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Yield and Quality of Popcorn (*Zea mays everta*) as Influenced by Planting Population and Fertility Levels in *Kharif* Season

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ABSTRACT

A field experiment was conducted during *Kharif* season of 2012 on vertisols of Post Graduate Research Farm, College of Agriculture, Kolhapur, to develop certain agro techniques for enhancing the productivity and quality of popcorn in Maharashtra. The experiment was laid out in factorial randomized and replicated thrice. It 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 results indicated that highest grain yield, popping percentage expansion volume, protein content, reducing sugars and total sugars obtained with the application 150:75:50 Kg NPK ha^{-1} (125% RDF), while the lowest of all these parameters were recorded with 90:45:30 kg NPK ha^{-1} (75% RDF). Among the different plat densities 75 x 20 cm^2 plant spacing recorded higher yield and quality characters over 60 x 15 cm^2.

Key words: Fertilizer levels, Plant densities, Popcorn.

Maize is the one of the important crops of Asia, next to rice and wheat because of higher yield per unit area Among all the types of maize, popcorn (*Zea mays everta*) is another type of corn grown in small acreage around the urban area. The ability to pop is the unique characteristic that distinguishes popcorn from other types of corn. The grains of popcorn are small pointed with hard endosperm. The endosperm has more of hard starch compared to soft starch. The difference in popping character of dent corn and popcorn is that, relatively higher soft endosperm of the dent or flour corn with fragile cell walls allow the steam generated during the application of heat to leak out before enough pressure is generated to cause an explosion. But in popcorn with more of hard endosperm, the starch granules are so embedded in tough elastic colloidal material that confines and restricts to stem pressure generated within the granule on heating until it reaches explosive force (Weatherwax, 1922). Thus when the kernels of popcorn heated the pressure built up within kernel resulted in an explosion and the grain turned inside out. This gives the popped form of maize.

Popping improves the nutritional quality by reducing the antinutrients, increasing the protein and carbohydrate digestibility and provides dietary fibre in soluble form. Pop based foods are nutritionally adequate and highly acceptable by preschool children. Flavoured, sugar coated and low fat popped cereals are gaining more importance in the international market. The popcorn flavour is enhanced to individual tastes with addition of salt and butter. There is a need to exploit this simple processing technique to maximum extent for better health such as, development of supplementary foods for children, soft and nutritious food to geriatric segment and therapeutic food for metabolic disorders. In the view of above facts the present investigation was undertaken.

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 yield and quality parameters were recorded and analysed as per described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The maximum gain (30.72 q ha^{-1}), stover yield (64.24 q ha^{-1}) and harvest index (32.33%) of popcorn was recorded with the application of 125% RDF (150:75:50 Kg NPK ha^{-1}) then that of 75% RDF (90:45:30 Kg NPK ha^{-1}) it did not reach the level of significance with 100% RDF (120:60:40 Kg NPK ha^{-1}) during the investigation period (Table 1). The increased levels of fertilizer accomplished the requirement of nutrition and caused rapid root development that resulted in improved plant growth consequently showed significant translocation and storage of photosynthates from source to sink which resulted in significant enhancement in grain and stover yields. Popcorn differed significantly in grain yield and stover yield. The higher grain (29.64 q ha^{-1}) and stover yield (64.55 q ha^{-1}) were recorded by the 75 x 15 cm^2 (88,888 plants ha^{-1}) as compared to 60 x 15 and 75 x 15 cm^2 but was on par with 60 x 20 cm^2 planting density might be due to less competition for space,

moisture, nutrients and other growth promoting factors on wide spaced plants. A similar trend of improvement in yield was reported by Singh and Choudhary (2008), Ashok kumar (2009) and Gozubenli and Kinuskan (2010).

Moisture content in grain and pop was higher with application of 75% RDF (90:45:30 Kg NPK ha^{-1}) and the planting pattern of 60 x 15 cm^2. The mean popping percentage, expansion volume and flake size of grain was significantly influenced by fertilizer levels. Application of 125% RDF (150:75:50 kg NPK ha^{-1}) recorded significantly higher popping percentage (92.26%), expansion volume (92.26 ml/g) and flake size (2.75 ml) as compared to 75% RDF (90:45:30 kg NPK ha^{-1}) and was on par with 100% RDF (12:60:40 kg NPK ha^{-1}). Spacing of 75 x 20 cm^2 recorded significantly the highest popping percentage (92.65%) expansion volume (92.65 ml/g) and flake size (2.74 ml) over 60 x15 cm^2, however the spacing levels of 60 x 20, 75 x 15 and 75 x 20 cm^2 were at par with each other because as water content increases from the optimum, the popping percentage, expansion volume and flake size declined significantly. These values decreased dramatically in popping with oil and salt.. Result was corroborated with those reported by Banerjee *et al.* (2004).

The effect of fertilizer levels on mean protein content in grain was found to be significant. The fertilizer levels of 100 and 125% RDF were at par and recorded significantly higher protein content in grain as compared to 75% RDF. However 125% RDF recorded higher protein content in grain (9.43%). This may be attributed to the increased availability of the nitrogen and its uptake and storage in grain. Nitrogen, being the principle constituent of proteins, might have substantially increased the

Table 1. 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 (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

Table 2. Mean moisture percentage in grain and pop, expansion volume and popping percentage in the grain as influenced by different treatments.

Treatments	Moisture percentage		Expansion Volume (ml/g)	Popping percentage (%)
	Grain	Pop		
Fertilizer levels :				
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	14.60	4.26	15.93	92.26
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	14.70	4.40	15.43	91.87
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	14.74	4.94	14.78	85.78
S.E. ±	0.02	0.02	0.18	1.32
C.D.at 5%	0.07	0.07	0.52	3.86
Spacing levels (cm^2) :				
S_1) 60 x 15 (1,11,111 plants ha^{-1})	14.78	4.64	14.58	86.07
S_2) 60 x 20 (83,333 plants ha^{-1})	14.74	4.59	15.75	91.90
S_3) 75 x 15 (88,888 plants ha^{-1})	14.76	4.61	15.39	89.27
S_4) 75 x 20 (66,666 plants ha^{-1})	14.43	4.29	15.81	92.65
S.E. ±	0.03	0.03	0.21	1.52
C.D. at 5%	0.08	0.08	0.60	4.46
Interaction				
S.E. ±	0.04	0.04	0.36	2.64
C.D.at 5%	N.S.	N.S.	N.S.	N.S.
General mean	14.67	4.53	15.38	89.97

Table 3. Mean flake size, protein content, reducing sugars and total sugars of popcorn as influenced by different treatments.

Treatments	Flake Size(ml)	Protein content (%)		Reducing Sugars(%)	Total Sugars(%)
		grain	pop		
Fertilizer levels :					
F_1) 125% RDF (150:75:50 Kg NPK ha^{-1})	2.75	9.43	9.34	0.027	0.308
F_2) 100% RDF (120:60:40 Kg NPK ha^{-1})	2.71	9.30	8.92	0.024	0.288
F_3) 75% RDF (90:45:30 Kg NPK ha^{-1})	2.46	8.56	8.08	0.019	0.170
S.E. ±	0.05	0.16	0.18	0.00061	0.0249
C.D.at 5%	0.15	0.46	0.52	0.00179	0.0730
Spacing levels (cm^2) :					
S_1) 60 x 15 (1,11,111 plants ha^{-1})	2.49	8.67	8.31	0.016	0.187
S_2) 60 x 20 (83,333 plants ha^{-1})	2.69	9.26	8.92	0.024	0.281
S_3) 75 x 15 (88,888 plants ha^{-1})	2.63	9.05	8.70	0.020	0.248
S_4) 75 x 20 (66,666 plants ha^{-1})	2.74	9.41	9.17	0.034	0.306
S.E. ±	0.06	0.18	0.20	0.00070	0.0287
C.D. at 5%	0.18	0.53	0.60	0.00206	0.0843
Interaction					
S.E. ±	0.10	0.31	0.35	0.00122	0.0498
C.D.at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
General mean	2.63	9.09	8.77	0.023	0.266

protein content of kernels. The spacing levels significantly influenced the mean protein content in grain. The plant spacing of 75 x 20 cm^2 produced significantly the maximum protein content in grain (9.41%) as compared to 60 x 15 cm^2 and it was on par with 60 x 20 and 75 x 15 cm^2 spacing levels. The lesser number of plants per unit area under planting pattern of 75 X 20 cm^2 and consequent vigorous root growth and absorption nutrients from larger volume of soil would have accumulated higher nitrogen content, leading to production of higher protein content in the kernels. The result was corroborated with those reported by Banerjee *et al.* (2004)

The mean reducing sugars 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 reducing sugars over 75% RDF (90:45:30 kg NPK ha^{-1}) and 100% RDF (120:60:40 kg NPK ha^{-1}). The reducing sugars content tended to increase progressively up to the highest level of nutrients tried. The spacing of 75 x 20 cm^2 recorded significantly the highest leaf area than 60 x 15, 60 x 20 and 75 x 15 cm^2. This may be due to desirable level of physiological and biochemical activity in the plants under non-competitive conditions for growth resources. The lowest reducing sugars content was recorded with the planting pattern of 60 x 15 cm^2 due to poor production and translocation of photosynthates from source to sink. availability of more space, moisture, nutrients and solar radiation at wider spacing of 75 x 20 cm^2. Similar results were reported by Raja (2001).

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 total sugars over 75% RDF (90:45:30 kg NPK ha^{-1}) at the all stages of crop growth. This might be due to production and translocation of more quantity of photosynthates to sink under higher level of nutrition. The total sugars were significantly influenced due to different spacing levels. The plant spacing of 75 x 20 cm^2 recorded significantly higher total sugars over 60 x 15 cm^2. The crop planted at 75 x 20, 75 x 15 and 60 x 20 cm^2 were at par with each other in respect of total sugars. It is because of better physiological and biochemical activity of popcorn under wider planting pattern might have enhanced the sugar content of kernels. The present findings corroborates with the findings of Raja (2001).

In conclusion, the study has revealed that best performance of popcorn with highest yield and quality parameters could be realized with planting pattern of 75 x 20 cm^2 along with application of 150:75:50 Kg NPK ha^{-1}.

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