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Growth parameters, Biochemical and yield characterisation of maize inbred lines

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ABSTRACT

The present study on Morpho-physiological Characterization of Inbred Lines in Maize was conducted during the Rabi season of 2019-20 at the Agricultural Research Station, Buldana. The experiment followed a randomized block design (RBD) with three replications, evaluating eleven maize inbred lines: BMI-6-2-2, BMI-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, and V1551-15. Sowing was performed on December 21, 2019, using the dibbling method, with a spacing of 60 × 20 cm. Standard agronomic practices, including the recommended NPK dose of 120:60:40 kg/ha, were adopted. Growth parameters were measured at 30, 60, and at harvest stages, while biochemical parameters were evaluated at 30 and 60 days after sowing (DAS). Yield and yield attributes were recorded at harvest. Among the inbred lines, MGT-53-2-1 exhibited significantly superior performance in growth parameters, including crop growth rate (g/day), relative growth rate (g/g/day), and net assimilation rate (g/dm^2/day). The line also demonstrated the highest chlorophyll content index (SPAD values), grain yield (g/plant), and harvest index (%). Furthermore, inbred lines MGT-53-2-1 and MGT-53-24-4 excelled in biochemical traits and yield attributes, respectively. These findings highlight the potential of MGT-53-2-1 and MGT-53-24-4 for improving key morphological, physiological, and yield traits in maize. The superior inbred lines identified in this study can be utilized in future breeding programs aimed at enhancing maize productivity and performance.

Keywords: *Maize, Inbred lines, Growth parameters, Yield, Breeding*

INTRODUCTION

Maize is a vital cereal crop cultivated on approximately 8.6 million hectares in India, with 80% of the area under cultivation during the Kharif season. The current production stands at 21.7 million tonnes, with an average productivity of 2.5 tonnes per hectare [1]. Despite being predominantly a rainfed crop, maize demonstrates higher productivity than rice, which is often grown under assured irrigated or rainfed conditions. Contributing nearly 9% to the national food basket and adding over ₹400 billion to the agricultural GDP at current prices, maize plays a significant role in the economy. The crop generates employment for over 1000 million person-days annually across farming, downstream agricultural, and industrial sectors. Primarily used as animal feed (60%), maize also serves as food for human consumption (24%), in industrial applications such as starch production (14%), and for beverages and seed production (1% each) [2]. Its extensive use in the starch and feed industries, which consume 75% of its production, has elevated maize's importance as an industrial crop in India.

Maize holds significant importance from both nutritional and production perspectives. Enhancing crop productivity can be achieved through physiological approaches, which focus on optimizing plant processes for efficient dry matter synthesis and its effective partitioning toward yield-contributing factors. As a staple food in many regions worldwide, maize and its derivative, cornmeal (ground dried maize), serve as essential dietary components. It is a primary source of starch, with corn starch (maize flour) being a key ingredient in home cooking and numerous industrial food products [3], maize is a vital source of cooking oil (corn oil) and maize gluten, further underscoring its value in both food and industrial applications.

Maize starch can be hydrolyzed and enzymatically treated to produce various syrups, particularly high-fructose corn syrup, which serves as a widely used sweetener. Additionally, maize can be fermented and distilled to produce grain alcohol, further enhancing its industrial value. From both nutritional and production perspectives, maize holds immense importance, especially due to its potential for higher yields. Productivity improvements can be achieved through physiological approaches that optimize plant processes for maximum dry matter synthesis and effective partitioning toward yield-contributing factors [4].

As noted by [5] physiological approaches to breeding maize involve defining specific physiological factors as selection criteria. There is a strong correlation between growth parameters and grain yield, with traits such as leaf area index, plant height, photosynthetic rate, chloroplast activity, photochemical activity, specific leaf weight, and nitrate reductase activity playing key roles [6] These genetic differences in physiological traits should be prioritized in breeding programs focused on improving yield components. [7] emphasized that selecting genotypes based on physiological traits is an effective method for enhancing grain yield in maize. To identify maize genotypes with superior physiological characteristics, a focused physiological approach is essential. Despite maize's significance as a major crop occupying vast areas in India, the specific physiological traits contributing to its yield remain inadequately understood. Addressing this gap can pave the way for significant advancements in maize productivity.

MATERIAL AND METHODS

The work on the 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

Table 1. 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

Computation of Growth Parameters

a) Crop Growth Rate (CGR) (g/day)

The crop growth rate (CGR) measures the rate at which the dry weight of the whole plant increases over a specific period. The classical approach developed by Blackman (1919) and Watson (1958) is used to compute the mean CGR over intervals, such as 30-60 DAS (days after sowing) and 60 DAS to harvest. The CGR is calculated using the formula:

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where:

- W_1 = Dry weight at time t_1
- W_2 = Dry weight at time t_2
- $t_2 - t_1$ = Time interval between two sampling points

This method provides a quantitative measure of plant growth over time, offering insights into the crop's performance during different growth stages.

b) Relative growth rate (g/g/day)

Relative growth rate is the increment in per unit dry weight per unit time. It was computed by using the Fischer's formula (1971).

$$RGR\ (g/g/day) = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1}$$

Where, W_1 = initial dry weight (g)

W_2 = final dry weight

T_2-T_1 = time interval (days)

Loge = log10 * 2.303

c) Net assimilation rate (g/dm^2/day)

NAR is the rate of increase in dry weight per unit leaf area per unit time (Watson, 1952). It is expressed as g dm^{-2} day^{-1}. the NAR was calculated by using the formula suggested by Williams (1946)

$$NAR = \frac{W_2\ W_1}{T_2 - t_1} \times \frac{\log_e LA_2 - \log_e LA_1}{LA_2 - LA_1}\ g\,dm^{-2} day^{-1}$$

LA_1 and LA_2 = leaf area (dm^2)

W_1 and W_2 = total dry weight of a plant (g)

At time interval t_1 and t_2 (days)

Log e = natural loge

Biochemical parameter

Chlorophyll content index

Chlorophyll content index was estimated at 30, 60 DAS from five randomly selected plants by using chlorophyll meter device (SPAD meter). Three readings of base, middle and top leaf were taken and average was calculated.

3.3.5 Yield and yield contributing parameters

a) Grain weight

grains were separated from the produce of each variety and weighed on electronic balance and recorded in grams.

b) Harvest index (%)

Harvest index (HI) of each genotype was calculated by the following formula.

$$\text{Harvest index} = \frac{\text{Grain yield (gm-2)}}{\text{Biological yield (grain+ straw) (g m}^{-2}\text{)}} \times 100$$

Result and Discussions

Growth Parameters

Growth analysis is one of the method for determining the seed yield of plant. The productivity of crop may be related with the parameters such as CGR (crop growth rate), RGR (relative growth rate), NAR (net assimilation rate)

Crop Growth Rate: (CGR)

Crop growth rate was increased from day to day up to 30-60 days. The analysed data of CGR is presented in table 2. Data revealed that CGR was more during the period of 30-60 DAS.

Considering all the inbred line under study, significantly higher CGR was recorded in treatment MGT-53-2-1 i.e., (3.90) g/day at 30-60 DAS and (3.21) g/day at 60 DAS-at harvest respectively. But it was lowest in BMI-34-3 i.e., 2.38 g/day at 30-60 DAS and 1.57 g/day at 60 DAS-at harvest respectively.

Table 2. Crop Growth Rate (g/day) of maize inbred lines during different growth stages.

Sr No	Inbred lines	Crop growth rate (g/day)	
		30- 60 DAS	60 DAS- At harvest
1	BMI-6-2-2	2.88	2.19
2	BMI-28-1	2.86	2.26
3	BMI-34-3	2.38	1.57
4	BMI-23-1	2.62	1.78
5	BVM-21-1	3.33	1.96
6	MGT-53-2-1	3.90	3.21

7	MGT-53-36	3.40	2.46
8	MGT-53-23	3.83	2.58
9	MGT-53-24-4	3.47	2.71
10	V1543-6-12	3.68	2.52
11	V1551-15	2.67	2.17
12	SE(m)	0.289	0.250
13	CD at 5%	0.853	0.738

At 30-60 DAS, crop growth rate varied from 2.38 to 3.90. Inbred line MGT-53-2-1(3.90 g/day) was recorded maximum value for crop growth rate. It was followed by MGT-53-23(3.83 g/day), V1551-15(3.68 g/day). However, minimum value for crop growth rate was recorded BMI-34-3(2.38 g/day). It was followed by BMI-23-1(2.62 g/day), V1551-15(2.67 g/day) were at par with each other.
At 60- Harvest, Crop growth rate ranged from 1.57 to 3.21 g/day. Inbred line MGT-53-2-1 was recorded maximum value for crop growth rate (3.21 g/day). It was followed by MGT-53-24-4(2.71 g/day), MGT-53-23(2.58 g/day). However, minimum value for crop growth rate was recorded BMI-34-4(1.57 g/day). It was followed by BMI-28-1(1.78 g/day), BVM-21-1(1.96 g/day) were at par with each other. [8] reported that highest crop growth rate during flowering stage (45-60 DAS) which then declined at cob development, grain filling and maturity period.

Relative growth rate (RGR)

The analysis data of relative growth rate is presented in table 3.

Table 3. Relative growth rate of maize inbred lines during different growth stages.

Sr no.	Inbred lines	RGR (g/g/day)	
		30-60 DAS	60-harvest DAS
1	BMI-6-2-2	0.08568	0.01991
2	BMI-28-1	0.08626	0.02087
3	BMI-34-3	0.08350	0.01876
4	BMI-23-1	0.07841	0.01839
5	BVM-21-1	0.08494	0.01962
6	MGT-53-2-1	0.09123	0.02198
7	MGT-53-36	0.08450	0.01898
8	MGT-53-23	0.08598	0.02064
9	MGT-53-24-4	0.08637	0.02138
10	V1543-6-12	0.08801	0.02168
11	V1551-15	0.08455	0.01935
12	SE (m) ±	0.00175	0.00068
13	CD at 5%	0.00519	0.00199

At 30-60 DAS, relative growth rate ranged from 0.07841 to 0.09123 g/g/day. Inbred line MGT-53-2-1 was recorded maximum value for relative growth rate (0.09123 g/g/day).it was at par with V1543-6-12(0.088015 g/g/day), MGT-53-24-4(0.086375 g/g/day), BMI-28-1 (0.08626 g/g/day) However, Minimum value for relative growth rate was found BMI-23-1 (0.07841 g/g/day).it was at par with BMI-34-3(0.08350 g/g/day).
At 60- Harvest, relative growth rate ranged from 0.01838 to 0.02198 g/g/day inbred line MGT-53-2-1(0.02197 g/g/day) was recorded maximum value for relative growth rate. BMI-28-1(0.02086 g/g/day), MGT-53-23(0.02064 g/g/day), MGT-53-24-4(0.02138g/g/day), V1543-6-12(0.02167g/g/day) were at par with MGT-53-2-1. However, significantly minimum value for relative growth rate was recorded BMI-23-1(0.01838 g/g/day). It was followed by BMI-34-3(0.01876 g/g/day).
[8] showed positive correlation between variety and relative growth rate.
[9] reported the highest relative growth rate during flowering stage (45-60DAS) which then declined at cob development, grain filling and maturity period.

Net Assimilation Rate (NAR)

Net assimilation rate (NAR) was measure of rate of dry matter accumulation per unit leaf area.

Table 4. Net assimilation rate of maize inbred lines during different growth stages.

Sr no.	Inbred lines	NAR (g/dm²/day)	
		30-60 DAS	60-Harvest DAS
1	BMI-6-2-2	0.02925	0.00103
2	BMI-28-1	0.02729	0.00112
3	BMI-34-3	0.02792	0.00106
4	BMI-23-1	0.01188	0.00103
5	BVM-21-1	0.02162	0.00116
6	MGT-53-2-1	0.03043	0.00152
7	MGT-53-36	0.02450	0.00117
8	MGT-53-23	0.02791	0.00112

9	MGT-53-24-4	0.02957	0.00128
10	V1543-6-12	0.02986	0.00131
11	V1551-15	0.02871	0.00122
12	SE (m) ±	0.00300	0.00009
13	CD at 5%	0.00888	0.00025

At 30-60 DAS, NAR was ranged from 0.01188 to 0.03042 g/dm^2/day NAR was highest in MGT-53-2-1(0.03043 g/dm^2/day) and it was followed by MGT-53-24-4(0.02986 g/dm^2/day) and V1543-6-12(0.02986 g/dm^2/day). However, minimum NAR was found in BMI-23-1(0.01188 g/dm^2/day)

At 60-harvest NAR was ranged from 0.00103 to 0.00152 g/dm^2/day. NAR was highest in MGT-53-2-1(0.0123 g/dm^2/day) and it was followed by MGT-54-24-4(0.00128 g/dm^2/day) and V1543-6-12 (0.00131 g/dm^2/day). However minimum NAR was found in BMI-23-1(0.00103 g/dm^2/day).

Biochemical parameters

The biochemical studies with respect to chlorophyll content in the leaves at different stages of observation was estimated and data regarding these parameters is presented below.

Chlorophyll content index

Chlorophyll, a green pigment found in the chloroplasts of all green plant cells and tissues, plays a vital role in photosynthesis. It absorbs light energy, which is crucial for synthesizing carbohydrates, thereby driving plant growth and development. The chlorophyll content in plant tissues is an important indicator of the photosynthetic capacity and overall health of the plant. The chlorophyll content index (CCI) in maize leaves provides valuable insights into the plant's photosynthetic efficiency and adaptability under various conditions. The results of the chlorophyll content index observed in maize leaves during the study are summarized in Table 4.10. These findings highlight the variations in chlorophyll content among different inbred lines, reflecting their physiological performance and potential for yield improvement.

Table 5. Chlorophyll content index of maize inbred lines during different growth stages.

Sr no	Inbred lines	Chlorophyll content index	
		30 DAS	60 DAS
1	BMI-6-2-2	35.26	48.45
2	BMI-28-1	36.44	45.63
3	BMI-34-3	32.23	47.58
4	BMI-23-1.	29.05	40.05
5	BVM-21-1	35.27	48.99
6	MGT-53-2-1	42.68	53.03
7	MGT-53-36	36.84	49.45
8	MGT-53-23	38.59	49.76
9	MGT-53-24-4	37.43	52.12
10	V1543-6-12	39.29	51.07
11	V1551-15	36.74	49.37
12	SE (m) ±	1.96	2.019
13	CD at 5%	5.79	5.956

At 30 DAS, chlorophyll content index differing from 29.05 to 42.68. Inbred MGT-53-2-1 was recorded maximum value for chlorophyll content index (42.68). V1551-15(36.94) and V1543-6-12(39.29) were at par with MGT-53-2-1. However, Minimum value for chlorophyll content index was recorded BMI-23-1 (29.05) and it was at par with BMI-23-1(29.05).

At 60 DAS, chlorophyll content index ranged from 40.05 to 53.03 Inbred MGT-53-2-1(53.03) was recorded maximum value for chlorophyll content index, MGT-53-24-4(52.12) and V1543-6-12(51.07) were at par with MGT-53-2-1. However, minimum chlorophyll content index was recorded in BMI-23-1 (40.05). and BMI-28-1(45.63) is at par with BMI-23-1.

Yield and yield contributing parameters

Grain yield (g/plant)

Grain yield per plant is the most important character which determines the worthiness of a line. Perusal of the data on grain yield per plant revealed significant differences among the lines.

Table 6. Grain yield and Harvest index of maize inbred lines during different growth stages.

Sr No	Inbred lines	Grain yield (g/plant)	Harvest Index (%)
1	BMI-6-2-2	61.88	39.96
2	BMI-28-1	65.46	40.98
3	BMI-34-3	35.67	33.98
4	BMI-23-1	35.14	32.68
5	BVM-21-1	81.96	35.55
6	MGT-53-2-1	102.46	42.99
7	MGT-53-36	35.98	40.54
8	MGT-53-23	61.97	41.19

9	MGT-53-24-4	69.75	41.76
10	V1543-6-12	89.22	42.19
11	V1551-15	44.57	37.41
12	SE (m) ±	12.490	1.997
13	CD	36.846	5.890

The data presented in table 5 revealed that grain yield of maize inbred ranged from 35.14 to 102.46 g/plant. MGT-53-2-1 recorded significantly superior yield over BMI6-2-2(61.88 g/plant), BMI-28-1(65.46 g/plant), BMI-34-3(35.67 g/plant), BMI-23-1(35.14 g/plant), MGT-53-36(35.98 g/plant), MGT-53-23(61.97 g/plant), V1551-15(44.57 g/plant). However, it is found at par with remaining inbred line. However, significantly minimum value for grain yield was recorded BMI-23-1(35.14 g/plant).

[10] recorded a strong positive genetic correlation among plant height, leaf area, leaves per plant, ear weight, kernels per row and grain yield indicating that selection for these characters can help to improve maize grain yield.

Harvest index (%)

Harvest index differed significantly among the genotypes. The data presented in table 6 revealed that harvest index of maize inbred ranged from 30.40 to 42.46. MGT-53-2-1 recorded significantly maximum value for harvest index (42.46%). It was followed by MGT-53-23 (41.13%), V1543-6-12(41.69%) However, significantly minimum value for harvest index was recorded BMI-23-1(30.40%).

CONCLUSION

Crop growth rate at 30-60 DAS found maximum in MGT-53-2-1(3.90 g/plant). However, minimum crop growth rate was observed in BMI-34-3(2.38 g/day). Relative growth rate at 30-60 found maximum in MGT-53-2-1(0.09123 g/g/day). However, minimum relative growth rate was observed in BMI-23-1(0.07841 g/g/day). Net assimilation rate at 30-60 DAS, was maximum in MGT-53-2-1(0.03043 g/dm^2/day). However, minimum NAR was found in BMI-23-1(0.01188 g/dm^2/day).Higher chlorophyll content index is considered to be desirable trait in maize. Inbred line MGT-53-2-1(53.03) registered higher chlorophyll content index at 60 DAS and observed to be promising.The highest grain yield/plant were recorded in MGT-53-2-1 (102.46 g/plant). And found promising for higher grain yield/plant. However lowest grain yield was recorded in BMI-23-1(35.14 g/plant).Maximum harvest index was found in MGT-53-2-1(42.99%). Whereas, Inbred line BMI-23-1 (32.68%) observed minimum harvest index.

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