



Original Research Article

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**Effect of Planting Time, Fertility Level and Plant Population on Development, Yield, Nutrient Uptake and Quality of Winter Popcorn (*Zea mays everta* Sturt) under Late Sown Condition**

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A popcorn (*Zea mays everta* Sturt.) composite variety, namely V.L. Amber was assessed for their potential role as winter crop in the management at Agricultural Research Farm of BHU, Varanasi, India, under late sown condition of 2009-10 and 2010-11, respectively. The three date of sowing i.e. 15<sup>th</sup> December, 30<sup>th</sup> December and 15<sup>th</sup> January with three plant population (60,000, 80,000 and 100,000 plants/ha) in main plots and three fertility levels (N<sub>100</sub>P<sub>50</sub>K<sub>50</sub>, N<sub>150</sub>P<sub>65</sub>K<sub>65</sub>, N<sub>200</sub>P<sub>85</sub>K<sub>85</sub> kg/ha) in sub plot laid out in split plot design with three replications. The sandy clay loam in texture with pH 7.6, 0.35 % organic carbon and 183 kg available nitrogen, 21.02 and 228 kg ha<sup>-1</sup> of available phosphorus and potassium, respectively were determined to find out the development, yield, nutrient uptake and quality of winter popcorn. Results from assigning total 27 treatment indicated that popcorn sown on 15<sup>th</sup> December with 80,000 plants/ha at N<sub>200</sub>P<sub>85</sub>K<sub>85</sub> kg/ha significantly (P=0.05) enhanced number of kernel/cob, grain weight/cob and recorded maximum grain and straw yield, N, P and K uptake and quality (popping volume and popping percentage) than highest plant population at very late sown. Developmental phase taken more days to 50% tasseling, 50% silking and 50 % physiological maturity and 80,000 plants/ha recorded minimum average day for these traits. No appreciable effect noticed in lowest values was observed with N<sub>200</sub>P<sub>85</sub>K<sub>85</sub> kg/ha during the investigation. Rest treatment, however, did not hold promise effect in all respect.

**Introduction**

In the view of good source of carbohydrate, energy and fibre for an individual of normal weight, carbohydrate is the best source of food and fuel. Regarding fibre, there are two kinds of fibre. Soluble one plays a role in regulating. Hunger and insoluble fibre is important in gastrointestinal health. So high value speciality grain of pop corn (*Zea mays everta*) has a universal acceptance as a snack food. Natural air/ low temperature drying is the

main drying method used by popcorn producers and processors because it helps in maintaining quality by limiting stress cracks and breakage susceptibility.

On looking of suitable production technology, the ability of the maize popcorn to grow in different seasons and high productivity of rabi/ winter and spring maize give it an added advantage for inclusion in the cropping

system as demand for more food production. Cultivation during winter is becoming a common practices in peninsular India. It is most popular food stuffs in peri-urban areas in big cities of all over the world and that call the king of nutritious snack food. Time of sowing is a non-monetary input plays significant role in production and productivity of any popcorn (Verma *et al.*, 2012). Optimum plant density is another important factor for high grain yield and declines when plant density is increased further (Tollenar *et al.*, 1994). Banerjee *et al.*, 2004) reported that increasing levels of N up to 150 kg ha<sup>-1</sup> significantly increased the grain yield, protein content of grain and percentage of popped grain, but decreased the grain moisture content and popping expansions. The uptake of N and P increased with increase in N level from 150 to 200 kg ha<sup>-1</sup> and phosphorus from 75 to 100 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> observed at sandy loam soils of Coimbatore (Ananthi *et al.*, 2010).

The field experiment was conducted at the Research farm of Institute of Agricultural Sciences, BHU, Varanasi during late winter season of 2009-10 and 2010-11 to determine the planting time, fertility level and plant population of popcorn. The soil was well drained, sandy clay loam in texture with pH 7.6. it was low in N and medium in P and K. the experiment was laid out in a split plot design on tested variety V.L. Amber on three different date viz. 15 December, 30 December and 15 January arranged in the main plot.

Three level of plant population of 60, 80 and 100 thousand ha<sup>-1</sup> (spacing of 60 cm x 27.8 cm, 60 cm x 20.8 cm and 60 cm x 16.6 cm, respectively) in sub plot and fertility levels of N<sub>100</sub>P<sub>50</sub>K<sub>50</sub>, N<sub>150</sub>P<sub>65</sub>K<sub>65</sub> and N<sub>200</sub>P<sub>85</sub>K<sub>85</sub> kg ha<sup>-1</sup> in sub-sub plots with three replications. The soil of experimental field was sandy clay loam in texture with pH 7.6, 0.35 % organic carbon and low in available nitrogen 183, 21.02 and 228 kg/ha of available phosphorus

and potassium, respectively by analyzed soil samples for available N (Estimated by Alkaline permanganate method, Subbiah and Asija, 1973), P<sub>2</sub>O<sub>5</sub> (Olsen method, Olsen, S.R. 1954) K<sub>2</sub>O (Flame photometer method, Jackson, 1973) and potassium. Popcorn cultivar "V.L. Amber" was sown by opening 5 cm deep furrow 60 cm apart seeds were placed at a distance of 27.8 cm, 20.8 cm and 16.6 cm to maintain the required plant population of 60,000, 80,000 and 100,000 plants/ha.

The nutrient sources used were, 174.86: 80.44:83.33 kg/ha, 270.79:141.30:108.33 kg/ha and 362.47:184.78:141.66 kg/ha for Urea: DAP (Di-ammonium phosphate) and MOP (Muriate of potash) to fulfill the 100:50:50, 150:65:65 and 200:85:85 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ha<sup>-1</sup>, respectively. The total quantity of P<sub>2</sub>O<sub>5</sub> requirement of and K<sub>2</sub>O along with 1/3 N (as per treatment) were applied as basal at the time of sowing. A blanket application of zinc sulphate at 25 kg/ha was applied to all the experimental plots as per recommended package of practices. The remaining quantity of N was top dressed in two equal splits at knee height and tasseling stages.

Others compulsory activities viz. intercultural and plant protection measures were applied as need based. The data were analyzed statistically for comparing the treatment means. Five plants in net plot were randomly selected and tagged for recording the biometric observations at different stages of growth. However, for measuring dry matter accumulation, two plants from the border rows were randomly selected. The observations on growth attributes were recorded at a monthly interval i.e. 30, 60, 90, 120 days after sowing (DAS) and at harvest. Yield attributes and yield were studied before and after harvesting as per investigation required.

## Results and Discussion

### Effect of treatments on planting time

Planting time influenced all the developmental characters significantly. All of tasseling, silking and physiological maturity were significantly delayed by late sowing increased the numbers of days exhibited significantly higher values than sowing on extra late resulting higher grain yield, nutrient uptake and quality of popcorn followed by 30 December and 15 January, respectively. Overall 15 December sowing of popcorn recorded 24.94 and 18.65 % more grain yield, 34.99 and 8.27% protein content and popping percentage than D<sub>3</sub> and D<sub>2</sub>. On an average delay in sowing after 15 December caused a reduction in the grain yield by 45.4 kg/day. The possible explanation for such result might be that the phosphorus is a constituent of the enzyme nitrogenase, which NO<sub>3</sub> to protein N. under the condition of 30<sup>th</sup> December and 15<sup>th</sup> January planting the availability of phosphorus was less and resulted in lower transformation of NO<sub>3</sub> to amino- N. this finding of present study is similar to the results reported by Sutaliya and Singh (2005). The highest protein value was also experienced at early date sowing by Verma *et al.*, (2012).

Plant population also brought significant difference in almost all the character except days to 50% tasseling, silking and physiological maturity. However, those were hastened by the highest plant population, and it remained closed with each other during experimentation might be due to earlier emergence at their respective dates. Grain yield was found to be significantly higher in P<sub>2</sub> (32.61 qtl/ha) which was about 21.86 and 11.33% more than P<sub>1</sub> and P<sub>3</sub> respectively. This was in contrast with the findings of *kharif* maize where 100,000 plant populations gave the highest yield (Sen *et al.*, 1996 and

1999). Reducing the spacing thereby higher population beyond 80 thousand plants/ha might have increased competition and created a stress environment for the plant growth which resulted in reduced grain yield and quality of popcorn. Kar *et al.*, (2006) also recommended 83.3 thousand plants/ha to obtain maximum green cob yield in sweet corn. Low population density restricted the yield due to lower number of plants which cant produced highest yield than P<sub>2</sub>. Although there were best quality characters produced with 80,000 plants/ha than highest plants population of 100 thousand /ha. The low nutrient uptake reduced the final yield and quality characters. In densely populated crop many kernels did not develop into full size due to limitation in assimilation capacity which caused kernel abortion. Increase in plant population increased grain yield up to 80,000 plants/ha which was reduced there after reducing the spacing thereby increase population up to 100 thousand plants/ha might have increased competition. The significant increase in kernel number/row and kernel /cob noticed at a population of 80,000 plants/ha also obtained by Singh *et al.*, (2016). The reason might be attributed to the availability of better resources in low to medium plant density. In high plant density, the number of individual plants per area is increased beyond the optimum plant density, there are severe consequences that are detrimental to ear ontogeny that result in barrenness (Sangoi, 2001). The quality characters (protein content in grain and stover, popping volume and popping percentage of corn grain) significantly influenced by different plant populations. The density of P<sub>2</sub> contained significantly higher per cent protein content being increased higher dry matter accumulation though leading to higher N uptake which is a constituent of protein and remained at par over P<sub>3</sub>.

Fertility level could bring about significantly difference in all the yield attribution characters. Both tasseling, silking and physiological maturity were significantly hastened by higher fertility levels. This was in

contrast with other cereals where higher fertilizer dose has been found to delay the ones of reproductive stage (Sen and Gulati 1986).

**Table.1** Effect of treatments on the development and yield attributes of winter popcorn under late sown condition (pooled data of two years)

Treatment	Days to 50% emergence	Days to 50% tasseling	Days to 50% silking	Days to 50% Physiological Maturity	Kernel /row	Kernel /cob	Shelling percentage
<b>Planting time</b>							
15 <sup>th</sup> December	10.90	100.00	109.2	140.25	3.35	372.88	76.69
30 <sup>th</sup> December		93.00	100.35	132.55	30.55	329.43	71.65
15 <sup>th</sup> January	16.45	89.00	95.95	119.90	27.40	273.12	66.68
S.Em±	14.00	0.75	0.90	0.80	0.60	9.06	1.06
C.D.(P=0.05)	0.81	2.25	2.70	2.30	1.85	27.17	3.17
2.65							
<b>Plant population (plants ha<sup>-1</sup>)</b>							
60,000 plant ha <sup>-1</sup>	15.65	93.50	101.20	130.30	29.70	350.23	73.86
80,000 plant ha <sup>-1</sup>	14.12	93.95	101.90	130.70	31.80	380.48	74.92
100,000 plant ha <sup>-1</sup>	11.57	94.50	102.45	131.65	27.05	321.22	72.74
S.Em±	0.70	0.75	0.90	0.80	0.60	9.06	1.07
C.D.(P=0.05)	NS	NS	NS	NS	1.07	27.17	NS
1.66							
<b>Fertility levels (N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ha<sup>-1</sup>)</b>							
100, 50, 50	15.48	95.05	107.72	138.00	26.50	323.42	68.69
150, 65, 65	13.67	93.80	104.32	131.10	29.95	362.60	72.82
200, 85, 85	12.19	93.10	100.52	125.75	33.25	401.92	77.52
S.Em±	0.58	0.45	0.53	1.35	0.60	12.60	0.97
C.D.(P=0.05)		1.35	1.65	4.05	1.80	36.13	2.79
1.58							

**Table.2** Effect of treatments on yield and N, P and K uptake of winter popcorn under late sown condition (pooled data of two years)

<b>Treatments</b>	<b>Grain yield</b>	<b>Stover</b>	<b>N uptake (Kg ha<sup>-1</sup>)</b>		<b>P uptake (Kg ha<sup>-1</sup>)</b>		<b>K uptake (Kg ha<sup>-1</sup>)</b>	
	(q/ha)	yield (q/ha)	Grain	Stover	Grain	Stover	Grain	Stover
<b>Planting time</b>								
15 <sup>th</sup> December	33.76	51.41	55.005	45.59	9.21	10.145	10.885	74.145
30 <sup>th</sup> December	28.57	47.61	44.05	40.595	7.97	8.795	9.375	69.25
15 <sup>th</sup> January	25.34	44.44	27.415	30.455	5.875	7.895	7.225	61.65
S.Em±	0.65	0.89	1.085	1.39	0.23	0.235	0.315	1.7
C.D.(P= 0.05)	1.94	2.67	3.245	4.18	0.7	0.71	0.95	5.095
<b>Plant population (Plants/ha)</b>								
60,000	26.76	45.755	53.925	33.145	7.06	8.61	9.235	68.745
80,000	32.61	47.955	44.955	45.59	7.84	9.145	10.215	73.465
100,000	29.29	49.74	43.525	40.895	6.16	8.085	8.09	61.335
S.Em±	0.65	0.89	1.085	1.39	0.23	0.235	0.315	1.7
C.D.(P= 0.05)	1.94	2.67	3.245	4.18	0.7	0.71	0.95	5.095
<b>Fertility level (N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/ha)</b>								
100: 50: 50	25.69	43.825	36.13	31.835	5.91	6.845	7.765	60.015
150: 65: 65	30.53	47.79	41.39	40.05	6.785	8.32	8.955	67.68
200: 85: 85	34.94	51.835	49.945	50.76	8.82	10.165	10.765	79.355
S.Em±	0.59	0.675	0.985	1.815	0.21	0.27	0.29	1.735
C.D.(P= 0.05)	1.70	1.94	2.825	5.195	0.595	0.775	0.83	4.98

**Table.3** Effect of treatments on quality characters of winter popcorn under late sown condition (pooled data of two year)

Treatment	Protein content (%)		Popping volume (cc/g)	Popping percentage
	Grain	Stover		
<b>Planting time</b>				
15 <sup>th</sup> December	10.03	5.89	13.97	96.56
30 <sup>th</sup> December	9.20	5.41	13.52	95.20
15 <sup>th</sup> January	6.52	4.09	12.77	91.06
S.Em±	0.14	0.19	0.02	0.16
C.D.(P= 0.05)	0.44	0.56	0.05	0.48
<b>Plant population (plants ha<sup>-1</sup>)</b>				
60,000 plant ha <sup>-1</sup>	7.95	4.30	12.25	97.95
80,000 plant ha <sup>-1</sup>	8.91	5.59	14.37	96.24
100,000 plant ha <sup>-1</sup>	8.88	5.48	13.59	92.12
S.Em±	0.14	0.18	0.02	0.16
C.D.(P= 0.05)	0.43	0.56	0.06	0.48
<b>Fertility levels(N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ha<sup>-1</sup>)</b>				
100, 50, 50	8.29	4.77	14.08	93.13
150, 65, 65	8.51	4.97	13.97	94.94
200, 85, 85	8.94	5.73	12.77	96.74
S.Em±	0.14	0.13	0.02	0.16
C.D.(P= 0.05)	0.39	0.41	0.06	0.46

In respect of all other yield contributing characters, F<sub>3</sub> recorded the highest values followed by F<sub>2</sub> and F<sub>1</sub>, which in turn led to the significantly highest grain yield in F<sub>3</sub> (34.94 qtl/ha) which was 36% and 14.44% more than F<sub>1</sub> and F<sub>2</sub> respectively. Sen *et al.*, (1999) and Sahoo and Mahapatra (2007) also reported an increase in grain yield by higher

dose of N, P and K fertilizer. Namakha *et al.*, (2008) also found that it may be due to optimum and regular supply of nitrogen nutrient to plant from soil during growth period by more assimilation rate and it is integral part of protein the building blocks of maize plant. The protein content (popcorn grain and stover), popping volume and

popping percentage were influenced significantly due to fertility levels. However, each succession of fertility levels there was significantly decreased in popping expansion volume and recorded largest volume at  $F_1$ . Further, the percentage of popped grains was increased significantly at  $F_3$ . However, popping expansion volume is dependent on moisture content in starch which get converted to steam and exerts pressure on the endosperm of the ultimately ceasing it to pop turning inside out. Since, increase in fertility dose up to  $F_3$ , significantly increased the protein content in grain (Bhat *et al.*, 2008), the relative proportion of starch and hence moisture content in starch decrease and resulted in less popping expansion volume.

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