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Phenology, Growth and Quality of Sweet Corn (*Zea mays saccharata* L.) as Influenced by Sowing Dates and Plant Spacing

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The field experiment entitled "Phenology, growth and quality of sweet corn (*Zea mays saccharata* L.) As influenced by sowing dates and plant spacing" was carried at SKUAST-K, Shalimar during *kharif* season 2014. The cultivar *Misthi* of Sweet corn was chosen for the study. The experiment comprised of two factors with four sowing dates *viz*. 24th May (D_1), 02nd June (D_2), 11th June (D_3) and 19th June (D_4) as main-plot treatments and three plant spacing *viz*. 60 cm x 20 cm(S_1), 70 cm x 20 cm (S_2)and 80 cm x 20 cm (S_3) as sub-plot treatments replicated thrice. Results of the experiment revealed that 24th May (D_1) sowing recorded significantly highest plant height and number of functional leaves as compared to other sowing dates. More number of days was taken by sweet corn sown on 24th May (D_1) and accumulated more heat compared to delay sowing. Among plant spacing, plant height which was significantly superior with 80 cm x 20 cm than 70 cm x 20 cm and 60 cm x 20 cm and more number of days was taken by sweet corn at plant spacing of 80 cm x 20 cm and accumulated more heat units compared to closer spacing. And non-significant effect of sowing dates and plant spacing was observed on quality of sweat corn.

Introduction

In India, maize is one of the top four cereals occupying an area of 7.89 mha with a production of 15.09 mt and productivity of 1904 kg ha^{-1}. Andhra Pradesh is one of the major maize producing states with a production of 4.15 mt from 0.85 million ha averaging 4073 kg ha^{-1} (CMIE, 2010). Approximately 25% of the total corn produced is being used for human consumption either in fresh or processed form. Sweet corn is emerging as one of the important enterprises projecting diversified and value added uses of maize. Steam boiled green cobs of sweet corn has gained immense popularity among the urbanites as a favourite dish, resulting in premium price for growers. Diversification and value addition of sweet corn are currently contemplated in view of rapid growth in the food processing industry.

Continuous and growing demand for fresh sweet corn cobs has led to cultivation of sweet corn round the year varied soil conditions and management practices. In Andhra Pradesh, lower yield levels of maize in general and sweet corn in particular could be attributed to sub optimal population stand, inappropriate fertilizer dose, and lack of suitable cultivars with good seed and processing qualities.

Presently greater emphasis is being given on enhancing the productivity and quality of sweet corn through suitable agro techniques with an intention to augment the net profits to farming community dwelling in the vicinity of big cities and metropolis (Shanti *et al.*, 2012).

Exploring possible combinations of sowing dates and plant spacing that would enable the urban farmer to efficiently utilize scarce resources and reduce the cost of cultivation is worth attempting.

Such a backdrop necessarily calls for certain reoriented research efforts commensurate with modern needs with reference to sweet corn. Therefore, the present investigation was planned to understand the ultimate phenology, growth and quality of sweat corn (*Zea mays saccharata* l.) as influenced by sowing dates and plant spacing.

Materials and Methods

The field experiment entitled "phenology, growth and quality of sweet corn (*Zea mays saccharata* L.) As influenced by sowing dates and plant spacing" was carried at SKUAST-K, Shalimar during *kharif* season 2014. Sweet corn *cv. Misthi* was chosen for the study.

The experiment comprised of two factors with four sowing dates *viz*. 24th May (D_1), 02nd June (D_2), 11th June (D_3) and 19th June (D_4) as main-plot treatments and three plant spacing *viz*. 60 cm x 20 cm(S_1), 70 cm x 20 cm (S_2)and 80 cm x 20 cm (S_3) as sub-plot treatments replicated thrice.

Number of days taken by sweet corn crop to reach various phenological stages till completion of picking (harvest) was observed throughout crop growth period and Growing Degree Days (GDD) was calculated from sowing date to completion of harvest according to the formula:

$$GDD = \frac{\text{Max. Temperature} + \text{Min. Temperature}}{2} - \text{Base temp.}$$

Where base temperature is 10^{o}C

Plant height

Plant height of five tagged plants in penultimate rows of each plot at 10 days interval DAS was recorded and averaged to plant height in centimeters. The plant height was taken from the base of soil surface to fully opened top leaf.

Functional leaves

Total number of functional leaves (green leaves) of 10 randomly marked plants in each plot were counted at harvest, averaged and recorded as number of functional leaves plant^{-1}.

Quality parameters

Green cob samples of 50 g each collected from picked lot of each plot and 1 kg fodder sample collected from harvest lot of each plot were sun dried and then oven dried at 60-65^{o}C for 36-48 hours to a constant weight.

The dry weight of samples was recorded in grams. The samples were ground and subsequently used for chemical analysis.

Protein content (%)

Protein content of cob and fodder was determined by multiplying respective nitrogen content with a factor 6.25.

TSS of cob and fodder

The hand refractometer of range (0-32) ^{o} Brix (Erma Make Japan) was used to determine total soluble solids of fresh sweet corn samples. The values were corrected at 20^{o}C (Ranganna, 1986).

Ascorbic acid (mg)

Vitamin C was estimated by the method as described by Ranganna (1986) using 2, 6 dichlorophenol indophenol as dye.

Dye factor was first calculated by titrating 5 ml standard ascorbic acid plus 5 ml (3%) metaphosphoric acid against 2,6, dichlorophenol indophenol till pink colour appeared and volume used noted.

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

The vitamin C of the sample was estimated by taking 10 ml of sample, volume made upto 100 ml with 3% metaphosphoric acid and filtered.

Then aliquot of 10 ml was taken in titration flask and titrated against dye 2, 6 dichlorophenol indophenol till light pink colour appeared (which should persist for 15 seconds).

Samples preserved by KMS (potassium metabisulphite) were analyzed after eliminating the interface of sulphur dioxide by using formaldehyde condensation procedure. Vitamin C was calculated using equation as:

Ascorbic acid (mg/100 g) =

$$\frac{\text{Titre value} \times \text{Dye factor} \times \text{Vol. made up}}{\text{ml of filtrate taken for estimation} \times \text{wt. of sample}} \times 100$$

Retinol (mg)

Vitamin A is estimated by the colorimetric method using antimony trichloride which reacts with vitamin A in chloroform solution a blue colour develops.

If the solution containing vitamin for analysis is freed from saponifiable material and an appropriate color filter is used on photoelectric colorimeter this reaction appears fairly reliable for vitamin A. The vitamin A is estimated by the colorimetric readings by the use of a standard curve.

Vitamin A/g sample = final volume/sample weight

Results and Discussion

The field experiment was conducted during year 2014 at the Experimental Farm of the Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. The detailed description of treatment effects on various growth characters of sweet corn was studied.

Delayed sowing decreased the number of days to reach various phenological stages of sweet corn. This can be attributed to the fact that lower temperature and accumulation of more heat units with early sowing resulted in delayed germination and emergence and more number of days to reach silking, tasseling and harvesting (Tables 1 and 2). The results are in conformity with Kim *et al.,* (1999), Khan *et al.,* (2002) and Williams (2008). Plant spacing of 80 cm × 20 cm (S_3) took more days for tasseling, silking and harvest completion than other spacings (Table 1). The probable reason may be that plants under narrow spacing had increased competition for sunlight, nutrients and moisture which delayed its shift to reproductive phase. These effects are reflected in the length of harvesting period, as harvest period decreased with decrease in spacing. Similar findings were reported by Sukanya *et al.,* (1999).

There was significant and consistent increase in plant height of sweet corn till 65 DAS (Table 3). Delayed sowing resulted in decrease in the rate of increase in plant height. The reason for the fact is that with delayed sowing the temperature was high which was conducive for the increase in the growth rate.

Earlier sowing resulted in taller plants compared to delay sowing because of the fact that the early sown crop got longer time period to utilize available growth resources. Similar results were reported by Imholte and Carte (1987) and Morin and Dormency (1993). The results are in agreement with observation of Moosavi *et al.,* (2012) who reported that there is a significant decline in the plant height with the delay in sowing time of corn, this significant decrease in plant height and stem traits following the delay in sowing can be associated with higher temperatures that the plants at third and fourth sowing dates experienced, which limited their growing period and assimilate building because of the early maturity of plants. There was significant and consistent increase in plant height of sweet corn till 65 DAS (Table 3). Plant height was higher under wider spacing compared to closer spacing. This may be due to the reason that under closer spacing regimes, inter plant competition for light, moisture, nutrients and other environmental sources are more and hence decreased photosynthesis, assimilates production and its partitioning, that finally resulted in reduction of plant height. Similar results were reported by Peykarestan and Seify (2012). Number of functional leaves per plant decreased with delayed sowing (Table 4). This can be attributed to the fact that delayed sowing results in the reduction of photoperiod which ultimately results in the decrease in the number of leaves. The results are confirmed by Beiragi *et al.,* (2011) who reported that the total number of leaves decreased with delayed sowing. Number of functional leaves plant^{-1} was higher with wider spacing compared to narrow spacing (Table 4). The wider spacing may have allowed better penetration of sunlight in the leaf canopy resulting in delayed leaf senescence percentage. Thakur *et al.,* (1997) reported similar findings.

The results of the experiment revealed that quality parameters viz. protein content, total soluble sugars, vitamin C and vitamin A of sweet corn were not influenced by sowing dates and plant spacing (Table 5). However, higher values of these parameters were recorded by early sowing of sweet corn which might be due to improved growth and higher temperature with delayed sowing which resulted in less assimilation of synthates. These results are in confirmation with Darby and Laver (2002) and Mokhtarpour *et al.,* (2013) reported that delayed sowing resulted in lower quality of sweet corn.

However, the highest value of these parameters were recorded at wider plant spacing which might be due to lower plant population per unit area, vigorous growth, more nutrient plant^{-1} without competition that results in higher concentration of assimilates in plant. Similar findings were reported by Verma and Joshi (1998).

Days to reach various phenological stages reduced with delayed sowing of sweet corn from 24th May (D_1) to 19th June (D_4). Plant spacing of 80 × 20 cm (S_3) recorded significantly more days to reach tasseling, silking, and harvesting respectively in comparison to 60 × 20 cm (S_1) plant spacing.

Early sowing 24th May (D_1) accumulated more heat to reach the harvesting stage than delayed sowing 19th June (D_4). Plant spacing of 80 × 20 cm (S_3) accumulated more heat units to reach harvesting stage than 60 × 20 cm (S_1) spacing.

Table.1 Days taken to reach different phenological stages of sweet corn (*Zea mays saccharata* L.) as influenced by sowing dates and plant spacing

TREATMENTS		Growth stages					
		Germination	Emergence	Knee High	Tasseling	Silking	Harvesting
MAIN PLOT SOWING DATE							
24th MAY	(D_1)	7	13	35	65	71	96
2nd JUNE	(D_2)	7	12	34	65	71	96
11th JUNE	(D_3)	5	10	34	63	68	94
19th JUNE	(D_4)	5	10	33	63	67	93
SUB PLOT PLANT SPACING							
60 × 20 (cm)	(S_1)	6	12	33	64	69	94
70 × 20 (cm)	(S_2)	6	12	34	64	69	95
80 × 20 (cm)	(S_3)	6	12	34	65	70	95

Table.2 GDD (Growing degree days) of sweet corn (*Zea mays saccharata* L.) as influenced by sowing dates and plant spacing

TREATMENTS		Growth stages						
		Germination	Emergence	Knee High	Tasseling	Silking	Harvesting	Total GDD
MAIN PLOT SOWING DATE								
24th MAY	(D_1)	(52.55)	(49.80)	(234.75)	(398.60)	(91.60)	(306.60)	1125.35
2nd JUNE	(D_2)	(66.05)	(48.20)	(244.80)	(440.50)	(82.25)	(242.20)	1124.00
11th JUNE	(D_3)	(51.50)	(54.75)	(286.15)	(417.65)	(58.50)	(214.25)	1082.80
19th JUNE	(D_4)	(50.75)	(57.05)	(286.55)	(422.45)	(44.50)	(195.15)	1056.45
SUB PLOT PLANT SPACING								
60 × 20 (cm)	(S_1)	(55.66)	(59.96)	(240.76)	(431.00)	(63.96)	(241.55)	1092.89
70 × 20 (cm)	(S_2)	(55.66)	(59.96)	(240.76)	(431.00)	(63.96)	(238.88)	1089.86
80 × 20 (cm)	(S_3)	(55.66)	(59.96)	(254.21)	(432.12)	(61.02)	(237.50)	1100.47

Table.3 Plant height (cm) of sweet corn (*Zea mays saccharata* L.) as influenced by sowing dates and plant spacing at different growth stages

TREATMENTS		Growth stages								
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS	65 DAS	75 DAS	85 DAS	95 DAS
MAIN PLOT SOWING DATE										
24^{th} MAY	(D_1)	14.00	24.63	54.95	100.11	127.44	161.26	205.35	210.88	214.66
2^{nd} JUNE	(D_2)	14.11	24.72	55.14	100.11	131.55	167.97	204.22	207.55	211.77
11^{th} JUNE	(D_3)	19.00	27.10	58.01	112.44	149.55	182.20	193.44	202.55	205.55
19^{th} JUNE	(D_4)	19.00	28.44	61.14	120.33	154.11	187.67	193.26	199.00	203.77
SEm ±		**1.17**	**0.72**	**0.58**	**2.07**	**2.10**	**0.76**	**0.34**	**2.06**	**1.58**
C.D (P≤0.05)		**4.04**	**2.49**	**2.02**	**7.17**	**7.26**	**2.63**	**1.19**	**7.12**	**5.46**
SUB PLOT PLANT SPACING										
60 × 20 (cm)	(S_1)	16.66	28.61	58.71	114.08	145.33	178.95	192.25	201.50	205.58
70 × 20 (cm)	(S_2)	16.75	25.60	57.45	108.66	140.58	174.45	199.64	204.00	207.83
80 × 20 (cm)	(S_3)	16.16	24.50	55.76	102.42	136.08	170.93	205.45	209.50	211.33
SEm ±		**0.19**	**0.71**	**0.55**	**2.17**	**2.17**	**0.75**	**0.33**	**1.25**	**0.87**
C.D (P≤0.05)		**NS**	**2.13**	**1.65**	**6.50**	**6.53**	**2.26**	**0.99**	**3.77**	**2.62**

Table.4 Number of functional leaves of sweet corn (*Zea mays saccharata* L.) as influenced by sowing dates and plant spacing at different phenological stages

Treatments		Phenological stages			
		Knee high	Tasseling	Silking	Harvest
Main plot Sowing dates					
24^{th} MAY	(D_1)	9.40	14.26	15.14	13.66
2^{nd} JUNE	(D_2)	9.10	14.16	14.78	13.35
11^{th} JUNE	(D_3)	8.55	12.85	14.21	12.35
19^{th} JUNE	(D_4)	8.20	12.85	13.98	12.28
SEm ±		0.16	0.35	0.14	0.19
C.D (P≤0.05)		0.55	1.22	0.50	0.66
SUB PLOT PLANT SPACING					
60 × 20 (cm)	(S_1)	8.30	12.80	14.30	12.78
70 × 20 (cm)	(S_2)	8.92	13.54	14.43	12.84
80 × 20 (cm)	(S_3)	9.31	14.26	14.86	13.27
SEm ±		0.26	0.24	0.13	0.11
C.D (P≤0.05)		0.77	0.74	0.40	0.34

Table.5 Effect of sowing dates and plant spacing on protein content (%) in cob and fodder, total soluble sugars in cob and fodder, Vitamin C and vitamin A of sweet corn

TREATMENTS	**Protein content (%)**		**TSS**		**Vitamin C (mg/100 g)**	**Vitamin A (mg/100 g)**
	Cob	**Fodder**	**Cob**	**Fodder**	**Cob**	**Cob**
MAIN PLOT SOWING DATE						
24th MAY (D1)	9.80	9.00	13.00	10.00	9.76	0.176
2nd JUNE (D2)	9.78	8.96	12.66	9.98	9.76	0.160
11th JUNE (D3)	9.52	8.71	11.97	9.94	9.75	0.150
19th JUNE (D4)	9.32	8.64	11.97	9.94	9.74	0.146
SEm ±	**0.30**	**0.18**	**0.51**	**0.03**	**0.010**	**0.013**
C.D (P≤0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
SUB PLOT PLANT SPACING						
60 × 20 (cm) (S1)	9.33	8.76	12.40	9.95	9.76	0.168
70 × 20 (cm) (S2)	9.34	8.81	12.40	9.96	9.75	0.158
80 × 20 (cm) (S3)	9.36	8.90	12.41	9.99	9.75	0.156
SEm ±	**0.20**	**0.10**	**0.02**	**0.02**	**0.01**	**0.02**
C.D (P≤0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Delayed sowing 19th June (D_4) significantly decreased plant height and number of functional leaves, whereas significantly higher values of these attributes were recorded with early sowing 24th May (D_1) compared to delayed sowing 19th June (D_4). Plant spacing of 80 × 20 cm (S_3) recorded highest plant height than 60 × 20 cm (S_1) spacing. Lowest plant height was recorded with 60 × 20 cm (S_1) spacing. Plant spacing of 80 × 20 cm (S_3) recorded higher number of functional leaves than narrow plant densities. Lower numbers of functional leaves were recorded with 60 × 20 cm (S_1) spacing.

Protein content, total soluble sugars, vitamin C and vitamin A were not significantly affected by sowing dates. However, the uptake of nutrients in grain and fodder showed a significant improvement with early sowing dates24th May (D_1). No significant effect was observed with plant spacing on protein content, total soluble sugars, vitamin C and vitamin A. At plant spacing of 80 x 20 cm (S_3) recorded higher values than 60 × 20 cm (S_1) spacing.

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