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Morphological and physiological characterisation of maize inbred lines

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Abstract
The present investigation entitled "Morpho-physiological characterization of inbred lines in maize" was carried out during rabi 2019-20, at research field of Agriculture Research Station, Buldana. The experiment was laid out in RBD design with three replications and eleven inbred lines. *viz*., BMI-6-2-2BMI-28-1, BMI-34-3, BMI-23-1, BVM-21-1, MGT-53-2-1, MGT-53-36, MGT-53-23, MGT-53-24-4, V1543-6-12, V1551-15. Sowing was done by dibbling method on 21st December 2019 at a spacing of 60 x 20 cm. There after all the intercultural operations were done as and when required. The recommended dose of 120:60:40 NPK kg/ha was applied. Morpho-physiological parameters were recorded at 30, 60 DAS and at harvest, days to 50% tasseling and silking was recorded at the proper stage. Growth parameters were recorded at 30-60 and 60-harvest. Biochemical parameter was recorded at 30 and 60 DAS. Yield and yield attributes were recorded at harvest.
Result revealed that, significantly maximum values of morphological parameters like plant height (cm), leaf area (cm^2), leaf area index were recorded in Inbred line V1551-15; physiological parameters like dry matter production (g), relative water content (%) were recorded in inbred line MGT-53-2-1. Form overall results it can be concluded that Inbred line V1551-15 was found to be superior for morphological parameters. Hence, they can be utilized for improving morphological and physiological, and for further breeding programme.

Keywords: Inbred lines, maize, morpho-physiological characterization, rabi 2019-20

Introduction
Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice. The number of chromosomes in *Zea mays* is 2n = 20. Maize is a tall, determinate, monoecious, annual C_4 plant varying in height from 1 to 4 meters. It produces large, narrow, opposite leaves, borne alternatively along the length of stem.
Maize, American-Indian word for corn, literally means "that which sustains life. Maize is globally a top-ranking cereal not only in productivity but also as human food, animal feed and as a source of large number of industrial products. Maize considered as queen of the cereal is one of the most important cereal crops in the world, which is having a promising option for diversifying agriculture in upland areas of India and has got more than 3500 value added products as food, feed etc.
Maize is a crop of wider adaptability grown in varied agro-ecologies from sea level to an altitude of more than 3000 meters and is one of the driving forces for crop diversifications. Globally, maize is cultivated on more than 166 m ha area across 166 countries having wider of soil, climate, biodiversity and management practices. India has 5% of corn acreage and contributes 2% of world production. Maize contributes maximum among the food cereal crops i.e., 40% annually (greater than 800 mt). in the global food production. Among the world maize growing countries, USA is the largest producer of maize and contributes nearly 35% of the total maize produced followed by China, Brazil and Mexico.

Materials and Methods
The project entitled "Morpho-Physiological characterization of inbred lines in maize" was carried out during rabi-2019. The details of the materials used and method adopted for these studies are described in this chapter under following heads. The field experiment was laid out in Randomized Block Design (RBD) with three replications consisting of eleven varieties of maize

Details of inbred lines

T_1	BMI-6-2-2
T_2	BMI-28-1
T_3	BMI-34-3
T_4	BMI-23-1
T_5	BVM-21-1
T_6	MGT-53-2-1
T_7	MGT-53-36
T_8	MGT-53-23
T_9	MGT-53-24-4
T_{10}	V1543-6-12
T_{11}	V1551-15

Morphological observations

a) Plant height (cm)

Height of 5 randomly selected plants from each inbred line was measured at 30, 60 DAS and at harvest stage from the base of plant to the terminal bud on primary shoot by using meter scale. Average of 5 plants were then worked out and expressed in cm.

b) Leaf area (cm^2/plant)

Leaf area was recorded at 30, 60 DAS and at harvest stage from 5 randomly selected plants. Leaves were detached from five plants and leaf area was then measured by using leaf area meter in cm^2.

c) Leaf area index (LAI)

The leaf area index was calculated by using the formula given by Watson (1952)

$$LAI = \frac{\text{Total leaf area of the plant}}{\text{Land area occupied by the plant}}$$

d) Days to 50% tasseling

Number of days from the date of sowing to date of 50 percent of plants shedding pollen were recorded.

e) Days to 50% silking

Number of days from the date of sowing to the date of 50 percent of plants with silk emergence were recorded**.**

Physiological observations

a) Total dry matter production (g/plant)

Dry matter of plants was determined periodically at 30, 60 DAS and at harvest stage to assess the dry matter accumulation. For this the plants were uprooted from field. Later on, these plants were sun dried and then oven dried at 70 °C to record a constant weight. Sufficient care was exercised to avoid charring. The dry weight of plants was recorded on electronic balance (g).

b) Relative Water content (%)

Relative water content of leaves describe water retaining ability of plant in leaf. RWC was recorded at 30, 60 DAS and at harvest. For this third leaf from top was selected from each treatment and replication wise. After that fresh weight was immediately taken, labelled and were placed in polythene bags separately to avoid water loss. Leaves were weighted on electric balance, and then transferred to petri dish containing water. The leaves were kept floating on water for 4hrs and then their turgid weight was measured. The dried weight of leaves was recorded after keeping it in hot air oven at 70 c. relative water content was calculated with the equation given by Barras and Weatherley, (1962) [2].

$$RWC\ (\%) = \frac{\text{Fresh weight – oven dry weight}}{\text{Turgid weight-oven dry weight}} 100$$

Morphological observations

Plant height (cm)

Plant height is important and visible measure of plant growth. Plant height is a function of internode elongation and leaf emergence.

Data regarding plant height was recorded at 30, 60 DAS and at harvest stage and subjected to statistical analysis. The data are presented in table 1.

Table 1: Plant height (cm) of maize inbred lines during different growth stages.

Sr. No.	Inbred lines	Plant height (cm)		
		30 DAS	60 DAS	At harvest
1	BMI-6-2-2	62.79	146.67	245.67
2	BMI-28-1	61.54	140.48	245.48
3	BMI-34-3	52.30	129.75	229.75
4	BMI-23-1	53.44	124.87	223.33
5	BVM-21-1	59.23	147.00	247.00
6	MGT-53-2-1	57.73	147.15	256.15
7	MGT-53-36	55.20	142.00	242.00
8	MGT-53-23	54.58	126.83	224.87
9	MGT-53-24-4	53.1	138.33	238.33
10	V1543-6-12	57.16	146.81	245.81
11	V1551-15	65.21	166.67	267.37
12	SE (m) ±	2.88	6.05	7.23
13	CD at 5%	-	19.18	21.35

At 30 DAS, the data regarding plant height was found non significant.

At 60 DAS, the range of plant height was from 124.87 to 166.67 cm. Inbred line V1551-15 was recorded with significantly maximum value for plant height (166.67 cm). This was followed by BVM-21-1 (147.00 cm) and MGT-53-2-1 (147.15 cm). However, minimum plant height was recorded in BMI-23-1 (124.87) and this was at par with BMI-28-1 (140.48 cm), BMI-24-3 (129.79), MGT-53-36 (142.00), MGT-53-23 (126.83) and MGT-53-24-4 (138.33).

At Harvest, the plant height ranged from 223.33 to 267.37 cm. Inbred line V1551-15Vwas recorded with maximum value for plant height (267.37 cm). MGT-53-2-1 (256.15 cm) and BVM-21-1 (247.00 cm) were at par with V1551-15. However, minimum plant height was recorded in BMI-23-1 (223.33 cm). Inbred line BMI-34-3 (229.75.cm), MGT-53-23 (224.87 cm) and MGT-53-24-4 (238.33 cm) were at par with BMI23-1.

Murali Krishna (2011) [3] observed significant variation in plant height in inbred lines of maize and also emphasized that the tall genotypes can be utilized for dual purpose of grain and fodder.

Leaf area of plant (cm^2/plant)

Leaf area depends upon the number and size of leaves. Leaves play an important role in the absorption of light radiations and using it in photosynthetic process. Leaf size is influenced by light, moisture and nutrients. Hence, yield depends on leaf area of crop.

Data on leaf area was recorded at three stages viz., 30, 60 DAS and at harvest stage and are furnished in table 2.

Table 2: Leaf area (cm^2/ plant) of maize inbred lines during different growth stages.

Sr. No.	Inbred lines	Leaf area (cm^2plant^{-1})		
		30 DAS	60 DAS	At harvest
1	BMI-6-2-2	631.42	3273.82	2775.11
2	BMI-28-1	640.52	3443.84	3115.72
3	BMI-34-3	622.77	3173.95	2675.33
4	BMI-23-1	627.80	2773.33	2497.12
5	BVM-21-1	641.23	3400.65	3001.34
6	MGT-53-2-1	648.66	3890.13	3266.07
7	MGT-53-36	612.32	3400.87	2994.79
8	MGT-53-23	637.87	3726.57	3019.99
9	MGT-53-24-4	629.05	3360.48	2860.48
10	V1543-6-12	631.84	3861.66	3076.32
11	V1551-15	632.35	4052.67	3579.06
12	SE (m) ±	6.671	205.30	166.49
13	CD at 5%	-	605.65	491.16

At 30 DAS, the data regarding leaf area of plant was found to be non-significant.

At 60 DAS, leaf area varied from 2773.33 to 4052.67 cm^2. Inbred line V1551-15 (4052.67 cm^2) was recorded with maximum value for leaf area. MGT-53-23 (3726.57 cm2), MGT-53-2-1 (3890.13 cm2) and V15-43-6-12 (3861.66 cm^2) were at par with V1551-15. However, minimum leaf area was found in BMI-23-1 (2773.33 cm^2). BMI-6-2-2 (3273.82 cm^2), BMI-34-3 (3173.95 cm2) and MGT-53-24-4 (3360.48 cm^2) were at par with BMI-23-1.

At Harvest, leaf area ranged from 2497.12 to 3579.60 cm^2. Inbred line V1551-15 (3579.60 cm^2) was recorded with maximum value for leaf area. BMI-28-1 (3115.72 cm^2) and MGT-53-2-1 (3286.70 cm^2) were at par with V1551-15. However, minimum leaf area was recorded in BMI-23-1 (2497.12 cm^2). MGT-53-24-4 (2860.48 cm^2), MGT-53-36 (29.44.79 cm^2) and BMI-6-2-2 (2775.11 cm^2) were at par with BMI-23-1.

The results revealed that leaf area increased from 30 to 60 DAS. But at harvest stage leaf area decreased due to leaf fall at this stage.

Leaf area index

The ratio of leaf area to the land area given to plant expressed in the same units is known as leaf area index. The data of leaf area index was calculated from the leaf area data. The data was recorded at 30, 60 and at harvest.

Table 3: Leaf Area Index (LAI) of maize inbred lines during different growth stages.

Sr. No.	Inbred lines	Leaf area index		
		30 DAS	60 DAS	At harvest
1	BMI-6-2-2	0.526	2.728	2.313
2	BMI-28-1	0.540	2.870	2.596
3	BMI-34-3	0.518	2.645	2.229
4	BMI-23-1	0.523	2.311	2.081
5	BVM-21-1	0.534	2.834	2.501
6	MGT-53-2-1	0.533	3.242	2.739
7	MGT-53-36	0.510	2.834	2.496
8	MGT-53-23	0.531	3.105	2.517
9	MGT-53-24-4	0.524	2.800	2.384
10	V1543-6-12	0.526	3.218	2.564
11	V1551-15	0.526	3.377	2.983
12	SE (m) ±	0.006	0.171	0.139
13	CD at 5%	-	0.505	0.409

At 30 DAS, the data regarding leaf area index of plant was found to be non-significant.

At 60 DAS, leaf area index was varied from 2.311 to 3.377. V1551-15 (3.3377) was recorded maximum value for leaf area index, MGT-53-23 (3.105), MGT-53-22-1 (3.242), V1543-6-12 (3.218) were at par with MGT-53-2-1. However, minimum leaf area index was recorded in BMI-23-1 (2.311) and BMI-6-2-2 (2.738), BMI-34-3 (2.645), MGT-53-24-4 (2.800) were at par with BMI-23-1.

At Harvest, leaf area index was ranged from 2.081 to 2.983. Inbred line V1551-15 (2.983) was recorded maximum value for leaf area index. BMI-28-1 (2.596) and MGT-53-2-1 (2.739) were at par with V1551-15. However, minimum leaf area index was found in BMI-23-1 (2.081). MGT-53-24-4 (2.384), BMI-34-3 (2.229) and BMI-6-2-2 (2.313) were found at par with BMI-21-1.

Daughtry and Hollinger (1984) [4] calculated the cost of measuring the leaf area index of maize. Accordance with their results direct measurement of leaf area with an electronic area meter had the lowest CV, required that the fewest plant be sampled, but required approximately the same amount of time as the leaf area/weight ratio method to detect comparable differences. Indirect methods based on measurement of length and width of leaves required more plants but less total time than the direct method.

Days to 50% tasseling

The data on days to 50% tasseling did not differ significantly among the inbred lines.

Days to 50% silking

The data on days to 50% silking did not differ significantly among the inbred lines.

Table 4: Days to fifty percent tasseling and silking for maize inbred lines

Sr. No	Inbred lines	Days to 50% tasseling	Days to 50% silking
1	BMI-6-2-2	57.68	60.26
2	BMI-28-1	57.82	59.07
3	BMI-34-3	59.96	60.90
4	BMI-23-1	59.06	61.96
5	BVM-21-1	56.17	59.62
6	MGT-53-2-1	53.97	55.33
7	MGT-53-36	57.27	59.80
8	MGT-53-23	59.74	60.46
9	MGT-53-24-4	54.74	55.69
10	V1543-6-12	54.11	57.41
11	V1551-15	57.00	56.67
12	SE (m) ±	2.233	3.067
13	CD at 5%	-	-

Physiological Observations

Dry matter production

One of the factors that determines crop economic yield is total dry matter accumulation. Data regarding total dry matter production was collected at the three growth stages i.e., 30, 60 DAS and at harvest stage which is presented in table 5.

At 30 DAS, the data on dry matter production per plant did not differ significant.

At 60 DAS, the results indicated significant differences among inbred lines. Dry matter differing from 86.67 to 126.67 g. Inbred line MGT-53-2-1 (126.67 g) was registered maximum value for dry matter production. BMI-28-1 (119.66 g), MGT-53-23 (114.43 g), MGT-53-24-4 (119.90

g), V1543-6-12 (120.70 g) were found at par with each other. However, minimum value for dry matter was observed in BMI-23-1 (86.67 g) BMI-34-3 (102.96 g) was at par with BMI-23-1.

At Harvest, Dry matter ranged from 283.77 to 321.10 g. Inbred line MGT-53-2-1 (321.10 g) was recorded higher value for dry matter production, MGT-53-24-4 (308.42 g) and V1543-6-12 (310.00 g) were at par with MGT-53-2-1. However, lower dry matter was found in BMI-23-1 (283.77 g). BMI-34-3 (288.15 g), BVM-21-1 (293.06 g), MGT-53-36 (293.33 g), V1551-15 (293.33 g) were at par with BMI-23-1.

Table 5: Dry matter production of maize inbred lines during different growth stages.

Sr. No	Inbred lines	Dry matter (g)		
		30 DAS	60 DAS	At harvest
1	BMI-6-2-2	13.01	107.71	302.88
2	BMI-28-1	13.18	119.66	302.95
3	BMI-34-3	13.35	102.96	288.15
4	BMI-23-1	14.14	86.67	283.77
5	BVM-21-1	11.13	107.92	293.06
6	MGT-53-2-1	14.55	126.67	321.10
7	MGT-53-36	12.70	105.71	293.33
8	MGT-53-23	12.86	114.43	303.32
9	MGT-53-24-4	14.11	119.90	308.42
10	V1543-6-12	13.69	120.70	310.00
11	V1551-15	12.55	105.34	293.33
12	SE (m) ±	0.764	6.15	6.02
13	CD at 5%	-	18.16	17.76

From the data, it is cleared that dry matter increased gradually from 30-60 DAS. Dry matter accumulation is a function of leaf area and maximum leaf area was observed during 30-60 DAS and it is period of maximum photosynthesis and yielded maximum dry matter production. Biomass (dry matter gain) in crop plants is controlled by complex interaction of photo assimilates production by source leaves and photosynthates utilization by sink tissues. The high dry matter accumulation and allied growth characters might be due to increased chlorophyll content. Ability of particular crop plant to carryout photosynthesis during growth period determines dry matter accumulation and even final yield of plant. Phloem transport process will be of equal importance for this and it determines that how effectively nutrients are made available to plant parts.

Vijayalaxmi *et al*. (2012) [5] noted that the significantly higher total dry matter production was observed in these treatments at harvest due to better utilization of resources as a well as effective control of weeds.

Relative Water Content

Data on relative water content were recorded at 30, 60 at harvest are presented in table 6. Data on relative water content showed significant variations at 60 and at harvest.

Table 6: Relative Water Content (RWC %) of maize inbred lines during different growth stages.

Sr. No	Inbred lines	RWC (%)		
		30 DAS	60 DAS	At harvest
1	BMI-6-2-2	75.20	63.81	39.25
2	BMI-28-1	70.92	65.00	42.33
3	BMI-34-3	71.63	63.18	38.22
4	BMI-23-1	73.69	57.70	38.16
5	BVM-21-1	73.54	66.78	39.01
6	MGT-53-2-1	71.93	72.01	47.22
7	MGT-53-36	66.27	65.25	42.04
8	MGT-53-23	60.70	69.87	39.87
9	MGT-53-24-4	68.96	70.08	42.15
10	V1543-6-12	70.25	68.90	39.89
11	V1551-15	67.00	65.12	37.13
12	SE (m) ±	2.905	2.18	1.59
13	CD at 5%	-	6.44	4.71

At 30 DAS, the data regarding relative water content was found non significant.

At 60 DAS, Relative water content ranged from 57.70 to 72.01 percent. Inbred line MGT-53-2-1 (72.01%) was recorded maximum value for relative water content. BVM-21-1 (66.78%), MGT-53-23 (69.87%), MGT-53-24-4 (70.08%), V1543-6-12 (68.90%) were at par with MGT-53-2-1. However, minimum value for relative water content was recorded in BMI-23-1 (57.70%). BMI-6-2-2 (63.81%) and BMI-34-3 (63.18%). were at par with BMI-23-1.

At Harvest, Relative water content ranged from 37.13 to 47.22 percent. Inbred line MGT-53-2-1 (47.22%) was recorded significantly superior over all the inbred lines.it was followed by BMI-28-1 (42.33%).However, minimum Relative water content was recorded in BMI-23-1 (37.13%). Inbred line BMI-6-2-2 (39.25), BMI-34-3 (38.22%), MGT-53-23 (39.87%) V1551-15 (38.22%), BVM-21-1 (39.01%) were at par with BMI-23-1.

Conclusion

The study on the morpho-physiological characterization of maize inbred lines revealed significant variation in key growth parameters. Inbred line V1551-15 exhibited superior traits in terms of plant height, leaf area, and leaf area index, particularly at the 60 DAS and harvest stages. Dry matter production was highest in MGT-53-2-1, while relative water content showed significant differences, indicating varying water retention capacities among the lines. These findings suggest that genotypic differences in growth characteristics, such as leaf area, dry matter accumulation, and water retention, can be crucial for improving maize productivity. Further studies are needed to assess these lines' yield potential under different environmental conditions.

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