Maize Journal (April 2023) 12(1): 37-44

RESEARCH PAPER

Influence of planting geometry and nutrient levels on growth dynamics, quality and cob yield of sweet corn in north western India

Amit Bhatnagar[1] · Sailesh Deb Karjee[2] · Gurvinder Singh[1] · Dinesh Kumar Singh[1] · Veer Singh[3]

Abstract: A field experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *kharif* season, 2018 to find out the response of sweet corn to varied planting geometry and nutrient doses. The experiment was laid out in split plot design keeping four planting geometries (60 cm × 25 cm, 60 cm × 30 cm, 75 cm × 25 cm and 75 cm × 30 cm) in main plots and three doses of NPK (120: 60: 40, 150: 75: 50 and 180: 90: 60 kg N: P_2O_5: K_2O/ha) in sub plots. Dry matter accumulation, LAI and net assimilation rate were significantly higher in the narrowest planting geometry (60 cm × 25 cm). This geometry also recorded significantly higher green cob yield (13325 kg/ha) than the other planting geometries. Nutrient level 180: 90: 60 being at par with 150: 75: 50 kg N: P_2O_5: K_2O/ha produced significantly taller plants, leaf area per plant, dry matter accumulation per plant, LAI, CGR, RGR and NAR than 120: 60: 40 kg N: P_2O_5: K_2O/ha. Green cob yield was maximum (12687 kg/ha) in180: 90: 60 kg N: P_2O_5: K_2O/ ha but did not vary due to nutrient levels.

Keywords: Growth · NPK dose · Planting geometry · Sweet corn

✉ Amit Bhatnagar: bhatnagaramit75@gmail.com

[1]Professor Agronomy, [2]Ex-PG Scholar, [3]Professor Soil Science, Department of Agronomy, College of Agriculture, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Received: 15 November 2022/ Accepted: 25 February 2023
© Maize Technologists Association of India 2023

Introduction

The demand of sweet corn (*Zea mays* L. *saccharata*) in India has been increased during past years due to its taste and multi use. The major agronomic constraints of sweet corn production in *kharif* season in north western India are erratic plant stand, excess soil moisture, high leaching loss of nitrogen, heavy infestation of weeds, more incidences of disease and pest etc. Among these constraints, optimum population and balanced nutrition are of prime importance. There is need to minimize the competition among the plants to get a healthy cob. Spatial arrangement of plants governs the shape and size of the leaf area per plant, affects interception of radiant energy by the canopy and influences intra and inters plant competition for growth resources. Planting geometry also affects proliferation and growth of roots and their activity. Cob yield of maize is decided by number of cobs per unit area and cob size. Higher plant population may increase the number of cobs per unit area but individual cob size may be reduced because of intense competition among the plants. On the other hand, cob size increases with lower plant population but the number of cob per unit area become low (Bhatt *et al.*, 2012). Thus, planting pattern of sweet corn should be adjusted in such a way that the highest cob yield can be obtained by a compensatory balance between number of cobs per unit area and cob size. Even at same plant population, intra and inter plant competition under different planting geometry affect crop performance. Thus, not only plant population but planting geometry also influence cob yield. An adequate and balanced supply of nutrients is essential for proper growth and development of crop. Rational use of nutrients needs priority in sweet corn production.

Nitrogen is an integral part of chlorophyll and proteins, which are essential for survival of plants. Yield and quality of green cobs are influenced by nitrogen fertilization to a great extent. Numerous field experiments have shown that nitrogen is one of the important growth-limiting factors (Khan *et al*., 2018). Therefore, its proper dose is must to realize higher yield potential. Phosphorus is known to influence growth and vigour of plant as well as root growth and improves the growth of crop. Phosphorus nutrition plays a key role in plant metabolism as it provides energy through ATP. It is an essential component of nucleic acids, phosphorylated sugars and lipids, which control all life processes (Grazia *et al*., 2003). Potassium is important in the synthesis and metabolism of carbohydrates and also contributes in photosynthetic activity. Potassium is essential for many plant processes such as enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomatal movements, solute phloem transport, electrical neutralization, regulation of membrane potential, co-transport of sugars and the maintenance of cation-anion balance in the cytosol as well as in the cell sap (Srikanth *et al*., 2009). Nutrient demand of a crop may vary with plant population. To exploit the yield potential of a crop applied nutrient amount should fulfill nutritional requirement of crop. Therefore, study was conducted to analyse the growth of sweet corn at different planting geometry under varying nutrient levels.

Materials and methods

A field experiment was conducted during the *kharif* season, 2018 at the Norman E. Borlaug crop research centre of G.B. Pant University of Agriculture and Technology, Pantnagar, district Udham Singh Nagar, Uttarakhand. Pantnagar lies in the *Tarai* belt and is situated at 29^o N latitude, 79.5^o E longitude and altitude of 243.83 m above mean sea level in the foot hills range of the Himalaya. The soil of experiment plot was silty clay loam in texture, neutral in reaction (pH 7.2), medium in organic carbon (0.69%), low in available nitrogen (216.3 kg/ha), medium in available phosphorus (21.5 kg P/ha) and available potassium (222.3 kg K/ha). The experiment consisted of four planting geometries (60 cm × 25 cm, 60 cm × 30 cm, 75 cm × 25 cm and 75 cm × 30 cm) in main plots and three doses of NPK (120: 60: 40, 150: 75: 50 and 180: 90: 60 kg N: P_2O_5: K_2O/ha) in sub plots was set in split plot design with three replications. The field was pulverized by three cross harrowings with the tractor mounted disc harrow. Thereafter, the field was leveled with leveler. Gross plot size was 6.0 m × 4.5 m. N, P and K were applied through NPK mixture (12: 32: 16), urea and muriate of potash. The 20 per cent of nitrogen and full dose of phosphorous and potassium were applied as basal. Remaining 80 per cent nitrogen was applied in 3 splits as 20, 30 and 30 per cent at 4 leaf-stage, knee height stage and tasseling, respectively. Nutrient dose was applied as per treatment in respective plots. Sweet corn variety 'Sugar-75' was sown on 29 June 2018 and harvested on 16 September 2018. The furrows were opened at 4-5 cm depth by hand operated furrow opener as per treatments in respective plots. Seeds were sown in flat beds manually and were placed at the distance as per treatment. Atrazine @ 1.0 kg a.i./ha in 500 liters of water was sprayed on next day after sowing in all treatments by using knapsack sprayer. One manual weeding was done at 25 days after sowing to manage the weeds. During the crop period no irrigation was given as the crop water demand was fulfilled by adequate rainfall of 1378.5 mm at regular interval.

Randomly five selected plants were tagged in each net plot and their height was measured at vegetative stage (30 and 45 DAS) from ground surface to the tip of newly emerged leaf. At harvest plant height was measured up to basal node of tassel with the help of meter scale. The values were averaged and expressed in cm. At the time of harvesting, stem girth was measured just below the point of emergence of cob with the help of thread and thread length was reported in cm. The plant assimilatory material accumulation pattern was computed by using growth analysis formula as reported by Radford (1967). All the leaves from five selected plants were removed and categorized in to three groups *viz*., small, medium and large. The representative three leaves from each category were taken out to measure length and width. Average values of leaf length and width was multiplied to get leaf area of each respective category. Leaf area recorded from each category was multiplied by the total number of leaves of respective category and summed up to get the leaf area of sample. Average leaf area per plant was computed by dividing the number of sampled leaves. The whole value was multiplied by correction factor of 0.75 (Montgomery, 1911). Five plants from sample row were selected and cut just above the ground level with the help of sickle. These cut plants were allowed to sun drying for 48 hours. After sun drying, these plants were dried in the oven at 65±5°C temperature for 72 hours or till the samples attained a constant weight and then average weight was expressed in gram per plant. At harvest stage, the weight of three plants along with cobs from net plot was recorded and added in biological yield. Dry matter per plant (g) was multiplied by plant population in each net plot and was divided by net plot area (m^2) to get dry matter accumulation per square metre. The days taken for 50 per cent tasseling and 50 per cent silking were calculated by taking the difference of date of sowing and dates of 50 per cent plants have tassel and silk. At milk stage cobs from the net plot area were harvested and weighed, without removing husk. The value was expressed on hectare basis in kg. Grains from middle portion of randomly selected cob were used. Hand refractometer was used to measure total soluble solids. Protein content in grain was worked out by multiplying nitrogen content of grains with a factor 6.25 (A.O.A.C., 1965).

Results and discussion

The increase in plant height was slower in first 30 days after sowing (DAS) but a rapid increase in plant height was observed between 30 and 45 DAS (Table 1). Rate of increase was slower between 45 DAS to harvest stage. The varying planting geometries did not influence plant height significantly at different growth stages. However, a trend of increase in plant height was found with increase in row to row and plant to plant spacing. Where the widest planting geometry *i.e.* 75 cm × 30 cm registered numerically the highest plant height at all growth stages (73.8, 134.0 and 155.4 cm, respectively). Plant height increased with increasing nutrient dose at all crop growth stages but differences were non-significant at 30 DAS. At 45 DAS and at harvest, application of 180: 90: 60 kg N: P_2O_5: K_2O/ha being at par with 150: 75: 50 kg N: P_2O_5: K_2O/ha resulted into significantly higher plant height (131.5 and 153.9 cm, respectively) than 120: 60: 40 kg N: P_2O_5: K_2O/ha. An increase in nutrient dose from 120: 60: 40 to 180: 90: 60 kg N: P_2O_5: K_2O/ha led to 5.8 and 8.6 per cent increment in plant height at 45 DAS and harvest stage, respectively.

Numerically more plant height under wider plant geometries may be attributed to less competition for water, nutrient, space, solar radiation etc. compared to narrow spacing. These factors helped in improving the growth in terms of plant height. The results are in conformity with the findings of Kurne *et al.* (2017) who reported taller plants under wider planting geometry. Nutrients play important role in plant growth and development. An adequate supply of N is associated with high photosynthetic activity and more cell division, cell elongation and nucleus formation. Similarly, P has significant role in energy storage and transfer and required for various physiological process. It also helps in N metabolism, biosynthesis of proteins and nucleic acids. K is required for enzyme activation for biochemical

Table 1. Effect of planting geometry and nutrient levels on plant height, dry matter and leaf area index (LAI) of sweet corn

Treatment	Plant height (cm)			Dry matter (g/m^2)				LAI			
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	60 DAS	Harvest	30 DAS	45 DAS	60 DAS	Harvest
Planting geometry											
60 cm × 25 cm	67.9	123.3	141.7	23.5	183.9	376.9	935.7	1.59	3.39	2.78	2.20
60 cm × 30 cm	70.4	127.8	148.1	21.3	183.2	354.3	820.5	1.47	3.15	2.71	2.14
75 cm × 25 cm	71.1	128.7	149.1	20.7	180.3	350.3	815.3	1.44	3.08	2.69	1.94
75 cm × 30 cm	73.8	134.0	155.4	18.9	158.7	311.5	716.4	1.31	2.76	2.46	1.69
SEm ±	2.1	2.9	2.1	0.7	6.3	10.6	19.5	0.03	0.12	0.06	0.08
CD at 5 %	NS	NS	NS	2.6	22.3	37.5	68.8	0.12	0.41	0.22	0.29
Nutrient levels (kg N:P_2O_5: K_2O/ha)											
120: 60: 40	68.5	124.3	141.7	19.0	164.7	324.1	786.1	1.39	2.98	2.51	1.87
150: 75: 50	71.2	129.7	150.2	20.9	177.6	350.2	822.1	1.46	3.07	2.65	2.02
180: 90: 60	72.6	131.5	153.9	23.4	190.2	370.6	856.3	1.51	3.23	2.80	2.09
SEm ±	2.2	1.0	1.3	0.5	4.6	7.5	17.4	0.03	0.06	0.05	0.06
CD at 5 %	NS	2.9	4.7	1.4	13.9	22.7	52.8	0.09	0.17	0.16	0.18

reaction in plants. More availability of these nutrients in high nutrient dose treatments resulted into higher plant height. These results are in close agreement with the findings of Kurne *et al*. (2017) who noted that high dose of nutrients increased all the growth parameters.

Dry matter accumulation per square metre progressively increased with the advancement of crop age and reached to be the maximum at harvest stage (Table 1). The different planting geometry of sweet corn significantly influenced dry matter production at different growth stages. Dry matter accumulation per square metre decreased with increase in geometry. Planting geometry of 60 cm × 25 cm resulted into significantly higher dry matter accumulation (23.5 g/m^2) at 30 DAS than 75 cm × 25 cm and 75 cm × 30 cm, respectively but was statistically at par with 60 cm × 30 cm. At 45 and 60 DAS, crop sown at 60 cm × 25 cm had significantly more dry matter accumulation (183.9 and 376.9 g/m^2, respectively) than that of 75 cm × 30 cm but was at par with 60 cm × 30 cm and 75 cm × 25 cm. Significantly highest dry matter accumulation (935.7 g/m^2) was recorded at the narrowest geometry of 60 cm × 25 cm. The lowest value was recorded from the widest planting geometry *i.e.* 75 cm × 30 cm at all growth stages. The per cent decrease in dry matter accumulation per square metre under 75 cm × 30 cm was 19.6, 13.7, 17.4 and 23.4 per cent over 60 cm × 25 cm at 30, 45 and 60 DAS and at harvest, respectively. Nutrient levels exerted significant effect on dry matter accumulation per square metre at all growth stages. An increasing trend in dry matter was observed with increase in nutrient dose. At 30 DAS, application of 180: 90: 60 kg N: P_2O_5: K_2O/ha produced significantly highest dry matter accumulation (23.4 g/m^2). Crop fertilized with 180: 90: 60 being at par 150: 75: 50 kg N: P_2O_5: K_2O/ha had significantly higher dry matter accumulation than 120: 60: 40 kg N: P_2O_5: K_2O/ha at 45 and 60 DAS and at harvest (190.2, 370.6 and 856.3 g/m^2, respectively). This treatment attained 23.2, 15.5, 14.3 and 8.9 per cent more value than 120: 60: 40 kg N: P_2O_5: K_2O/ha at 30, 45, and 60 DAS and at harvest stage, respectively. Dry matter accumulation in unit area depends on dry matter accumulation per plant and number of plants in unit area. Though narrow geometry produced less dry matter accumulation per plant than wider geometry but it occupied more numbers of plants per square metre. Therefore, narrow planting geometry produced more dry matter accumulation per square meter compared to wider planting geometry. Similar results were also reported by Arvadiya *et al*. (2012). More dry matter accumulation per square metre under high nutrient dose was the result of more dry matter accumulation per plant under these treatments. This was the reason of more dry matter accumulation per square metre. Similar findings were reported by Jat *et al*. (2009).

LAI increased with advancement of the crop age up to 45 DAS and declined thereafter (Table 1). Widening of planting geometry from 60 cm × 25 cm to 75 cm × 30 cm significantly reduced LAI at all growth stages. At 30 DAS, 60 cm × 25 cm planting geometry being at par with 60 cm × 30 cm recorded significantly more LAI (1.59) than other geometries. Crop grown under 60 cm × 25 cm planting geometry also exhibited significantly more LAI at 45 and 60 DAS and at harvest stage (3.39, 2.78 and 2.20, respectively) than 75 cm × 30 cm but did not differ significantly with other planting geometries. Significantly lower values were found under the widest planting geometry of 75 cm × 30 cm at all crop growth stages. Increase in nutrient supply brought significant enhancement in LAI of sweet corn at all growth stages. Crop fertilized with 180: 90: 60 kg N: P_2O_5: K_2O/ha being at par with 150: 75: 50 kg N: P_2O_5: K_2O/ha recorded significantly higher LAI than 120: 60: 40 kg N: P_2O_5: K_2O/ha at 30, 45 and 60 DAS and harvest stage (1.51, 3.23, 2.80 and 2.09, respectively). The lowest value of LAI (1.39, 2.98, 2.51 and 1.87, respectively) was recorded with minimum NPK dose at all growth stages. Leaf area index is ratio of leaf area per plant to ground area available per plant. Though, wider geometry produced more leaf area per plant than narrow plant geometry but it occupied more ground area per plant. Therefore, wider planting geometry showed low leaf area index compared to narrow geometry. The results are in close agreement with Verma & Tomar (2014). More LAI under higher dose of nutrients might be attributed to the adequate supply of NPK which helped in more leaf production and maintained the leaves active for longer period. Besides, more availability of nutrients in high nutrient level treatments increased leaves size by improving metabolic activities as evident by leaf area per plants. Because of these reasons, more LAI was recorded in high nutrient level treatments. Similar findings were also reported by Bhatt (2012). Data indicated that $\overline{CGR}$ increased with the advancement of crop age (Figure 1). The maximum CGR was observed

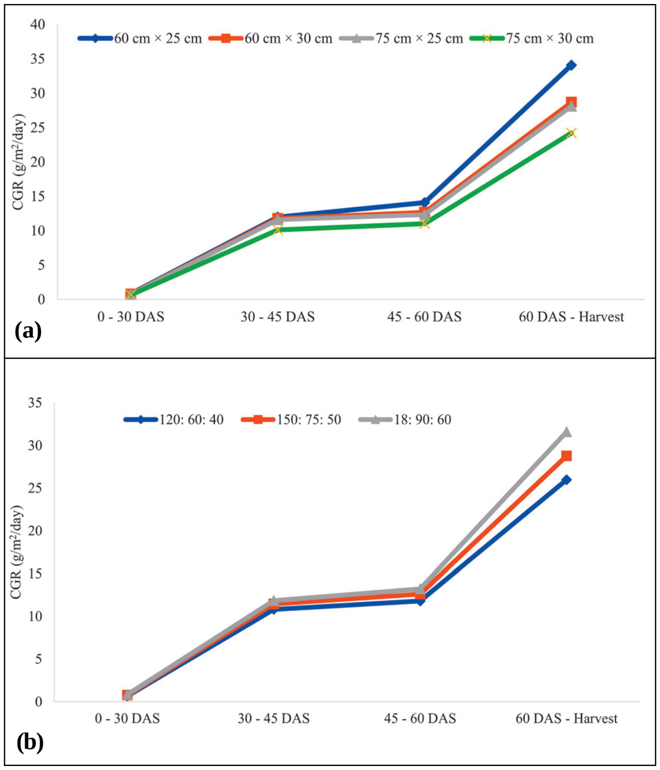

Figure 1. Influence of different planting geometry (a) and nutrient levels (b) on crop growth rate (CGR) of sweet corn at different growth stage intervals

in the narrowest planting geometry of 60 cm × 25 cm at all growth stage intervals. At 0–30 and 30–45 DAS, this geometry was significantly superior (0.84 and 11.98 g/m^2/day, respectively) to 75 cm × 30 cm but remained at par with 60 cm × 30 cm and 75 cm × 25 cm. At 45 - 60 DAS, 60 cm × 25 cm was also significantly higher (14.09 g/m^2/day) than other geometries except 60 cm × 30 cm. At 60 DAS – harvest stage, significantly highest CGR was noticed (34.09 g/m^2/day) at 60 cm × 25 cm planting geometry. Significantly lower $\overline{CGR}$ (0.68, 10.12, 11.02 and 24.22 g/m^2/day, respectively) was recorded in widest planting geometry 75 cm × 30 cm at all growth stages intervals. Increase in nutrient dose from 120: 60: 40 to 180: 90: 60 kg N: P_2O_5: K_2O/ha significantly enhanced $\overline{CGR}$. Crop fertilized with 180: 90: 60 kg N: P_2O_5: K_2O/ha produced significantly more $\overline{CGR}$ (0.84, 11.85, 13.2 and 31.59 g/m^2/day at 0–30 DAS, 30–45 DAS, 45–60 DAS and 60 DAS–harvest stage, respectively) than 120: 60: 40 kg N: P_2O_5: K_2O/ha but remained at par with 150: 75: 50 kg N: P_2O_5: K_2O/ha. Crop growth rate denotes dry matter accumulation in unit land area per day. Dry matter accumulation per unit area is product of dry matter per plant and plant population per unit area. Crop grown under narrow geometries though had less dry matter accumulation per plant compared to that of grown under wider geometries but owing to more plant population led to higher CGR under these treatments. These results are in close agreement with the findings of Bhatt (2012). Crop fertilized with high levels of nutrients accumulated more dry matter per plant. Because of this reason, more CGR was obtained under high nutrient level treatments. These results are in accordance with Singh (2014). RGR exhibited significant variations due to different planting geometries and nutrient levels (Figure 2). An increase in RGR was observed with increase in planting geometries. Difference in RGR in relation to different planting geometries was significant during 45–60 DAS and 60 DAS – harvest stage. During 30–45 DAS, different planting geometry did not affect RGR significantly. However, crop sown under 75 cm × 30 cm geometry recorded numerically maximum RGR (146.9 mg/g/day). Planting geometry of 75 cm × 30 cm exhibited significantly higher RGR (48. 5 and 50.2 mg/g/day at 45–60 DAS and 60 DAS – harvest, respectively) than 60 cm × 25 cm spacing but remained at par with 60 cm × 30 cm and 75 cm × 25 cm. RGR increased with increase

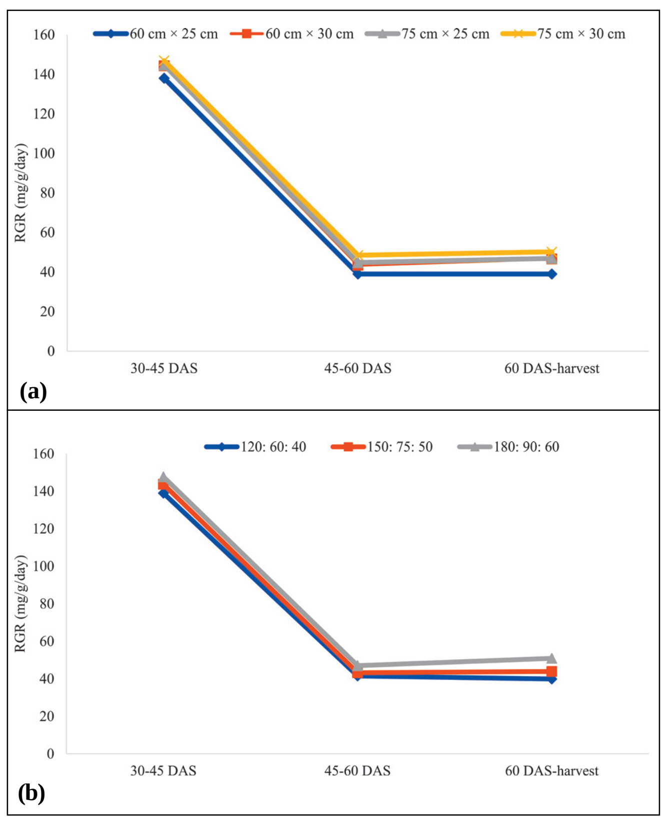

Figure 2. Relative growth rate (RGR) of sweet corn as influenced by different planting geometry (a) and nutrient levels (b) at different growth stage intervals

in nutrient dose and differed significantly at 45–60 DAS and 60 DAS – harvest stage. But at 30–45 DAS, nutrient levels failed to show significant effect in RGR while numerically the highest value (147.7 mg/g/day) was noted in 180: 90: 60 kg N: P_2O_5: K_2O/ha. Application of 180: 90: 60 kg N: P_2O_5: K_2O/ha recorded significantly maximum RGR (47.0 and 50.9 mg/g/day at 45–60 DAS and 60 DAS – harvest stage, respectively) whereas 120: 60: 40 kg N: P_2O_5: K_2O/ha recorded significantly lower values (41.5 and 39.9 mg/g/day, respectively). NAR reached maximum at 60 DAS – harvest stage (Figure 1). NAR decreased significantly with increase in plant geometries at all growth stage interval of crop. During the period of 30–45 DAS, 45–60 DAS and 60 DAS – harvest significantly higher NAR (5.89, 4.57 and 13.82 g/m^2/day, respectively) was observed in 60 cm × 25 cm plant geometry than 75 cm × 25 cm and 75 cm × 30 cm but it was remained at par with 60 cm × 30 cm. Nutrient levels also significantly influenced NAR at all growth stages. Crop nourished with 180: 90: 60 kg N: P_2O_5: K_2O/ha being at par with 150: 75: 50 kg N: P_2O_5: K_2O/ha attained significantly higher NAR at 30–45 DAS, 45–60 DAS and 60 DAS – harvest stage (5.85, 4.67 and 13.77 g/m^2/day, respectively) than 120: 60: 40 kg N: P_2O_5: K_2O/ha. NAR is governed by leaf area and dry matter production per unit leaf area in unit time. Not only leaf area but also dry matter production per plant is important in determining NAR. Both leaf area per plant and dry matter accumulation per plant were obtained significantly higher under the widest plant geometry of 75 cm × 30 cm but due to less number of leaves owing to less number of plants per unit area caused low NAR. On the other hand, the narrowest planting geometry of 60 cm × 25 cm produced less leaf area and dry matter accumulation per plant but due to more number of plants per unit area resulted into more NAR.

Planting geometry did not differ significantly for days taken to 50 per cent tasseling (Table 2). However, the narrowest (60 cm × 25 cm) and the widest (75 cm × 30 cm) geometry have taken minimum and maximum number of days to reach 50 per cent tasseling, respectively. Crop fertilized with different nutrient doses did not exhibit significant variations on days taken to reach 50 per cent tasseling. However, numerically the highest (51.6) and the lowest (51.2) days were noted in 180: 90: 60 and 120: 60: 40 kg N: P_2O_5: K_2O/ha, respectively. Different planting geometries and nutrient levels failed to bring significant difference in days taken to 50 per cent silking (Table 2). However, numerically the earliest silking (55.3 days) was recorded under the narrowest planting geometry with 60 cm × 20 cm.

Among the nutrient doses, days required to reach 50 per cent silking was minimum (55.3) under 120: 60: 40 kg N: P_2O_5: K_2O/ha. Phenology of maize plant is largely determined by genetic characters and not expected to be changed with external factors such as planting geometry and optimum nutrient dose. These results are in close conformation of Singh (2014) who also reported non-significant difference among various nutrient levels in days to reach 50 per cent tasseling and 50 per cent silking.

Table 2. Effect of planting geometry and nutrient levels on stem girth, flowering, quality and green cob yield of sweet corn

Treatment	Stem girth	Days to 50%		TSS	Protein content	Green cob yield
	(cm)	Tasseling	Silking	(degree brix)	(%)	(kg/ha)
Planting geometry						
60 cm × 25 cm	4.8	51.2	55.3	15.2	7.96	13325
60 cm × 30 cm	5.2	51.3	55.5	15.4	8.14	12285
75 cm × 25 cm	5.3	51.3	55.5	15.5	8.38	12096
75 cm × 30 cm	5.6	51.5	55.7	15.6	8.52	11114
SEm ±	0.2	0.7	0.5	0.3	0.16	410
CD at 5 %	0.5	NS	NS	NS	NS	1447
Nutrient levels (kg N: P_2O_5: K_2O/ha)						
120: 60: 40	5.0	51.2	55.3	15.4	7.81	11711
150: 75: 50	5.3	51.3	55.5	15.5	8.31	12217
180: 90: 60	5.4	51.6	55.7	15.5	8.63	12687
SEm ±	0.1	0.5	0.5	0.4	0.14	258
CD at 5 %	0.1	NS	NS	NS	0.43	NS

Stem girth significantly increased with increase in planting geometry from 60 cm × 30 cm to 75 cm × 30 cm (Table 2). Plants grown at wider geometry at 75 cm × 30 cm produced significantly more stem girth (5.6 cm) than that of 60 cm × 25 cm (4.8 cm) but were at par with other geometries. The increase in stem girth under planting geometry at 75 cm × 25 cm was to the tune of 16.7 per cent over 60 cm × 25 cm planting geometry. An increase in nutrient dose resulted into significant increase in stem girth. Application of 180: 90: 60 kg N: P_2O_5: K_2O/ha being at par with 150: 75: 50 kg N: P_2O_5: K_2O/ha exhibited significantly more stem girth (5.4 cm) than 120: 60: 40 kg N: P_2O_5: K_2O/ha (5.0 cm). Under wider planting geometry, plants have less inter plant competition which helped in proper growth and thus more stem girth was obtained in these treatments.

Different planting geometries were failed to bring significant variations in total soluble solids at milk stage (Table 2). However, numerically the maximum (15.6 degree brix) and minimum (15.2 degree brix) TSS were observed in 75 cm × 30 cm and 60 cm × 25 cm, respectively. Different nutrient levels also did not exhibit significant variations in TSS. However, numerically the maximum TSS (15.5 degree brix) was noted in 180: 90: 60 kg N: P_2O_5: K_2O/ha followed by 150: 75: 50 kg N: P_2O_5: K_2O/ha. An increase in protein content in grain from 7.96 to 8.52 per cent was observed with increase in spacing but variations were non-significant (Table 2). Protein content in grain differed significantly due to increase in nutrient levels. Crop fertilized with 180: 90: 60 kg N: P_2O_5: K_2O/ha being at par with 150: 75: 50 kg N: P_2O_5: K_2O/ha showed significantly more protein content (8.63 %) in grain than that of 120: 60: 40 kg N: P_2O_5: K_2O/ha. Protein content depends on nitrogen availability to plants and its assimilation into amino acids. More availability of nitrogen in high nutrient level treatments resulted into its more uptake by crop. High nutrient level also provided more phosphorus and potassium which might help in nitrogen assimilation into protein via energy supply and enzyme activation, respectively. Similar findings were also reported by Khan *et al*. (2018).

Significant difference in green cob yield was noted due to different planting geometries (Table 2). A progressive reduction in green cob yield was recorded with increase in planting geometry. Crop grown at 60 cm × 25 cm spacing being at par with 60 cm × 30 cm and 75 cm × 25 cm produced significantly higher green cob yield (13325 kg/ha) than that of 75 cm × 30 cm. Planting geometry of 75 cm × 30 cm had 16.6 per cent lower cob yield than 60 cm × 25 cm. Increase in nutrient dose from 120: 60: 40 to 180: 90: 60 kg N: P_2O_5: K_2O/ha increased green cob yield but difference was not significant. Crop fertilized with 180: 90: 60 kg N: P_2O_5: K_2O/ha resulted into numerically the maximum green cob yield (12687 kg/ha). Wider planting geometry attained less number of cobs per hectare under this treatment due to low plant population which led to low cob yield. These results corroborate the findings of Kar *et al*. (2006) and Kurne *et al*. (2017).

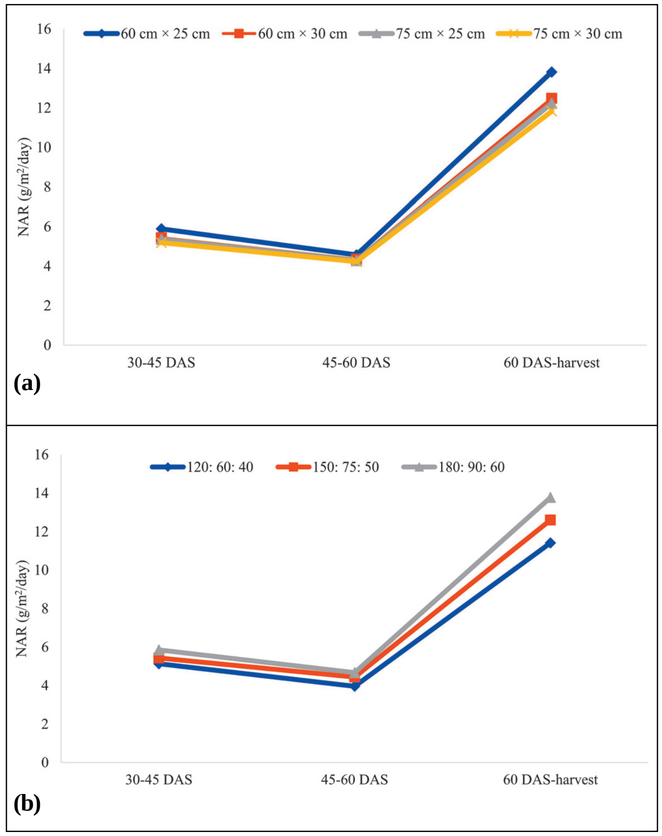

Figure 3. Influence of different planting geometry (a) and nutrient levels (b) on net assimilation rate (NAR) of sweet corn at different growth stage intervals

Conclusion

On the basis of present study it can be inferred that sweet corn in north western plain of India during *kharif* season should be sown at planting geometry 75 cm × 25 cm for its better growth and higher green cob yield. It should be fertilized with 120: 60: 40 kg N: P_2O_5: K_2O/ha.

References

A.O.A.C. (1965). Official methods of analysis of the Association of official Agricultural Chemists. 10th ed. Washinton D.C. pp. 744-745.

Arvadiya, L. K., Raj, V. C., Patel, T. U. & Arvadia, M. K. (2012). Influence of plant population and weed management on weed flora and productivity of sweet corn (*Zea mays*). *Indian Journal of Agronomy*, **57**(2): 162-167.

Bhatt, P. S. (2012). Response of sweet corn hybrid to varying plant densities and nitrogen levels. *African Journal of Agricultural Research*, **7**(46): 6158-6166.

Bhatt, P. S., Yakadri, M. & Sivalakshmi, Y. (2012). Influence of varying plant densities and nitrogen levels on yield attributes and yield of sweet corn. *International Journal of Bio-Resource and Stress Management*, **3**(3): 169-172.

Grazia, J. D., Tittonell, P. A., Germinara, D. & Chiesa, A. (2003). Phosphorus and nitrogen fertilization in sweet corn (*Zea mays* L.var. saccharata Bailey). *Spanish Journal of Agricultural Research*, **1**(2): 103-107.

Jat, V., Tuse, B. P., Jawale, S. M., Shaikh, A. A. & Dalavi, N. D. (2009). Effect of fertilizer levels and dates of sowing on growth and yield of sweet corn (*Zea mays saccharata*). *Journal of Maharashtra Agricultural Universities*, **34**(1): 109-111.

Kar, P. P., Barik, K. C., Mahaptra, P. K., Garnayak, L. M., Rath, B. S., Bastia, D. K. & Khanda, C. M. (2006). Effect of planting geometry and nitrogen on yield, economics and nitrogen uptake of sweet corn (*Zea mays*). *Indian Journal of Agronomy*,**51**(1): 43-45.

Khan, A. A., Hussain, A., Ganai, M. A., Sofi, N. R. & Hussain, S. T. (2018). Yield, nutrient uptake and quality of sweet corn as influenced by transplanting dates and nitrogen levels. *Journal of Pharmacognosy and Phytochemistry*, **7**(2): 3567-3571.

Kurne, R. A., Jadav, Y. R. & Mohite, A. B. (2017). Effect of fertilizer levels and plant densities on growth, productivity and economics of sweet corn in summer season. *Contemporary Research in India*, **7**(3): 2231-2237.

Montgomery, E. G. (1911). Correlation studies in corn. Annual report no. 24, Nebraska Agricultural Experimental Station, Lincoln, NB, USA, pp. 108–159.

Radford, P. J. (1967). Growth analysis formulae, their use and abuse. *Crop Science*, **7**(4): 71-175.

Singh, J. (2014). Studies on integrated nutrient management in sweet corn (*Zea mays saccharata*). Thesis, M.Sc. Agriculture G. B. Pant University of Agriculture and Technology, Pantnagar.

Srikanth, M., Amanullah, M. M., Muthukrishnan, P. & Subramanian, K. S. (2009). Growth and yield of hybrid maize (*Zea mays* L.) as influenced by plant density and fertilizer levels. *International Journal of Agricultural Sciences*, **5**(1): 299-302.

Verma, A. & Tomar, G. S. (2014). Effect of planting geometry and nitrogen levels on growth, green cob yield and economics of sweet corn (*Zea mays saccharata* Sturt). *International Journal of Agricultural Sciences*, **10**(2): 766-769.