry matter accumulation per plant (g) as influenced by different treatments.

Treatments	Mean dry matter accumulation per plant (g)				
	Days after sowing				
	30	45	60	75	At harvest
Fertilizers levels :					
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	16.89	32.81	99.50	176.30	195.11
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	15.06	29.92	95.20	172.23	186.59
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	13.43	24.95	89.83	158.40	174.71
S.E. ±	0.62	1.57	1.48	2.45	3.14
C.D.at 5%	1.83	4.61	4.33	7.21	9.20
Spacing levels (cm^2) :					
S_1) 60 x 15 (1,11,111 plants ha^{-1})	13.50	24.35	87.85	162.79	176.44
S_2) 60 x 20 (83,333 plants ha^{-1})	15.36	30.05	97.11	170.32	185.92
S_3) 75 x 15 (88,888 plants ha^{-1})	14.88	29.94	95.69	167.34	184.94
S_4) 75 x 20 (66,666 plants ha^{-1})	16.77	32.56	98.71	175.45	194.58
S.E. ±	1.72	1.81	1.70	2.84	3.62
C.D. at 5%	2.11	5.32	5.00	8.32	10.62
Interaction					
S.E. ±	1.24	3.14	2.95	4.92	6.27
C.D.at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	15.12	29.22	94.84	168.97	185.47

Table 5. Mean number of days to 50% tassel and silk emergence as influenced by different treatments.

Treatments	Days to 50% tassel emergence	Days to 50% silk emergence
Fertilizers levels :		
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	49.40	54.77
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	50.80	55.68
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	55.28	59.70
S.E. ±	0.90	0.88
C.D.at 5%	2.63	2.57
Spacing levels (cm^2) :		
S_1) 60 x 15 (1,11,111 plants ha^{-1})	55.25	59.18
S_2) 60 x 20 (83,333 plants ha^{-1})	50.68	57.04
S_3) 75 x 15 (88,888 plants ha^{-1})	51.19	57.40
S_4) 75 x 20 (66,666 plants ha^{-1})	50.19	53.25
S.E. ±	1.03	1.01
C.D. at 5%	3.04	2.97
Interaction		
S.E. ±	1.80	1.75
C.D.at 5%	N.S.	N.S.
General mean	51.83	56.72

Table 6. Mean grain and stover yields (q ha^{-1}) and harvest index of popcorn as influenced by different treatments.

Treatments	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
Fertilizers levels :			
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	30.72	64.24	32.33
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	28.59	61.91	31.59
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	24.03	60.37	28.30
S.E. ±	0.73	0.93	0.54
C.D.at 5%	2.14	2.72	1.60
Spacing levels (cm^2) :			
S_1) 60 x 15 (1,11,111 plants ha^{-1})	25.39	60.30	29.46
S_2) 60 x 20 (83,333 plants ha^{-1})	28.30	62.71	30.98
S_3) 75 x 15 (88,888 plants ha^{-1})	27.77	61.15	31.09
S_4) 75 x 20 (66,666 plants ha^{-1})	29.64	64.55	31.43
S.E. ±	0.84	1.07	0.63
C.D. at 5%	2.47	3.14	1.84
Interaction			
S.E. ±	1.46	1.85	1.09
C.D.at 5%	N.S.	N.S.	N.S.
General mean	27.78	62.17	30.74

spacing of 75 x 20 cm^2. Similar results were reported by Singh *et al.*(2012).

The application of 125% RDF (150:75:50 kg NPK ha^{-1}) recorded significantly higher dry matter accumulation per plant than 75% RDF (90:45:30 kg NPK ha^{-1}) at all the crop growth stages and it was on par with 100% RDF (120:60:40 kg NPK ha^{-1}). The maximum dry matter accumulation was obtained under 100% and 125% RDF, which may be due to more availability of nutrients. The adoption of 75 x 20 cm^2 plant spacing significantly increased dry matter accumulation per plant as compared to 60 x 15 cm^2 spacing and at par with 75 x 15 and 60 x 20 cm^2 spacing at 30, 45, 60, 75 DAS and at harvest. This might be due to more space and less competition for nutrients, moisture, space and sun light. Similar results were reported by Ashok kumar (2009).

The fertilizer levels significantly influenced number of days for 50% tasseling and silking. The 125% and 100% RDF were at par and took significantly minimum days for tassel and silk emergence over 75% RDF. This may be due to abundant nitrogen stimulated for flowering in popcorn, which is a nitro positive crop. These results are in conformity with those reported by Gokmen *et al.*(2001) and Gozubenli and Kinuskan (2010).

The spacing levels significantly affected number of days for 50% tasseling and silking. The plant spacing of 75 x 20 cm^2 recorded significantly minimum days for 50% tassel and silk emergence over 60 x 15 cm^2 spacing levels because of better performance of individual plants due to reduced competition among the plants for the natural resources like solar radiation, moisture and nutrients. The similar result was reported by Gokmen *et al.* (2001).

Application of 125% RDF (150:75:60 kg NPK ha^{-1}) recorded significantly higher grain yield (30.72 q ha^{-1}), stover yield (64.24 q ha^{-1}) and harvest index (32.33%) over 75% RDF (90:45:30 kg NPK ha^{-1}) and was on par with 100% RDF (120:60:40 kg NPK ha^{-1}). The grain yield of popcorn found to be significant due to different spacing levels. The plant spacing of 75 x 20 cm^2 recorded significantly higher grain yield (29.64 q ha^{-1}) and stover yield (64.55 q ha^{-1}) as compared to 60 x 15, 75 x 15 cm^2 but was on par with 60 x 20 cm^2 spacing. The plant spacing of 75 x 20 cm^2 recorded significantly higher harvest index (31.43%) over 60 x 15 cm^2, but was on par with 60 x 20 and 75 x 15 cm^2 spacing levels.

The better performance at higher levels of fertilizer levels and wider planting pattern might be due to cumulative effect of substantial improvement in growth characteristics *viz.,* plant height, number of leaves $plant^{-1}$, leaf area $plant^{-1}$ and drymatter accumulation through efficient metabolic activity and increase photosynthesis which ultimately reflected in increased grain and stover yields of popcorn. These results are in accordance with the finding of Singh and Choudhary (2008), Ashok kumar (2009) and Gozubenli and Kinuskan (2010).

From the investigations it was clearly evident that adoption of 75 x 20 (66,666 plants ha^{-1}) plant density with application of 125% RDF (150:75:50 Kg NPK ha^{-1}) in *Kharif* was found to be optimum for getting higher yields.

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