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Research Paper

Response of popcorn (*Zea mays* everta) varieties to varying plant densities and fertility levels

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ABSTRACT

A field experiment was conducted during the rainy season of 2013 and 2014 at Instructional Farm, Rajasthan College of Agriculture, Udaipur, to ascertain suitable popcorn (*Zea mays* everta) variety, its fertility level and plant density. Treatments consisted 3 popcorn varieties, ('VL Amber Popcorn', 'Bajaura Popcorn' and 'Amber Popcorn'), 3 fertility levels, viz. (90 + 30 and 110 + 40 kg N + P_2O_5/ha) and site-specific nutrient management (SSNM) based fertility level, viz. (134 + 52 kg N + P_2O_5/ha) and 2 plant densities, viz. (66,666 and 83,333 plants/ha). The soil of experimental site was having medium fertility status. Pooled results indicated that highest values of growth, yield-attributing parameters, grain (1.62 t/ha), stover yield (2.47 t/ha), net returns (× 10^3 ₹65.21/ha and benefit: cost ratio 3.29) were obtained with 'VL Amber Popcorn'. Application of SSNM-based fertility level improved the growth, yield components and consequently the grain (1.68 t/ha), stover (2.65 t/ha) over rest of the fertility levels and proved economically beneficial with the highest net return (×10^3 ₹68.03/ha) and B:C ratio (3.34). Significantly highest grain (1.55 t/ha), stover (2.39 t/ha), net returns (×10^3 ₹61.51/ha) and benefit: cost ratio (3.09) recorded under 83,333 plants/ha, being significantly higher than those with 66,666 plants/ha. At harvesting experimental soil with 'VL Amber Popcorn' had significantly lower N and P status; however, K status of soil did not vary significantly. At harvesting, SSNM-based fertility level had significantly higher N and P content of soil. The K status of did not differ significantly under varying fertility levels. Likewise, plant densities did not influence N, P and K status of soil.

Key words: Fertility levels, Plant densities, Popcorn varieties, SSNM

Maize is an important cereal of our country and is grown on 9.23 million ha, with the production of 13.67 million tonnes and productivity of 2.56 t/ha (DES, 2015). In Rajasthan this crop occupies 0.89 m ha area with production of 1.55 m t and productivity of 1.74 t/ha (DoA, 2015). Out of total production, 25% of maize is consumed as staple food in various forms and among them popcorn is one of the important one. Owing to its immense nutritionally rich food and high remunerative commercial value, identification of suitable genotype having wider adaptability and responsiveness to fertilizer and plant densities is considered essential for exploiting higher yield of popcorn in south eastern part of Rajasthan. Amongst nutrients, nitrogen and phosphorus are of paramount importance in plant system. The general recommendation of nitrogen and phosphorus for maize developed by researchers is based on crop responses over large areas. This often results in over- or under-fertilization leading to yield and economic losses. Thus considering these facts and paucity of research findings on these aspects in south-east Rajasthan, the present study was carried out with objectives to ascertain economically viable popcorn variety, plant density and nutrient recommendation for popcorn.

MAERIALS AND METHODS

A field experiment was carried out during the rainy (*kharif*) season of 2013 and 2014 at the instructional Farm, Rajasthan College of Agriculture, Udaipur, (23°34' N, 72°42' E, 582.17 meter above the mean sea-level) Rajasthan. The soil of experimental site was clay loam in texture, having alkaline reaction (*p*H 7.6 and 7.7). The soil was medium in available nitrogen (270.4 and 266.8 kg/ha) and available phosphorus (17.2 and 18.1 kg/ha) but high in available potassium (295.5 and 299.5 kg/ha). The treatments consisting 3 popcorn varieties ('VL Amber Popcorn', 'Bajaura Popcorn' and 'Amber Popcorn'), 3 fertility levels (90 kg N + 30 kg P_2O_5/ha, 110 kg N + 40 kg

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P_2O_5/ha and SSNM based fertility level, viz. 134 kg N + 52 kg P_2O_5/ha) and 2 plant densities (66,666 and 83,333 plants/ha) were tested in factorial randomized block design and replicated thrice. The crop was sown with onset of rain on 3 and 5 July, during both the years. In well-prepared field, furrows were opened at 60 cm apart and seeds were placed manually as per treatment spacing (20/25 cm) at a depth of 3–4 cm. Site-specific nutrient management (SSNM) dose was calculated through software developed by 'International Plant Nutrition Institute (Majumdar and Satynarayana, 2009) and validated at different All India Coordinated Research Project (AICRP) centres with the help of Indian Institute of Maize Research (IIMR), New Delhi. As per treatment nitrogen and phosphorus were applied through urea and *diammonium* phosphate (DAP). One-third of nitrogen and full dose of phosphorus were applied basal at the time of sowing by drilling fertilizer in crop rows about 4-5 cm below the seeds. The remaining nitrogen was given in 2 equal splits, viz. knee-high stage and at 50% tasseling stage as top- dressing. In order to minimize weed competition, pre-emergence application of atrazine at 0.5 kg/ha followed by 1 hoeing and earthing up were carried out 20 and 30 days after sowing respectively. Leaf chlorophyll concentration of fresh leaf sample collected at 50% tasseling stage was estimated as per standard procedure. The growth-efficiency parameters, viz. crop growth rate, and relative growth rate, were computed empirically by the use of standard formulae. Different growth and yield attributes were computed on basis of average of 5 samples. The crop was harvested at physiological maturity which was determined by formation of black/ brown layer in placental region of maize grain. Before harvesting the plants under each experimental unit, border rows were harvested and removed from experimental field. Cobs from net plots were picked up and kept in gunny bags. After thorough drying these were shelled. After picking cobs, stover from net plot was harvested and sun-dried for few days and weighed for individual plot, and final stover yield was expressed in t/ha. The standard methods of analysis were adopted for estimation of protein, nutrient in grain and stover and for grain popping %. Data obtained were statistically analyzed in factorial randomized design using the standard techniques of analysis of variance. To workout the most profitable treatment, economics of different treatments was calculated on the basis of prevailing market prices in terms of net return (₹/ ha) and benefit: cost (B:C) ratio.

RESULTS AND DISCUSSION

Performance of varieties

The popcorn variety 'VL Amber Popcorn' produced significantly taller plant over rest of the varieties. Similarly, dry-matter accumulation and leaf-area index (LAI) 60 days after sowing, chlorophyll content, cob height, crop

Table 1. Effect of varieties, plant densities and fertility levels on growth and yield-attributing characters of popcorn (pooled data of 2 years)

Treatment	Plants /ha at harvesting	Days to 50% silking (cm)	At 90 DAS			Chlorophyll content at 50%	Cob height (cm)	CGR at 30–60 DAS	RGR at 30-60 DAS	Length of cob (cm)	Girth of cob (cm)	Grains/ cob (000'/ha)
			Plant height (g/plant)	Dry matter DAS	LAI 60 at silking							
Varieties												
'Amber Popcorn'	73.1	52.6	198.0	63.7	2.67	2.27	70.1	7.58	0.117	17.4	9.7	525
'VL Amber Popcorn'	73.2	50.7	207.9	71.6	2.84	2.30	81.4	8.63	0.117	18.1	10.0	555
'Bajaura Popcorn'	72.9	51.9	193.8	60.1	2.63	2.36	66.4	7.25	0.119	17.0	8.7	325
SEm±	0.39	0.31	3.52	1.26	0.06	0.01	1.80	0.21	0.001	0.31	0.25	6.7
CD (P=0.05)	NS	0.89	9.92	3.54	0.16	0.04	5.08	0.60	NS	0.86	0.70	18.9
Fertility levels												
90 kg N + 30 kg P_2O_5/ha	73.0	52.2	192.6	60.9	2.55	2.28	69.8	7.35	0.116	16.4	9.1	442
110 kg N + 40 kg P_2O_5/ha	73.1	52.1	201.5	64.9	2.77	2.32	72.6	7.73	0.117	17.5	9.6	472
SSNM	73.1	51.0	205.6	68.6	2.82	2.34	75.5	8.38	0.120	18.6	9.7	492
SEm±	0.39	0.31	3.52	1.26	0.06	0.01	1.80	0.21	0.001	0.31	0.25	6.7
CD (P=0.05)	NS	0.89	9.92	3.54	0.16	0.04	5.08	0.60	0.003	0.86	NS	18.9
Plant densities												
66,666 plants/ha	64.2	51.7	193.5	62.3	2.67	2.30	71.0	7.58	0.121	17.6	9.6	474
83,333 t plants/ha	81.9	51.8	206.3	67.3	2.75	2.32	74.2	8.06	0.115	17.4	9.4	463
SEm±	0.32	0.26	2.87	1.02	0.05	0.01	1.47	0.17	0.001	0.25	0.20	5.5
CD (P=0.05)	0.89	NS	8.10	2.89	NS	NS	NS	0.49	0.002	NS	NS	NS

LAI, Leaf-area index; SSNM, site specific nutrient management level 134 kg N + 52 kg P_2O_5/ha; CGR, crop growth rate (g/m^2/day); RGR, relative growth rate (g/g/day)

growth rate (CGR) between 30–60 days after sowing of 'VL Amber Popcorn' were significantly higher over rest of the varieties. The varieties did not show variation in plant population recorded at harvesting and relative growth rate (RGR) between 30–60 days after sowing. The days of 50% silking of 'VL Amber Popcorn' were significantly lower than rest of the varieties. The yield components, viz. cob length, cob girth, grains/cob, grains row/cob, test weight and shelling percentage, were significantly higher in 'VL Amber Popcorn' over rest of the popcorn varieties. This manifested increase in productivity in terms of grain and stover yields over rest of the varieties. Harvest index and cobs/ha did not differ significantly. The highest net returns ($\times 10^3$₹65.2/ha) and benefit: cost ratio (3.29) were realized with growing of variety 'VL amber popcorn' indicating net gain of $\times 10^3$₹10.60/ha, benefit: cost ratio 0:54 over that of next best variety 'Amber Popcorn'. Under identical agronomical conditions, the marked variation in growth of both varieties could be ascribed to their genetic capabilities to exploit available resources for their growth and development (Suthar *et al.,* 2013; Snehlata *et al.,* 2016).

Fertility levels

Application of SSNM-based fertility level improved plant height, dry-matter accumulation and LAI, chlorophyll content, cob height, CGR between 30 to 60 DAS and RGR between 30-60 DAS over 110 kg N + 40 kg P_2O_5/ha and 90 kg N + 30 kg P_2O_5/ha. Enriching fertility with SSNM-based fertility level significantly reduced days to 50% silking compared to application of 110 kg N + 40 kg P_2O_5/ha and 90 kg N + 30 kg P_2O_5/ha. The fertility levels did not show variation in plant population at harvesting. Application of SSNM-based fertility level improved yield components, viz. length of cob, girth of cob, grains/cob, grain rows/cob, test weight and shelling percentage, consequently grain and stover yield over rest of 2 fertility levels and proved economically beneficial with highest net return ($\times 10^3$₹68.0/ha) and benefit: cost ratio (3.34). The cobs/ha, cob girth and harvest index (HI) did not vary significantly. These improvements might be on account of enrichment of soil with both of these nutrients to the level of sufficiency. The larger canopy development and plant height under the application SSNM level could be reasoned for increased interception, absorption and utilization of radiant energy which in turn increased overall growth, photosynthesis, LAI, total tillers, plant height and finally dry matter and yield. The results corroborate findings of Amanullah (2008), Kumar *et al.*(2015) and Bisht *et al.* (2012).

Table 2. Effect of varieties, plant densities and fertility levels on yield attributes, yield, quality, economics of popcorn and nutrient status of soil (pooled data of 2 years)

Treatment	Grain row/ cob	Test weight (g)	Shelling (%)	Cobs (000'/ha)	Yield (t/ha)		Protein content (%)		HI (%)	Popping (%)	Net return ($\times 10^3$/ha)	Benefit: cost ratio	Nutrient status of soil at harvest (kg/ha)	
					Grain	Stover	Grain	Stover					Nitrogen	Phosphorus
Varieties														
'Amber Popcorn'	12.6	105.8	68.8	71.3	1.42	2.15	9.98	3.91	39.8	79.7	54.6	2.75	274.3	18.4
'VL Amber Popcorn'	13.6	108.5	74.5	71.5	1.62	2.47	10.15	4.09	39.6	85.0	65.2	3.29	268.0	17.8
'Bajaura Popcorn'	09.5	112.4	66.9	71.3	1.31	2.08	9.96	3.88	38.9	80.2	49.3	2.49	274.9	18.5
SEm±	0.30	1.39	1.71	0.63	0.03	0.04	0.05	0.02	0.25	1.69	1.6	0.08	1.80	0.24
CD (P=0.05)	0.91	3.91	4.84	NS	0.09	0.13	0.14	0.05	0.70	4.76	4.7	0.24	5.09	0.69
Fertility levels														
90 kg N + 30 kg P_2O_5/ha	10.9	101.1	64.2	71.4	1.19	1.78	9.75	3.83	39.4	77.0	43.0	2.26	267.4	17.6
110 kg N + 40 kg P_2O_5/ha	11.9	109.4	70.5	71.5	1.48	2.27	10.12	4.01	39.5	81.8	58.0	2.94	273.5	18.3
SSNM	12.8	116.2	75.5	71.3	1.68	2.65	10.23	4.05	39.4	86.0	68.0	3.34	276.1	18.8
SEm±	0.30	1.39	1.71	0.63	0.03	0.04	0.05	0.02	0.25	1.69	1.6	0.08	1.80	0.24
CD (P=0.05)	0.91	3.91	4.84	NS	0.09	0.13	0.14	0.05	NS	4.76	4.7	0.24	5.09	0.69
Plant densities														
66,666 plants/ha	11.8	108.5	69.9	62.7	1.35	2.08	10.09	3.99	39.5	81.3	51.2	2.60	273.8	18.3
83,333t plants/ha	11.9	109.4	70.2	80.1	1.55	2.39	9.97	3.94	39.3	81.9	61.5	3.09	270.9	18.2
SEm±	0.28	1.13	1.40	0.52	0.02	0.03	0.04	0.01	0.20	1.38	1.3	0.07	1.47	0.20
CD (P=0.05)	NS	NS	NS	1.46	0.07	0.11	0.11	0.04	NS	NS	3.8	0.19	NS	NS

SSNM, site-specific nutrient management level 134 kg N + 52 kg P_2O_5/ha; B:C, benefit: cost

Plant densities

The crop under influence of 83,333 plants/ha accumulated maximum dry matter and attained significantly higher height over 66,666 plants/ha. Similarly, the crop-growth rate (CGR) increased with the increase in plant density for 66,666 to 83,333 plants/ha. However, relative growth rate (RGR) decreased with increase in plant density from 66,666 to 83,333 plants/ha. Plant densities failed to record significant variation in days to 50% silking, LAI, chlorophyll content and cob height. Most yield-attributing parameters were statistically at par under influence of both the plant densities, except number of cobs/ha which were significantly higher with higher plant density over lower plant density. The grain and stover yields, net returns and benefit: cost ratio recorded under 83,333 plants/ha were significantly higher over 66,666 plants/ha. The plant densities did not result in significant variation in HI. The 25% increase in plant density over 66,666 plants/ha, probably did not cause much more competition among plants for varying resources, viz. space, nutrients, moisture, light and thus enhanced growth and yield components and yield over lower density Amanullah, *et al.* (2008). Likewise, Hozumi *et al.* (1955) established this as a "cooperative interaction" wherein smaller plants tend to catch-up with taller ones by means of it and compete more on even terms.

Available nutrients

At harvesting, the soils under cultivation of 'Bajaura Popcorn' and 'Amber Popcorn' had higher N and P status of soil compared to 'VL amber Popcorn'. However, K status of soil did not vary significantly amongst varieties. This might be on account of higher mining of nutrient from soil by 'VL Amber Popcorn' (Snehlatha *et al* ., 2016). Likewise, the highest N and P were retained in soil under application of SSNM-based fertility level which were statistically at par with 110 kg N + 40 kg P_2O_5/ha; however, proved significantly higher over 90 kg N + 30 kg P_2O_5/ha. The K status of soil did not differ significantly under different fertility levels. After maintaining critical concentration of N and P in plants, the additional nutrients as well as other nutrient on account of their mineralization from native source in soil caused improvement in N and P status of soil with SSNM-based fertility level. The results of present investigation are in line with finding of Gill (2008), Totawat *et al.* (2010) and Snehlatha *et al.* (2016). The N, P and K retained with 83,333 and 66,666 plants/ha did not record significant variation during both the years and on pooled basis.

Based on our results it is recommended that for profitable popcorn production variety 'VL Amber Popcorn' should be grown by fertilizing SSNM-based recommendation (134 kg N + 52 kg P_2O_5/ha) keeping a density of 83,333 plants/ha.

REFERENCES

Amanullah, H., Rahman, Z.S. and Shah, P. 2008. Plant density and nitrogen effect on growth dynamics and light interaction of maize. *Archive of Agronomy and Soil Science* **54**(2): 401–411.

Bisht, A.S., Bhatnagar, A., Pal, M.S. and Singh, V. 2012. Growth dynamics, productivity and economics of quality protein maize (*Zea mays* L.) under varying plant density and nitrogen management practices. *Madras Agricultural Journal* **99**(1-3): 73–76.

Gill, M.S., Shukla, A.K. and Pandey, P.S. 2008. Yield nutrient response and economic analysis of important system in India. *Indian Journal of Fertilizers* **4**(1): 11–38.

DES. 2015. Directorate of Economics and Statistics, Department of Agriculture and Co-Operation, Ministry of Agriculture, Government of India, pp. 11–12.

DoA. 2015. Vital Agriculture Statistics, Statistical Cell, Directorate of Agriculture, Pant Krishi Bhawan, Jaipur, Rajasthan pp. 47.

Hozumi, K., Koyami, H. and Kira, T. 1955. Inter specific competition among higher plants. IV. A Preliminary account of interaction between adjacent individuals. *Journal of Institutional Poly Techniques, Osaka City, University*, Ser. D6, 121–130.

Kumar, M.R., Hiremath, S.M. and Nadagouda. B.T. 2015. Effect of single cross hybrids, plant population and fertility levels on productivity and economics of maize (*Zea mays* L). *Indian Journal of Agronomy* **60**(3): 431–435.

Majumdar, K. and Satynarayana, M. 2009. *Nutrient Expert of Maize Hybrid*. International Plant Nutrition Institute. www.ipni.net.

Snehlata., Singh, D. and Nepalia, V. 2016. Performance of quality protein maize (*Zea mays* L.) at varying fertility levels. *Annals of Agriculture Research New Series* **37**(1): 20–25.

Suthar, M., Singh, D. and Nepalia, V. 2013. Performance of sweet corn (*Zea mays.* L. ssp. *Saccharata*) varieties at varying fertility levels. *Forage Research* **38**(2): 115–118.

Totawat, K.L., Somani, L.L. and Singh, G. 2010. Integrated nutrient management in maize–wheat cropping sequence on typic haplustalfs of western India. *Annals of Arid Zone* **40**(2): 439–444.