



Effect of Plant Density and Fertilizer levels on Productivity and Economics of Popcorn (*Zea mays everta*) in *Kharif* Season

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ABSTRACT

A field experiment was conducted on medium black soils of Post Graduate Research Farm, College of Agriculture, Kolhapur, Maharashtra, during *kharif* 2012 on Popcorn. 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 cm², 60 x 20 cm², 75 x 15 cm² and 75 x 20 cm². The experiment was laid out in randomized block design (Factorial) with twelve treatment combinations and the treatments were replicated thrice. The yield contributing characters viz., number of cobs per plant, length and diameter of cob, number of grains cob⁻¹, grain yield per cob were significantly higher with 75 x 20 cm² plant spacing over 60 x 15 cm², except 60 x 20 and 75 x 15 cm². However, the number of cobs ha⁻¹ was significantly higher under 60 x 15 cm² over 75 x 20 cm². The grain and stover yields of popcorn were significantly higher under 75 x 20 cm² plant spacing (29.64 q ha⁻¹) over 60 x 15 and 75 x 15 cm², except 60 x 20 cm². The harvest index was significantly higher with 75 x 20 cm² over 60 x 15 cm². Application of 150:75:50 Kg NPK ha⁻¹ (125% RDF) and 120:60:40 Kg NPK ha⁻¹ (100% RDF) were at par and recorded significantly the higher yield contributing characters as compared to 90:45:30 kg NPK ha⁻¹ (75% RDF) resulting into significant increase in grain (30.72 and 28.59 q ha⁻¹) and stover yields (64.24 and 61.91 q ha⁻¹) under 100% and 125% RDF with no significant difference between them. Amongst, the plant spacings the 75 x 20 cm² recorded the maximum gross and net monetary returns (Rs. 83,267 and 52,234 ha⁻¹) and also benefit cost ratio (2.65). Application of 125% RDF recorded the maximum gross and net monetary returns (Rs. 86,158 and 53,139 ha⁻¹) followed by 100% and 75% RDF. The benefit cost ratio under 125% and 100% RDF was almost similar and the lower benefit cost ratio was recorded under 75% RDF.

Key words: Fertilizer levels, Plant densities, Popcorn.

Maize is one of the third most important cereals next to rice and wheat, in the world as well in India, contributing about 20% share of world's total cereal production. It is one of the most versatile crops and can be grown in the diverse environmental conditions and has diversified uses in industries, human food and animal feed. It is a C₄ plant and efficient converter of nutrients resulting into high yield potential among all cereals.

Popcorn has high production potential especially under irrigated conditions when compared to any other cereal crop. The productivity of maize largely depends on its nutrient requirement, particularly that of nitrogen, phosphorus and potassium. The information on fertilizer requirement for popcorn is very meager. So, there is a need to study the effect of nutrient levels on the growth and yield of popcorn. Plant

density has unique importance in crop production in order to obtain the maximum number of cobs per unit area. Therefore, it is also felt necessary to work out the spacing requirement of popcorn. Similarly, an interactive effect of fertilizer levels and different spacings is also highly essential to obtain maximum cob yield of popcorn. In view of these considerations, the present investigation was carried out.

MATERIAL AND METHODS

A field experiment was conducted 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 P₂O₅ (24.73 kg ha⁻¹) and available K₂O (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 cm², 60 x 20 cm², 75 x 15 cm² and 75 x 20 cm². 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 one 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 yield and quality parameters were recorded and analysed as per described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The 125% RDF recorded significantly the highest number of cobs per plant, length and diameter of cob, number of grains per row, number of grain rows per cob, number of grains per cob

and grain yield per cob over 75% RDF. This was due to better growth stature in terms of maximum number of leaves, leaf area and greater accumulation of drymatter might have enabled the production of larger yield structure as evidenced by conversion have responsible for recording superior yield attributes. The similar result was reported by Ashok kumar (2008) and Thakur *et al.* (2010).

The plant spacing of 75 x 20 cm² recorded significantly number of cobs per plant, length and diameter of cob, number of grains per row, number of grain rows per cob, number of grains per cob and grain yield per cob over 60 x 15 cm². This might be due to lack of competition among the community. Each individual plant might have efficiently utilized all the growth resources, which in turn produced higher quantity of photosynthates and translocated to sink. In densely populated crop many kernels did not develop into full size due to kernel abortion. The most important yield adjustment components in response to plant density were number of kernels and number of kernel row cob⁻¹, which were found to be higher with lower plant density. The result was corroborated with those reported by Gozubenli *et al.* (2010).

The fertilizer level of 125% RDF recorded significantly higher number of cobs ha⁻¹ over 75% RDF, however the 125 and 100% RDF were at par with each other. The mean number of cobs ha⁻¹ significantly influenced due to spacing levels. The Plant spacing of 60 x 15, 75 x 15 and 60 x 20 cm² were at par and recorded significantly higher number of cobs as compared to 75 x 20 cm².

The grain yield was significantly influenced by different fertilizer levels. Application of 125% RDF (150:75:60 kg NPK ha⁻¹) recorded significantly higher grain yield (30.72 q ha⁻¹) 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 balance fertilizer use improved the growth and yield attributing characters, which resulted into higher values of number of cobs plant⁻¹ (1.44), grains cob⁻¹ (418.76) and grain yield cob⁻¹ (61.38 g). The result corroborated with those reported by Banerjee *et al.* (2004) and Singh and Choudhary (2008).

The plant spacing of 75 x 20 cm² recorded significantly maximum grain yield (29.64 q ha⁻¹) as compared to 60 x 15, 75 x 15 cm² but was on par

Table 1. Mean number of cobs per plant, length and diameter of cob and number of grains per row as influenced by different treatments.

Treatments	No. of cobs per plant	Length of cob (cm)	Diameter of cob (cm)	No. of grains row ⁻¹
Fertilizer levels :				
F ₁) 125% RDF (150:75:50 Kg NPK ha ⁻¹)	1.44	18.54	10.86	35.06
F ₂) 100% RDF (120:60:40 Kg NPK ha ⁻¹)	1.40	17.44	10.21	33.45
F ₃) 75% RDF (90:45:30 Kg NPK ha ⁻¹)	1.30	15.17	9.04	28.61
S.E. ±	0.02	0.66	0.30	1.14
C.D.at 5%	0.07	1.92	0.84	3.34
Spacing levels (cm ²) :				
S ₁) 60 x 15 (1,11,111 plants ha ⁻¹)	1.13	15.11	8.93	28.40
S ₂) 60 x 20 (83,333 plants ha ⁻¹)	1.46	17.85	10.29	33.50
S ₃) 75 x 15 (88,888 plants ha ⁻¹)	1.44	16.71	10.07	32.61
S ₄) 75 x 20 (66,666 plants ha ⁻¹)	1.48	18.54	10.84	34.98
S.E. ±	0.03	0.76	0.33	1.31
C.D. at 5%	0.08	2.22	0.97	3.86
Interaction				
S.E. ±	0.04	1.30	0.57	2.28
C.D.at 5%	N.S.	N.S.	N.S.	N.S.
General mean	1.38	17.05	10.03	32.37

Table 2. Mean number of grain rows per cob, number of grains per cob, grain yield per cob and number of cobs per hectare as influenced by different treatments.

Treatments	No. of grain rows cob ⁻¹	No. of grains cob ⁻¹	Grain yield (g) cob ⁻¹	No. of cobs ha ⁻¹ (000)
Fertilizer levels :				
F ₁) 125% RDF (150:75:50 Kg NPK ha ⁻¹)	14.12	418.76	61.38	121.36
F ₂) 100% RDF (120:60:40 Kg NPK ha ⁻¹)	12.82	391.93	55.67	115.51
F ₃) 75% RDF (90:45:30 Kg NPK ha ⁻¹)	12.05	328.17	40.78	104.47
S.E. ±	0.28	11.78	1.99	2.23
C.D.at 5%	0.82	34.52	5.85	6.53
Spacing levels (cm ²) :				
S ₁) 60 x 15 (1,11,111 plants ha ⁻¹)	12.20	319.39	42.52	122.45
S ₂) 60 x 20 (83,333 plants ha ⁻¹)	12.90	389.69	55.10	116.73
S ₃) 75 x 15 (88,888 plants ha ⁻¹)	12.79	383.50	51.47	118.77
S ₄) 75 x 20 (66,666 plants ha ⁻¹)	14.09	425.90	61.35	97.17
S.E. ±	0.33	13.59	2.31	2.57
C.D. at 5%	0.94	39.86	6.75	7.54
Interaction				
S.E. ±	0.56	23.54	3.99	4.46
C.D.at 5%	N.S.	N.S.	N.S.	N.S.
General mean	12.97	379.62	52.61	113.78

with 60 x 20 cm² spacing. The higher plant density viz, 60 x 15 cm² (1, 11,111 plants ha⁻¹) and 75 x 15 cm² (88,888 plants ha⁻¹) resulted into higher plant competition for growth factors like moisture, nutrients and sunlight and reduce popcorn grain yield, whereas, the plant population of 66,666 plants ha⁻¹ (75 x 20 cm²) and 83,333 plants ha⁻¹ (60 x 20 cm²) produced maximum popcorn yield due to beneficial effect of spacing, moisture, nutrients and

other growth promoting factors on widely spaced plants. These results are in accordance with the finding of Singh and Choudhary (2008), Ashok kumar (2009) and Gozubenli and Kinuskan (2010).

The 125% RDF recorded significantly higher stover yield (64.24 q ha⁻¹) over 75% RDF and was on par with 100% RDF. This could be attributed to accumulation of more dry matter due to increased nutrient availability under higher

Table 3. 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 (%)
Fertilizer 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 (cm²) :			
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

Table 4. Cost of cultivation, gross and net monetary returns and benefit cost ratio as influenced by different treatments.

Treatment	Cost of cultivation (Rs ha ⁻¹)	Gross monetary returns (Rs ha ⁻¹)	Net monetary returns (Rs ha ⁻¹)	B:C ratio
Fertilizer levels :				
F ₁) 125% RDF (150:75:50 Kg NPK ha ⁻¹)	33019	86158	53139	2.55
F ₂) 100% RDF (120:60:40 Kg NPK ha ⁻¹)	31862	80275	48412	2.54
F ₃) 75% RDF (90:45:30 Kg NPK ha ⁻¹)	30463	67893	37429	2.10
Spacings levels (cm²) :				
S ₁) 60 x 15 (1,11,111 plants ha ⁻¹)	32801	71568	38766	2.11
S ₂) 60 x 20 (83,333 plants ha ⁻¹)	31581	79554	47973	2.46
S ₃) 75 x 15 (88,888 plants ha ⁻¹)	31711	78045	46334	2.37
S ₄) 75 x 20 (66,666 plants ha ⁻¹)	31033	83267	52234	2.65
General mean	31782	78109	46327	2.39

fertilizer levels. Similar result were observed by Rao and Padmaja (1994), Banerjee et al. (2004), Singh and Choudhary (2008) and Ashok kumar (2009). The plant spacing of 75 x 20 cm² recorded significantly the highest stover yield over 60 x 15 and 75 x 15 cm², expect 60 x 20 cm². Significantly lowest stover yield was recorded at 60 x 15 cm² (60.30 q ha⁻¹). The plant spacing of 75 x 20 and 60 x 20 cm² produced maximum stover yield due to less competition for growth factors. Similar results were reported by Singh and Choudhary (2008) and Ashok-Kumar (2009).

The fertilizer levels significantly influenced the harvest index. The 100 and 125% RDF were at par and recorded significantly higher harvest index as compared to 75% RDF. These results are in accordance with the findings of Rao and Padmaja (1994). The plant spacing of 75 x 20 cm² recorded significantly higher harvest index (31.43%) over 60 x 15 cm², but was on par with 60 x 20 and 75 x 15 cm² spacing levels. Similar findings were reported by Singh and Choudhary (2008).

The fertilizer level of 125% RDF recorded the higher gross and net monetary returns (Rs. 86,158 and 53,139 ha⁻¹, respectively) followed by 100% and 75% RDF. The lowest gross and net monetary returns were obtained under 75% RDF. The benefit cost ratio was more or less same under 125% and 100% RDF, while the lower benefit cost ratio was noticed under 75% RDF. These results is in accordance with the findings of Singh and Choudhary (2008) and Jadhav and Shelke (2012).

The total cost of cultivation of Rs. 32,801 ha⁻¹ was higher under 60 x 15 cm², followed by Rs. 31,711 ha⁻¹ with 75 x 15 cm² spacing and minimum was noticed under 75 x 20 cm². The 75 x 20 cm² plant spacing recorded the maximum gross and net monetary returns (Rs. 83,267 and 52,234 ha⁻¹) followed by 60 x 20, 75 x 15 and 60 x 15 cm². The benefit cost ratio was also higher under 75 x 20 cm² and the lower benefit cost ratio was obtained with plant spacing of 60 x 15 cm². This was in conformity with the previous findings of Singh and Choudhary (2008).

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