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Studies of growth, yield attributes and yield of *rabi* maize (*Zea mays* L.) genotypes

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Abstract
A field experiment was conducted during Rabi season of 2019-20 at College of Agriculture, Teerthanker Mahaveer University (Moradabad) Uttar Pradesh. The experiment comprised of 18 maize genotypes and layout in randomized block design with three replications. Data were recorded on plant height, leaf area, dry matter accumulation, yield attributes and yield per plant. The results showed significant variations in maize genotypes in all the growth and growth indices. Genotype sweet corn-1 (172 cm) produced significantly tallest plant and more number of leaves. Maximum leaf area was found in sweet corn-1 (2790.63 cm^2) and lowest in CIMMYT-80 (2050.64 cm^2). The highest dry matter accumulation was recorded at harvest stage and was found highest in Sweet corn-1(299.9 g/plant) which was significantly at par with DMR-782 (298.4 g/plant), sweet corn-7 (286.7 g/plant), G 9108 (285.4 g/plant) and pop corn-1 (281.58 g/plant) and it was lowest in CIMMYT-80 (250.75 g/plant). Maximum number (2.5 cob/plant), more number of grains per cob (208.90 grains/cob) were noted by maize genotype Sweet corn-1 Sweet corn-1 while genotype CIMMYT-80 recorded less number of cob/plant and number of grains per cob. The maximum yield was obtained in sweet corn-1 (52.70 g/plant) followed by DMR-782 (51.90 g/plant) and lowest yield was recorded in CIMMYT-80 (47.40 g/plant). Sweet corn-1 were boldest among genotypes tested while minimum seed weight was recorded in CIMMYT-782. The harvest index of maize genotypes varied from 19.96% in sweet corn-1 to 17.35% in CIMMYT-80.

Keywords: Maize, dry matter accumulation, yield, leaf area, *rabi*

Introduction
Maize is not only an important human nutrient, but also a basic element of animal feed and raw material for manufacture of many industrial products. Maize crop is utilized in many ways like other grain crops. Over 85 percent of maize produced in the country is consumed as human food. Green cobs are roasted and consumed by people with great interest. The grains special variety called 'popcorn' is characterized by a hard corneous interior structure which is converted into the 'popped' form a favorite food for children. The grains, a part from food as bread, pops and gruel are used for many industrial products like manufacture of starch, alcohol, acetic and lactic acids, glucose, paper, rayon, plastic, textile, adhesive, dyes, synthetic rubber, resins artificial leather and boot polish. It is also a feed for cattle.

Maize grain contains about 10 percent protein, 4 percent oil, 70 percent carbohydrate, 2-3 percent crude fiber, 10.4 percent albuminoids, 1.4 percent ash. Maize protein 'zein' is deficient intryptophaneand lysine, the two essential amino acids. Maize grain has significant quantities of vitamin A, nicotinic acid, riboflavin and vitamin E. Maize is low in calcium, fairly high in phosphorus. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals**.**

Rabi maize is grown on an area of 1.2 million ha with the grain production of 5.08 million tonnes, with an average productivity of 4.00 t ha^{-1} (DACNET, 2012). The predominant Rabi maize growing states are Andhra Pradesh (45.5%), Bihar (20.1%), Tamil Nadu (9.3%), Karnataka (8.5%), Maharastra (7.7%), and West Bengal (5.3%). The *rabi* productivity also increased in the states of Andhra Pradesh, Gujarat, Rajasthan and Maharashtra. On the other hand, the productivity during *kharif* declined in Andhra Pradesh, Chhattisgarh, Jharkhand, Haryana, Punjab, Gujarat, J&K, Rajasthan and Maharashtra, due to deficient monsoon rains. The acreage of maize and has touched 9.2 million ha and production 24.17 million t, which is the highest so far in the history of maize production in India. The trends in the last three years indicate that area under maize cultivation is expanding not only in *rabi* but also in *kharif* season. The major enhancement in the area has occurred during recent past in the peninsular Indian states of Maharashtra and West Bengal (*kharif* and *rabi*); Tamil Nadu, Gujarat and Bihar (*rabi*).

The area of maximizing photosynthesis process, achieving efficient translocation of its products to the organ of storage and simultaneously ensuring development of adequate organs

of storage, the so called economic sinks and to accumulate these assimilates appear to hold greatest promise and widest scope for helping achieve the desired results. However, in their attempts to break the existing yield barriers in different crops the breeders have not only to strive for increasing photosynthetic production and morphological aspects of sink size, but are also required to understand fully as how far and in what ways do the assimilates produced in different photosynthesizing organs during the successive ontogeny phases contribute to the development of economic yield.

Realization of the fact that conventional breeding technique, involving selection for morphological components of yields, have failed to provide expected increases in yield of many crops made it imperative for agricultural scientists to search for the causes of such failure, on the one hand and for the approaches that were required to be utilized for achieving the desired goals on the others.

Materials and Methods

A field experiment was conducted during Rabi season of 2019-20 at College of Agriculture, Teerthanker Mahaveer University (Moradabad) Uttar Pradesh . Soil of experimental field was sandy clay loam in texture, pH 7.4, EC (0.22 dSm–1), low in organic carbon (0.39%), available N (164.72 kg/ha), medium in available P (18.18 kg/ha) and available K (194.3 kg/ ha). The experiment comprised of 18 maize genotypes and layout in randomized block design with three replications. The crop was fertilized with dose of 100 kg of nitrogen, 60 kg of phosphorous and 40 kg of potash per hectare. The potassic and phosphatic fertilizer were applied before sowing of seed, while the basal dose of nitrogen (50kg) and 20 kg of $ZnSO_4$ was uniformly broadcast on the soil surface. From reaming 25 kg nitrogen were applied at knee height stage and reminder was applied at anthesis stage of the crop. Maize crop was sown @ 20 kg/ha seed rate apart 60x20 cm row to row and plant to plant spacing during Ist October. For control of weeds the crop was sprayed by Atrazine @ 1.5 kg in 800 liter of water at pre-emergence stage i.e. two days after sowing. The observations were recorded on plant height, leaf area and dry matter accumulation, yield attributes and yield per plant of rabi maize using standard procedures. The data were analyzed statistically among the standard procedure of ANOVA technique and treatments compressions are made at 5% level of significance (Fisher, (1937) [2].

Results and Discussion

Growth parameters

Results showed that all genotypes of Maize showed slow rate of growth in height up to 50 DAS after which there was slight triggering up to 90 DAS, acceleration being maximum in 130 DAS stage. Significant tallest plant was recorded in sweet corn-1 (172 cm) which was significantly higher than DMR-782 (160.3 cm), Sweet corn-7 (160.2cm), DMR 792 (158.5 cm), DMR 783 (157.5 cm), DMR 781 (155.8), and minimum plant height was recorded in pop corn-2 (133.8 cm) at harvest stage. Leaf area per plant was higher at 130 DAS developmental phase and lowest at 50 DAS. It ranges between 950.25 to 1300.43, 1320.67 to 1842.51 and 2050.64 to 2790.63 cm^2 at 50 DAS, 90 DAS and 130 DAS stages, respectively. Leaf area at 130 DAS of maize genotypes, maximum leaf area was found in sweet corn-1 (2790.63 cm^2) closely followed by DMR-782 (2700.55 cm^2), Sweet corn-7 (2680.65 cm^2), 9108 (2600.57 cm^2) and it was lowest in CIMMYT-80 (2050.64 cm^2). Total dry matter per plant of maize genotypes increased with increasing growth stages and found maximum total dry matter at maturity stage and lowest at 50 DAS. The highest dry matter accumulation was in Sweet corn-1(299.9 g/plant) which was significantly at par with DMR-782 (298.4 g/plant), sweet corn-7 (286.7 g/plant), G 9108 (285.4 g/plant) and pop corn-1 (281.58 g/plant) and it was lowest in CIMMYT-80 (250.75 g/plant). Maize also is essentially a photosynthetic system, the later being made up of two major component, the leaf area and the efficiency of leaves to produce assimilate. Sweet corn-1 appeared best and always gave maximum leaf area on the other hand CIMMYT-80 gave minimum leaf area. Similar results also reported by Kumar *et al.* (1992) and Adebo and Olaoye (2010) [1].

Table 1: Plant height (cm) at different growth stages of rabi maize genotypes

Maize Genotypes	Plant height (cm)			
	50 DAS (cm)	90 DAS (cm)	130 DAS (cm)	At maturity
Sweet corn-1	40	86	172	171.8
Azad uttam	30.5	78	146	144.9
Azad kamal	31.7	82	153	152.5
9108	35.0	79	147	145.4
Sweet corn-7	36.4	84	161	160.2
Pop corn-3	33.2	81	155	153.7
Pop corn-2	28.0	76	136	133.8
Pop corn-1	31.5	79	151	149.3
DMR 781	34.3	83	156	155.8
DMR 782	37.0	85	162	160.3
DMR 783	30.3	74	160	157.5
DMR 784	34.5	75	155	154.8
TSK 101	23.8	80	140	141.1
DMR 792	33.0	85	159	158.5
CIMMYT- 80	31.3	82	152	151.3
CIMMYT-13	29.5	77	148	146.2
CIMMYT-14-1-1	38.1	82	162	138.9
CIMMYT-4	32.2	83	142	158.4
S.E.(d) ±	0.97	1.66	3.33	4.13
C.D. at 5%	1.96	3.39	6.77	8.39

Table 2: Leaf area per plant (cm^2) at different growth stages of rabi maize genotypes

Maize Genotypes	Leaf area per plant (cm^2)		
	50 DAS (cm^2)	90 DAS (cm^2)	130 DAS (cm^2)
Sweet corn-1	1300.43	1842.51	2790.63
Azad uttam	1155.65	1680.64	2590.38
Azad kamal	1055.55	1455.65	2420.50
9108	1220.62	1760.45	2600.57
Sweet corn-7	1265.37	1790.92	2680.65
Pop corn-3	1020.47	1470.22	2400.90
Pop corn-2	1180.22	1690.90	2600.15
Pop corn-1	1195.50	1699.70	2620.25
DMR 781	1150.72	1650.30	2590.67
DMR 782	1275.42	1800.14	2700.55
DMR 783	1144.20	1655.64	2489.90
DMR 784	1153.33	1652.84	2480.55
TSK 101	1020.72	1455.33	2250.00
DMR 792	1050.42	1460.70	2265.50
CIMMYT- 80	950.25	1320.67	2050.64
CIMMYT-13	960.53	1350.44	2200.50
CIMMYT-14-1-1	1000.22	1450.55	2460.52
CIMMYT-4	1029.27	1450.12	2480.80
S.E.(d) ±	24.97	41.57	55.19
C.D. at 5%	50.76	84.51	112.20

Table 3: Dry matter per plant (g) at different growth stages of rabi maize genotypes

Maize Genotypes	Dry matter per plant (g)			
	50 DAS	90 DAS	130 DAS	At maturity
Sweet corn-1	76.30	185.30	245.70	299.80
Azad uttam	64.75	148.98	237.13	275.99
Azad kamal	62.45	139.75	218.18	263.96
9108	70.60	167.00	239.91	285.00
Sweet corn-7	73.30	177.50	242.00	286.70
Pop corn-3	61.34	137.82	217.22	262.88
Pop corn-2	64.97	150.08	238.45	278.29
Pop corn-1	65.24	150.92	215.90	281.58
DMR 781	63.42	144.48	222.52	267.27
DMR 782	73.30	185.10	245.20	298.40
DMR 783	64.03	147.93	231.36	271.48
DMR 784	64.00	147.26	229.49	268.90
TSK 101	61.52	137.48	219.24	264.91
DMR 792	65.25	137.40	217.29	261.08
CIMMYT- 80	58.24	130.15	210.62	250.75
CIMMYT-13	60.04	133.46	215.31	256.95
CIMMYT-14-1-1	60.12	135.52	215.55	259.49
CIMMYT-4	62.79	141.18	225.27	267.44
S.E.(d) ±	1.11	3.62	6.49	8.37
C.D. at 5%	2.27	7.35	13.20	17.02

Table 4: Yield and yield attributes of rabi maize genotypes

Maize Genotypes	Cob/plant	Grains/cob /plant	Grain weight/ plant(g)	1000 seed weight (g)	Harvest index (%)
Sweet corn-1	2.5	208.90	52.70	255.20	19.96
Azad uttam	1.5	180.40	48.60	249.60	17.60
Azad kamal	1.8	182.40	49.90	250.60	18.90
9108	2.2	200.20	51.20	253.50	19.30
Sweet corn-7	2.3	203.10	51.80	253.60	19.40
Pop corn-3	1.4	179.30	48.90	249.90	18.60
Pop corn-2	2.0	188.60	50.20	251.90	18.03
Pop corn-1	1.8	181.30	49.50	251.80	17.57
DMR 781	1.5	186.40	50.20	251.50	18.78
DMR 782	2.4	204.50	51.90	253.80	19.44
DMR 783	1.9	184.20	49.80	250.20	18.34
DMR 784	1.2	178.30	48.90	250.00	18.18
TSK 101	2.2	192.50	51.50	252.90	18.90
DMR 792	1.8	185.50	50.40	251.60	17.96
CIMMYT- 80	1.0	175.50	47.40	248.20	17.35
CIMMYT-13	1.5	182.70	51.30	252.50	17.57
CIMMYT-14-1-1	1.8	180.20	49.80	251.60	19.19

CIMMYT-4	2.1	200.20	51.70	253.20	18.06
S.E.(d) ±	0.10	3.24	0.83	1.30	0.31
C.D. at 5%	0.21	6.59	1.69	2.64	0.64

Yield contributing characters i.e. number of cob per plant, Grains/cob /plant, Grain weight/ plant(g), 1000 seed weight (g) and Harvest index (%). Maximum number of cob per plant was noted by maize genotype Sweet corn-1 (2.5 cob/plant) followed by DMR-782 (2.4 cob/plant) and lowest cob was recorded in genotype CIMMYT-80 (1 cob/plant). Genotypes Sweet corn-1 (208.90 grains/cob) yielded significantly maximum grains per cob while genotype CIMMYT-80 (175.5 grains/cob) produced minimum grains/cob. The maximum yield was obtained in sweet corn-1 (52.70 g/plant) followed by DMR-782 (51.90 g/plant) and lowest yield was recorded in CIMMYT-80 (47.40 g/plant). 1000 seed weight of maize genotypes ranged from 248.20 g to 255.20 g and genotype sweet corn-1 were boldest among genotypes tested while minimum seed weight was recorded in CIMMYT-782. The harvest index of maize genotypes varied from 19.96% in sweet corn-1 to 17.35% in CIMMYT-80. By and large, the low yield genotypes CIMMYT-80 appeared least efficient in transforming total dry matter produced to the grain where the sweet corn-1 genotype which yield highest were able to convert relatively larger amount of biomass in to grain. Jha *et al.* (2002) [5] reported that yield attributes viz. cob/ha, cob length, grain/cob and seed index of winter maize were found superior than monsoon crop. Bonomo *et al* (2000) [7] also reported similar results.

Table 5: Correlation coefficient of rabi maize genotypes between yield and its physiological parameter

Parameters	**Yield**	**Cob/plant**	**1000 seed weight (g)**	**Grain /plant**	**Harvest index (%)**
Yield	1.000	0.867**	0.966**	0.889**	0.001
Cob/plant		1.000	0.876**	0.891**	-0.304
1000 seed weight (g)			1.000	0.897**	-0.103
Grain/ plant				1.000	-0.322
Harvest index (%)					1.000

*significant at 5% level of significance

Correlation coefficient between grain yield and its attributes, yield of Maize genotypes was positively and significantly correlated with no. of cob/ plant (0.866), 1000 seed wt. (0.966), grains/plant (0.889) at 5% level of Significance enhancing the cob/plant, 1000 seed weight, and grains/plant. Yield of genotypes of Maize non-significant to harvest index (at 5%). Cob/plant positively significant correlated with 1000 seed weight and grain par plant and negatively correlated with Harvest index. 1000 Seed weight positively correlated with grain/plant. At phenotypic level all the character showed similar interrelationship with each other interms of direction like genotypic one but the magnitude are quite low result several work. Firoza *et al.* (1999) [6] reported positive and significant relationship with grain yield and its components.

Conclusion

On the basis of growth and yield and yield attributes it can be concluded that genotypes namely sweet corn-1, DMR-782, sweet corn-7 and 9108 were found as superior genotype for various characters; hence can be utilize for development of productive lines or heterotic combination for commercial exploitation.

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