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RR Trambadiya
M.Sc. Scholar, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

SK Chhodavadia
Assistant Professor Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

DJ Bhutiya
M.Sc. Scholar, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
RR Trambadiya
M.Sc. Scholar, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Effect of Planting Geometry on Growth, Yield and Yield Attributes of Sweet Corn

RR Trambadiya, SK Chhodavadia and DJ Bhutiya

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Abstract
A field experiment was conducted during the *Rabi* season of the year 2023-24 at the Instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India to study the effect of planting geometry on growth, yield and yield attributes of sweet corn. The experiment was laid out in randomized block design (RBD) with five replications and six treatments with different planting geometries viz., T_1 (30 cm × 10 cm), T_2 (30 cm × 20 cm), T_3 (45 cm × 10 cm), T_4 (45 cm × 20 cm), T_5 (60 cm × 10 cm), T_6 (60 cm × 20 cm). The results of field experiment revealed that the treatment T_6 (60 cm × 20 cm) recorded significantly higher values of growth parameters viz., plant height at 30, 60, 90 DAS and at harvest (cm), dry biomass at emergence, tasseling, silking and maturity (g/plant), plant water content at emergence, tasseling, silking and maturity (%), chlorophyll content at 30, 60 DAS and at harvest (mg/g). While, significantly higher leaf area index was recorded with the treatment T_1 (30 cm × 10 cm). The treatment T_4 (45 cm × 20 cm) recorded significantly higher values of yield attributes and yield viz., number of cobs per plant, cob length (cm), cob girth (cm), number of seeds row per cob, number of seeds per row and fresh cob yield (kg/ha). While, significantly higher green fodder yield (kg/ha) and dry fodder yield (kg/ha) was recorded with the treatment T_1 (30 cm × 10 cm).

Keywords: Rabi Sweet corn, planting geometry, growth, yield

Introduction
Maize (*Zea mays* L.), which is also popularly known as "Corn" has an immense production potential. It is the 3rd most important cereal crop after wheat and rice and is also called "Queen of Cereals". Currently, nearly 1147.7 million tonnes of maize is being produced together by over 170 countries from an area of 193.7 million ha with an average productivity of 5.75 t/ha (Anon., 2020). Maize is classified into seven groups based on the characters of grain. viz., dent corn, flint corn, sweet corn, flour or soft corn, popcorn, baby corn and waxy corn. Among which, sweet corn (*Zea mays* L. var. saccharata) is considered as a vegetable, is a special type of corn with particular characteristics, such as sweet taste, thin pericarp and endosperm with delicate texture and a high nutritional value. It is destined exclusively for human consumption, in fresh form or in processed foods, whereas the fodder can be used for silage after harvest. The higher content of water soluble polysaccharide in the kernel adds texture and quality in addition to sweetness (Khan *et al*., 2011) [7]. Sweet corn is gaining importance popularity both in rural and urban areas of India because of its higher sugar (11-20 %) and low starch content and delicious nature. Crop management practices such as date of sowing and row spacing greatly affect the micro-climate due to their effect on canopy temperature, soil moisture, relative humidity, light interception and rate of water loss etc. (Kaur *et al*., 2019) [6]. The variation in planting dates and plant geometry, row spacing and plant density modifies the microclimate to which the plants are exposed and it is responsible for biomass production and ultimately the yield. Optimum time of sowing is one of the important factors which provide score for better utilization of natural resources by the crop during its growth to take full advantage of favourable weather conditions during growing season. Like date of sowing, spacing also determines to a large extend the yield of crops. It has an important role in giving optimum space to individual plant, which is the main requirement to obtain maximum yield for any crop. Growth and yield of crop tend to get affected by very high plant population, as it may lead to inter and intra-plant competition for

moisture, light, nutrients and space. In case of low plant population, it may not take full advantage of above given factors. So, optimum spacing provides easy access for easy inter-culturing, weeding, application of fertilizer and other aftercare operations. Plant population affects primarily the amount of solar radiation intercepted per plant and the light quality modified by different plant populations may play an important role on early plant growth and portioning responses (Villalobos *et al*., 1994) [16].

Materials and Methods

The experiment was conducted in C-7 plot of Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India (21.5°N latitude and 70.5°E longitude and 60 m above the mean sea level) during *Rabi* season of 2023-24. This site is located in the South Saurashtra Agro-Climatic Zone of Gujarat. The experimental field has an even topography with a gentle slope having good drainage. The soil samples were taken randomly from experimental plot to a depth of 0-15. The soil was clayey in texture, medium in organic carbon (0.60 %), medium in available phosphorus (31.8 kg/ha) and available potash (251.12 kg/ha) with average nitrogen (259 kg/ha). Its pH was alkaline (8.16) and low in soluble salts. The experiment was laid out in randomized block design (RBD) comprising of total six treatments with different planting geometries viz., T_1 (30 cm × 10 cm), T_2 (30 cm × 20 cm), T_3 (45 cm × 10 cm), T_4 (45 cm × 20 cm), T_5 (60 cm × 10 cm), T_6 (60 cm × 20 cm) and each treatment was replicated five times. The recommended dose of nitrogen, phosphorus and potassium (N: P_2O_5: K_2O @ 120:60:00 kg/ha) was applied through urea and DAP. Sweet corn (Sugar-75) seeds were sown with seed rate of 15-20 kg/ha. The first irrigation was given just after sowing and remaining irrigations were given as and when required by the crop. Weed management was done by hand weeding and interculturing at 30 and 45 DAS respectively. The crop was infested by Fall armyworm (*Spodoptera frugiperda*). Which was controlled by spraying insecticide viz; Emamectin Benzoate 5% SG @ 6 g/pump at 45 DAS. Growth parameters *viz.*, plant height at 30, 60, 90 DAS and at harvest(cm), leaf area index at 30, 45, 60, 75 and 90 DAS, dry biomass at emergence, tasseling, silking and maturity (g/plant), plant water content at emergence, tasseling, silking and maturity (%) and chlorophyll content at 30, 60 DAS and at harvest(mg/g) were recorded. Yield and yield attributing characters *viz.*, number of cobs per plant, cob length (cm), cob girth (cm), number of seeds row per cob, number of seeds per row, fresh cob yield (kg/ha), green fodder yield (kg/ha) and dry fodder yield (kg/ha) were recorded at harvesting of the crop.

Results and Discussion

Growth parameters

Plant height (cm)

The data presented in Table 1 revealed that significantly higher plant height at 30 DAS (48.39 cm), at 60 DAS (149 cm), at 90 DAS (181.6 cm) and at harvest (187.1 cm) was found under the treatment T_6 (60 cm × 20 cm). Numerically more plant height under wider planting geometries may be attributed to less competition for water, nutrient, space, solar radiation *etc*, compared to narrow spacing. In such conditions, individual plants have sufficient space to expand their root and shoot systems, enabling efficient resource capture and better physiological functioning. This favourable environment allows plants to attain their full growth potential, resulting in taller plants. Conversely, in narrow plant geometry, overcrowding increases competition, limits resource availability and restricts vertical growth. The results are in close agreement with the findings of Kurne *et al*. (2017) and Lyocks *et al*. (2013) [8, 9].

Table 1: Effect of planting geometry on plant height at 30, 60, 90 DAS and harvest

Treatment (Planting geometry)		Plant height (cm) at			
		30 DAS	60 DAS	90 DAS	Harvest
T_1	30 cm × 10 cm	42.37	125.0	153.0	162.6
T_2	30 cm × 20 cm	43.67	126.6	161.8	169.0
T_3	45 cm × 10 cm	44.62	145.1	171.2	180.4
T_4	45 cm × 20 cm	47.15	146.2	174.4	181.2
T_5	60 cm × 10 cm	48.27	147.1	176.3	182.5
T_6	60 cm × 20 cm	48.39	149.0	181.6	187.1
S.Em.±		1.48	4.40	5.96	5.56
C.D. at 5%		4.36	12.97	17.58	16.39
C.V.%		7.22	7.03	7.85	7.01

Leaf area index

The data presented in Table 2 showed that different treatments significantly influenced the leaf area index. Significantly highest leaf area index at 30 DAS (1.98), at 45 DAS (2.47), at 60 DAS (2.97), at 75 DAS (3.41) and at 90 DAS (3.75) was observed under the treatment T_1 (30 cm × 10 cm). Leaf area index is ratio of leaf area per plant to ground area available per plant. It serves as a crucial indicator of canopy development, light interception efficiency and potential photosynthetic capacity. Plants grown under wider planting geometry produced a greater individual leaf area per plant compared to those under narrow geometry. However, since the ground area occupied per plant was also higher in wider spacing, the calculated LAI was lower. Conversely, narrow planting geometry, despite having relatively smaller leaf area per plant, recorded higher LAI values due to the reduced ground area per plant. The results are in close agreement with Bhatt (2012) and Verma and Tomar (2014) [5, 15].

Dry biomass (g/plant)

The data revealed that significantly highest dry biomass at emergence (2.93 g/plant), at tasseling (76.85 g/plant), at silking (91.10 g/plant) and at maturity (151.3 g/plant) was observed under the treatment T_6 (60 cm × 20 cm). Dry matter production is outcome of physiological process governed by photosynthetic rate, photosynthesizing area and photosynthate accumulation. Photosynthetic rate is influenced by utilization of solar radiation. In wider geometry, plants have better growth as evident by leaf area per plant, plant height and stem girth. It helped in increasing photosynthesizing area. Besides, better air circulation and adequate interception of solar radiation particularly by lower leaves in wider spaced plants might helped in more photosynthesis. These were probable reasons for more dry matter accumulation per plant under wider geometry. The results are in close agreement with the findings of Arvadiya *et al*. (2012) and Massey and Gaur (2013) and Aravinth *et al*. (2011) and Suryavanshi *et al*. (2009) [4, 11, 3, 14].

Table 2: Effect of planting geometry on leaf area index (LAI)at 30, 45, 60, 75 and 90 DAS

Treatment (Planting geometry)		Leaf area index (LAI) at				
		30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
T_1	30 cm × 10 cm	1.98	2.47	2.97	3.41	3.75
T_2	30 cm × 20 cm	1.94	2.42	2.95	3.39	3.73
T_3	45 cm × 10 cm	1.90	2.38	2.88	3.36	3.70
T_4	45 cm × 20 cm	1.80	2.23	2.72	3.34	3.48
T_5	60 cm × 10 cm	1.73	2.19	2.68	3.16	3.45
T_6	60 cm × 20 cm	1.69	2.15	2.66	3.13	3.33
S.Em.±		0.06	0.08	0.08	0.08	0.10
C.D. at 5%		0.18	0.23	0.24	0.22	0.30
C.V.%		7.28	7.41	6.36	5.09	6.36

Table 3: Effect of planting geometry on dry biomass at emergence, tasseling, silking and maturity

Treatment (Planting geometry)		Dry biomass (g/plant) at			
		Emergence	Tasseling	Silking	Maturity
T_1	30 cm × 10 cm	1.56	56.67	75.94	127.6
T_2	30 cm × 20 cm	2.00	62.43	77.31	130.5
T_3	45 cm × 10 cm	2.21	65.64	79.21	136.0
T_4	45 cm × 20 cm	2.47	68.82	80.61	141.4
T_5	60 cm × 10 cm	2.72	72.23	84.70	145.3
T_6	60 cm × 20 cm	2.93	76.85	91.10	151.3
S.Em.±		0.08	2.23	2.69	4.38
C.D. at 5%		0.23	6.59	7.92	12.93
C.V.%		7.64	7.45	7.37	7.06

Plant water content (%)

According to Table 4 plant water content at emergence, tasseling, silking and maturity was significantly influenced by planting geometry. Significantly highest plant water content at emergence (92.73 %), at tasseling (70.80 %), at silking (63.78 %) and at maturity (57.06 %) was observed under the treatment T_6 (60 cm × 20 cm). Different spacing arrangements influence canopy structure, light interception, soil evaporation and ultimately plant water uptake and retention. Wider spacing often allows better root development and reduces competition for water, potentially increasing leaf relative water content (RWC). It also helps in maintaining soil moisture for a longer duration by minimizing inter plant competition. In contrast, narrow spacing tends to create a denser canopy, which may reduce evaporation from the soil surface but often leads to rapid depletion of available soil moisture due to higher plant density and intense competition for water and nutrients, thereby affecting physiological functions and crop yield. The results are in close agreement with the findings of Ahiablame and Ezenwaji (2016) [1].

Table 4: Effect of planting geometry on plant water content at emergence, tasseling, silking and maturity

Treatment (Planting geometry)		Plant water content (%) at			
		Emergence	Tasseling	Silking	Maturity
T_1	30 cm × 10 cm	81.45	60.38	54.76	48.64
T_2	30 cm × 20 cm	83.46	63.98	56.38	50.56
T_3	45 cm × 10 cm	86.25	65.80	57.06	52.50
T_4	45 cm × 20 cm	87.04	65.88	57.82	54.76
T_5	60 cm × 10 cm	88.68	67.76	60.38	56.38
T_6	60 cm × 20 cm	92.73	70.80	63.78	57.06
S.Em.±		2.36	2.08	1.85	1.79
C.D. at 5%		6.97	6.12	5.45	5.28
C.V.%		6.10	7.06	7.08	7.51

Chlorophyll content (mg/g)

The results showed in Table 5 revealed that different planting geometry significantly influenced the chlorophyll content. Significantly highest chlorophyll content at 30 DAS (0.602 mg/g), at 60 DAS (0.804 mg/g) and at harvest (0.904 mg/g) was recorded with T_6 (60 cm × 20 cm). Plant spacing significantly influences the microclimate around the crop canopy, which in turn affects photosynthetic activity and chlorophyll synthesis in maize. Wider spacing improves light penetration and air circulation, leading to better leaf development and often higher chlorophyll content due to reduced shading and competition for light and nutrients. In contrast, narrow spacing can cause mutual shading and stress, resulting in lower chlorophyll accumulation. These results are in close proximity with findings reported by Mali and Singh (1989) [10].

Table 5: Effect of planting geometry chlorophyll content at 30, 60 DAS and at harvest

Treatment (Planting geometry)		Chlorophyll content (mg/g) at		
		30 DAS	60 DAS	Harvest
T_1	30 cm × 10 cm	0.536	0.736	0.830
T_2	30 cm × 20 cm	0.545	0.744	0.849
T_3	45 cm × 10 cm	0.582	0.789	0.859
T_4	45 cm × 20 cm	0.592	0.795	0.864
T_5	60 cm × 10 cm	0.595	0.796	0.895
T_6	60 cm × 20 cm	0.602	0.804	0.904
S.Em.±		0.02	0.02	0.02
C.D. at 5%		0.05	0.05	0.05
C.V.%		6.59	5.11	4.30

Yield and yield attributes

Number of cobs per plant

The data presented in Table 6 showed the numbers of cobs per plant were influenced significantly due to different treatments. The maximum number of cobs per plant (1.53) were recorded with T_4 (45 cm × 20 cm). Treatment T_4 (45 cm × 20 cm) gave higher result in case number of cobs per plant. This treatment was closely followed by T_6 (60 cm × 20 cm). Wider plant spacing produced higher value of yield parameter as compared to narrow spacing. This can be attributed to the fact that reduced competition for essential growth resources such as nutrients, water and sunlight under wider spacing conditions promotes more vigorous vegetative and reproductive growth. The improved availability of light penetration within the canopy enhances photosynthetic efficiency, while better root proliferation increases the plant's capacity for nutrient and moisture uptake. These favorable conditions contribute to superior yield attributing characters under wider spacing. These results are in close proximity with findings reported by Mathukia *et al*. (2014) [12].

Cob length (cm)

Among the different treatments significantly highest length of cob (18.09 cm) was recorded with T_4 (45 cm × 20 cm). Plants grown at wider spacing might have been able to efficiently utilize the available natural resources. Furthermore, these plants showed a heightened responsiveness to external inputs, which was expressed generously in their growth and development and in turn, cob length was increased. On the other hand, plants grown at narrow spacing experienced intense competition for resources due to the close proximity of neighboring plants. This stiff competition seemed to limit their ability to fully

exploit the natural resources and as a result their response to externally applied inputs was comparatively restricted. These results are in close proximity with findings reported by Mathukia *et al*. (2014) and Narayanaswamy and Siddaraju (2011) [12, 13].

Cob girth (cm)

According to Table 6, the cob girth was significantly influenced by treatment. Significantly highest cob girth (15.61 cm) was recorded with T_4 (45 cm × 20 cm). Treatment T_4 (45 cm × 20 cm) gave higher result in case number of cob girth. This treatment was closely followed by T6 (60 cm × 20 cm). Plants grown at wider spacing might have been able to efficiently utilize the available natural resources. On the other hand, plants grown at narrow spacing experienced intense competition for resources due to the close proximity of neighboring plants. The lesser competition for nutrients and sunlight by plants under wider spacing could have improved yield attributing characters. These results are in close proximity with findings reported by Mathukia *et al*. (2014) [12].

Table 6: Effect of planting geometry on number of cobs per plant, cob length and cob girth

Treatment (Planting geometry)		Number of cobs per plant	Cob length (cm)	Cob girth (cm)
T_1	30 cm × 10 cm	1.21	14.64	12.84
T_2	30 cm × 20 cm	1.25	16.03	13.66
T_3	45 cm × 10 cm	1.34	17.32	14.47
T_4	45 cm × 20 cm	1.53	18.09	15.61
T_5	60 cm × 10 cm	1.43	17.98	14.48
T_6	60 cm × 20 cm	1.45	17.69	15.29
S.Em.±		0.05	0.64	0.46
C.D. at 5%		0.16	1.90	1.35
C.V.%		8.69	8.50	7.12

Number of seeds row per cob

Different treatments did appreciable influence on number of seeds row per cob. Among the different treatments significantly more number of seeds rows per cob (19.01) was recorded with T_4 (45 cm × 20 cm). Wider spacing allowed plants to utilize resources more efficiently and respond better to external inputs, which in turn enhanced their growth and improved yield attributing characters. Number of seeds row per cob is strongly related to cob girth. Therefore, higher cob girth under wider plant spacing may be responded to higher number of seeds row per cob in these treatments. Similar findings were also reported by Kurne *et al*. (2017) [8].

Number of seeds per row

The data presented in Table 7 showed that significantly the maximum number of seeds per row 40.30 was recorded under the treatment T_4 (45 cm × 20 cm). Plants grown at wider spacing might have been able to efficiently utilize the available natural resources. Furthermore, these plants showed a heightened responsiveness to external inputs, which was expressed generously in their growth and development and in turn, cob length was increased. Number of seeds per row is strongly related to cob length. Therefore, higher cob length under wider plant spacing may be responded to higher number of seeds row per cob in these treatments. Similar findings were also reported by Kurne *et al*. (2017) [8].

Table 7: Effect of planting geometry on number of seeds row per cob, number of seeds per row and fresh cob yield

Treatment (Planting geometry)		Number of seeds row per cob	Number of seeds per row	Fresh cob yield (kg/ha)
T_1	30 cm × 10 cm	14.54	32.77	7038
T_2	30 cm × 20 cm	15.87	35.91	7043
T_3	45 cm × 10 cm	16.96	36.00	7780
T_4	45 cm × 20 cm	19.01	40.30	8129
T_5	60 cm × 10 cm	17.04	37.87	7835
T_6	60 cm × 20 cm	18.17	39.37	7924
S.Em.±		0.54	1.22	256
C.D. at 5%		1.59	3.59	756
C.V.%		7.12	7.34	7.52

Fresh cob yield (kg/ha)

An evaluation of data presented in Table 7 indicated that variations in fresh cob yield of *Rabi* sweet corn to different treatments were found significant. Among the different treatments, T_4 (45 cm × 20 cm) exhibited significantly higher fresh cob yield (8129 kg/ha). Treatment T_4 (45 cm × 20 cm) gave higher result in case of fresh cob yield. This treatment was closely followed by T_6 (60 cm × 20 cm). Wider plant spacing resulted in higher yield compared to narrow spacing. This can be attributed to reduced competition for essential resources such as nutrients, water and sunlight, which promotes better vegetative and reproductive growth. Improved light penetration within the canopy enhances photosynthetic efficiency, while greater root proliferation increases the uptake of nutrients and moisture. These favorable conditions collectively contribute to higher yield under wider spacing. Similar findings were also reported by and Mathukia *et al*. (2014) [12].

Green fodder yield (kg/ha)

Different treatments did appreciable influence on green fodder yield. Among the different treatments significantly higher green fodder yield (30089 kg/ha) was recorded with T_1 (30 cm × 10 cm). Green fodder yield is decided by number of plants/ha and dry matter accumulation per plant. Narrow planting geometry has more number of plants/ha which resulted into higher green fodder yield. Under wider geometries, crop exhibited more dry matter accumulation per plant but less number of plants/ha led to low green fodder yield per hectare. These results corroborate the findings of Bhatt (2012) [5] who also found higher biomass yield of sweet corn in narrow planting geometry.

Table 8: Effect of planting geometry on green fodder yield and dry fodder yield

Treatment (Planting geometry)		Green fodder yield (kg/ha)	Dry fodder yield (kg/ha)
T_1	30 cm × 10 cm	30089	14811
T_2	30 cm × 20 cm	28231	13741
T_3	45 cm × 10 cm	25648	11697
T_4	45 cm × 20 cm	24800	11003
T_5	60 cm × 10 cm	23110	10839
T_6	60 cm × 20 cm	22312	9850
S.Em.±		1026	377
C.D. at 5%		3026	1111
C.V.%		8.93	7.02

Dry fodder yield (kg/ha)

Significantly highest dry fodder yield (14811 kg/ha) was recorded with T_1 (30 cm × 10 cm). Narrow planting

geometry accommodated a higher number of plants per hectare, which consequently resulted in a greater dry fodder yield per unit area. In contrast, wider geometries supported fewer plants per hectare, leading to comparatively lower dry fodder yield. The increased plant population under narrow spacing ensured more biomass accumulation per unit area despite higher competition for growth resources. Similar findings were also reported by Bhatt (2012) [5].

Conclusion

Based on the results of one year experimentation, it can be concluded that sweet corn sown at plant spacing 45 cm × 20 cm recorded highest yield and yield attributes as compared to other plant spacings. This was closely followed by plant spacing 60 cm × 20 cm. Prevalence of distinct microclimatic condition might have led to higher fresh cob yield in wider plant spacing as compare to narrow plant spacing.

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