

# Assessing the Morphological Variability and Some Seed Quality Contributing Traits for Mid Altitude Maize Inbred Lines (*Zea Mays* L.) in Western Ethiopia, Bako

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**Abstract:** Maize is one of the highly cross pollinated crop having two or more parents forming hybrid. Distinctness, Uniformity and Stability (DUS) characterization of parental lines are crucial for sustained quality seed production and formation of new varieties. This Study was initiated to provide information on Phenological characters of fourteen inbred lines. These were: (BKL001, BKL002, BKL003, BKL004, CML161, CML165, CML395, CML204, CML536, CML444, CML202, CML312BK, 142-1-e, 124-b (109), sourced from Bako national Maize research. Most of them were originally introduced from CIMMYT Kenya and Nigeria, among these parents two (CML161 and CML165) are Quality protein maize while 12 of the inbred lines are conventional. DUS characterization was conducted as per as UPOV guidelines. The result revealed that, inbred lines were vary widely differ in their characters. Among the 14 inbred lines, CML161 and CML165 were distinct from other in their yellow kernel color and 142-1-e had the distinguishable character of tassel anthocyanin coloration at glumes base. Dendrograms were constructed based on the morphological characters that briefs differences among the individuals indicating reportable variation among the 14 maize inbred lines which would aid in selection of inbred lines with desirable characters for further seed DUS identification. Generally knowing the DUS character of these parents have significant value to develop a new hybrid for the feature in Maize breeding and help to register new hybrid will be formed and serve as guide lines for different seed producers.

**Keywords:** DUS, Morphological Variability, Inbred Lines

## 1. Introduction

Maize (*Zea mays* L.) is an important cereal crop belonging to the genus *Zea*, family Poaceae, and tribe Maydeae. It is the world's third most widely grown cereal [2] commercially valued economic crop of global importance widely used in poultry and cereal food industries. It provides raw materials for starch, gluten, corn oil, corn syrup, sugar, corn meal and com flour and occupies an important place in Indian agriculture. Alvarado-Beltrán, G. et al. [8] reported that morphological characteristics of late-cycle varieties: tall plants, with more primary ramifications of the spike, ears of greater length and diameter and with greater length and thickness of grain for maize

Liu, Y. L. et al. [3] highlighted that about 28% of maize

produced is used for food purpose, about 11% as livestock feed, 48% as poultry feed, 12% in wet milling industry (e.g., starch and oil production) and 1% as seed. The direct collection of corn tassel is a viable method for industrial use and increases the corn production efficiency as waste from corn production is transformed into value-added products. The pigmentations in glume, anther, and pollen grains are important sources of phytochemicals in corn tassel. However, the tassel architecture and the development stage affect the phytochemical yield per unit of production area. In various plants, phytochemical accumulation in plant flowers, such as rose [4] tea, [5] safflower [6] and cactus [1], has been shown to be dependent on the development stage. The average effects of the parent's genes determine the genotypic value of

its offspring [3]. Therefore, the value of parent is estimated by the mean performance of its progeny and progeny selection is one of the key steps of plant breeding programs. Therefore, knowledge on genetic diversity of inbred lines would help the breeder in planning crosses for superior hybrid development. Researchers and Different seed Producers used morphological characters of inbred lines to identify easily and for different agronomic activities like Rouging, Detasseling, harvesting, sorting, cleaning, grading, planting etc. hence having the DUS of These released inbred lines encourage different stake holders in involved in seed production. This study is initiated with the objective below.

- 1) To clearly identify the inbred lines morphology by visual observation during seed production.
- 2) To investigate diversity among 16 yield contributing traits of 14 inbred line maize.

## 2. Materials and Method

### 2.1. Description of Experimental Site

The experiment was conducted at Bako National Maize Research Center (BNMRC), which is located in Western Ethiopia. Bako Maize Research Center lies between 906' North latitude and 37009' east longitude at an altitude of 1650 meters above sea level (m.a.s.l.) in the sub-humid agroecology of Ethiopia.

### 2.2. Experimental Materials and Layout

Fourteen Maize inbridlines (BKL001, BKL002, BKL003, BKL004, CML161, CML165, CML395, CML312, CML202, 142-1-e, CML444, CML536, 124-b (109) and CML204) were used for the study and The experiment were laid by RCBD design having three replication. Two seeds per hill, which was sowed later thinned to one plant per hill. Each experimental unit consisted two rows of 5.1m long with spacing of 0.75m between rows and 0.25m between plants. All agronomic management were done as per as recommended for the area.

### 2.3. Data Collected

#### 2.3.1. Data Collected on Plot Basis

The following data's were collected on plot basis: Days to Anthesis: The number of days from emergence to the date when 50% of the plants in a plot started shedding pollens.

Days to silking: The number of days from plant emergence to the date when 50% of the plants in a plot have produce 2-3 cm long silks. Anthesis- silking interval (ASI): Recorded as the number of days between days to silking and days to Anthesis. Days to physiological maturity (DM): The number of days from planting to when 50% of the plants in a plot form black layer at the tip where the kernel attaches to the cob. Actual moisture content: After harvest, samples from the bulk of shelled grain in each experimental unit were taken and actual moisture content was recorded by using electronic moisture tester. 1000 kernel weight (TKW) (g): After harvest, 1000 kernel from the bulk of shelled grain from each experimental unit were counted and weighed by adjusting to 12.5% moisture content of the grain. Grain yield (t/ha): At harvest, the weight of the ears per plot was recorded and this was adjusted to 12.5% moisture level and 80% shelling percentage to estimate grain yield in tons (t ha<sup>-1</sup>) for each parent.

#### 2.3.2. Data Collected on Sample Plants/Ears Basis

Five plants/ears were randomly taken from each experimental unit and the required measurements for each parameter was recorded from each plant/ear; then the mean values of each sample were calculated for data analysis. The data collected were: *Ear height (cm)*: Ear height was measured and recorded in centimeter by measuring five randomly taken plants from the ground level to the upper most useful ear-bearing node and the mean was recorded. *Plant height (cm)*: Plant height was measured in centimeter from five randomly selected plants as a distance from the ground level to the first tassel branch and the mean was recorded. *Ear length (cm)*: The average length of five randomly taken ears from each experimental unit was measured from the base to tip of the ear at the time of harvest. *Ear position (ratio)*: It was calculated as the ratio of ear height to plant height. *Ear diameter (cm)*: The average diameter of each ear of the same samples used for ear length measured in cm at the mid-way along the length of the ear using caliper. *Number of rows per ear*: The total number of kernel rows of the ear was counted from five randomly taken ears and the average value was used as kernel rows per ear. *Number of kernels per row*: This was recorded as the average number of kernels per row from five randomly sampled ears. Then the kernels of ten randomly taken rows from each of the sampled ears were counted and the average value was recorded.

## 3. Results and Discussion

### 3.1. Descriptor of the Parental Lines

Table 1. Some descriptor for maize inbred lines.

Inbred lines	Leaf angle	Leaf attitude	Stem brace root	50% Days to Anthesis (DAS)	50% Days to Silking (DAS)	Tassel anthocyanin color
BKL001	Small	Erected	Present	92-94	93-96	pink
BKL002	Wide	Dropping	Absent	79-82	85-90	pink
BKL003	Wide	Straight	Present	89-91	90-94	pink
BKL004	Wide	Straight	Present	87-90	89-91	pink

Inbred lines	Leaf angle	Leaf attitude	Stem brace root	50% Days to Anthesis (DAS)	50% Days to Silking (DAS)	Tassel anthocyanin color
CML 161	Medium	dropping	Absent	84-89	88-91	Red green
CML 165	Medium	dropping	Absent	85-90	90-93	Red green
CML 395	Very wide	dropping	Absent	76-83	83-90	Whitish to pink
CML 312	Medium	Straight	Absent	83-85	85-88	White to green
CML 202	Medium	Straight	Absent	80-85	85-88	White to green
142-1-e	Small	dropping	Present	95-100	100-105	White to green
CML 444	Medium	Straight	Absent	90-95	95-98	Whitish to pink
CML 536	Medium	Dropping	Present	85-90	90-95	Whitish to pink
124-b (109)	Medium	Dropping	Absent	82-84	85-90	Green to pink
CML204	Medium	Straight	Present	90-95	95-98	Green to pink

\*Physiological maturity, ear length, Tkw and Seed yield were recorded in between expressed in range.

*Table 1. Continued.*

Inbred lines	Glume color excluding base	Maturity date (days)	Ear Length (cm)	TKW (g)	Seed yield (tons/ha)
BKL001	Absent	150-155	38-45	272.67-280	3.32-3.5
BKL002	Absent	140-145	35-40	286-290	3.62-3.89
BKL003	Absent	150-155	37-42	312-320	4.11-4.5
BKL004	Present	150-155	37-43	324-329	5.14-5.5
CML 161	Present	150-155	37-42	292-395	3.26-3.75
CML 165	Present	150-155	35-40	224-230	2.8-3.3
CML 395	Absent	150-150	40-45	334-339	5.18-5.45
CML 312	Absent	155-160	35-40	314-319	2.95-3.1
CML 202	Present	155-160	35-40	302-307	4-4.5
142-1-e	Absent	160-165	40-45	305-310	5.5-5.9
CML 444	Present	150-155	37-42	275-280	4.02-4.75
CML 536	Present	150-155	40-45	304-309	5.03-5.4
124-b (109)	Absent	140-145	45-50	300-305	2.94-3
CML204	Present	150-155	40-45	251-256	2.92-3

\*Physiological maturity, ear length, Tkw and Seed yield were recorded in between expressed in range.

*Table 2. Ear based DUS characters for Maize inbred lines in 2018 and 2019 at Bako research station.*

#	Inbred lines	SH/Length	H/Tightness	L.H/ Ear	E/Shape	G/ Shape	E/Color
1	BKL001	Short	Tight	Extended	Cylindrical	Flint like	White
2	BKL002	Short	Tight	Adequate	Cylindrical	Flint like	White
3	BKL003	Long	Loose	Extended	Cylindrical	Dent like	White
4	BKL004	Medium	Loose	Extended	Conico-cylindrical	Dent like	White
5	CML 161	Long	Loose	Extended	Cylindrical	Flint	Yellow
6	CML 165	Long	Tight	Extended	Conico-cylindrical	Flint like	Yellow
7	CML 395	Short	Loose	Adequate	Cylindrical	Dent like	White
8	CML 312BK	Medium	Medium	Adequate	Cylindrical	Flint like	White
9	CML 202	Medium	Medium	Adequate	Conico-cylindrical	Flint like	White
10	142-1-e	Medium	Loose	Extended	Cylindrical	Flint	White
11	CML 444	Medium	Tight	Adequate	Conico-cylindrical	Flint like	White
12	CML 536	Long	Tight	Extended	Cylindrical	Flint	White
13	124-b (109)	Long	Loose	Extended	Cylindrical	Flint	White
14	CML 204	Medium	Medium	Medium	Cylindrical	Flint	White

1) Shank Length:(Short, Medium, Long)

2) Husk Tightness:(Loose, Medium, Tight)

3) Length of husks off the tip of the ear: (short, adequate, extended)

4) Grain shape: (flint, flint-like, intermediate, dent-like, dent, sweet, pop, waxy, flour)

5) Ear shape: (conical, conico-cylindrical, cylindrical)

6) Ear color: (white, yellowish white, yellow, yellow orange, orange, red orange, red, purple, brownish, blue black).

### 3.2. Phenological Trait Distributions Analysis

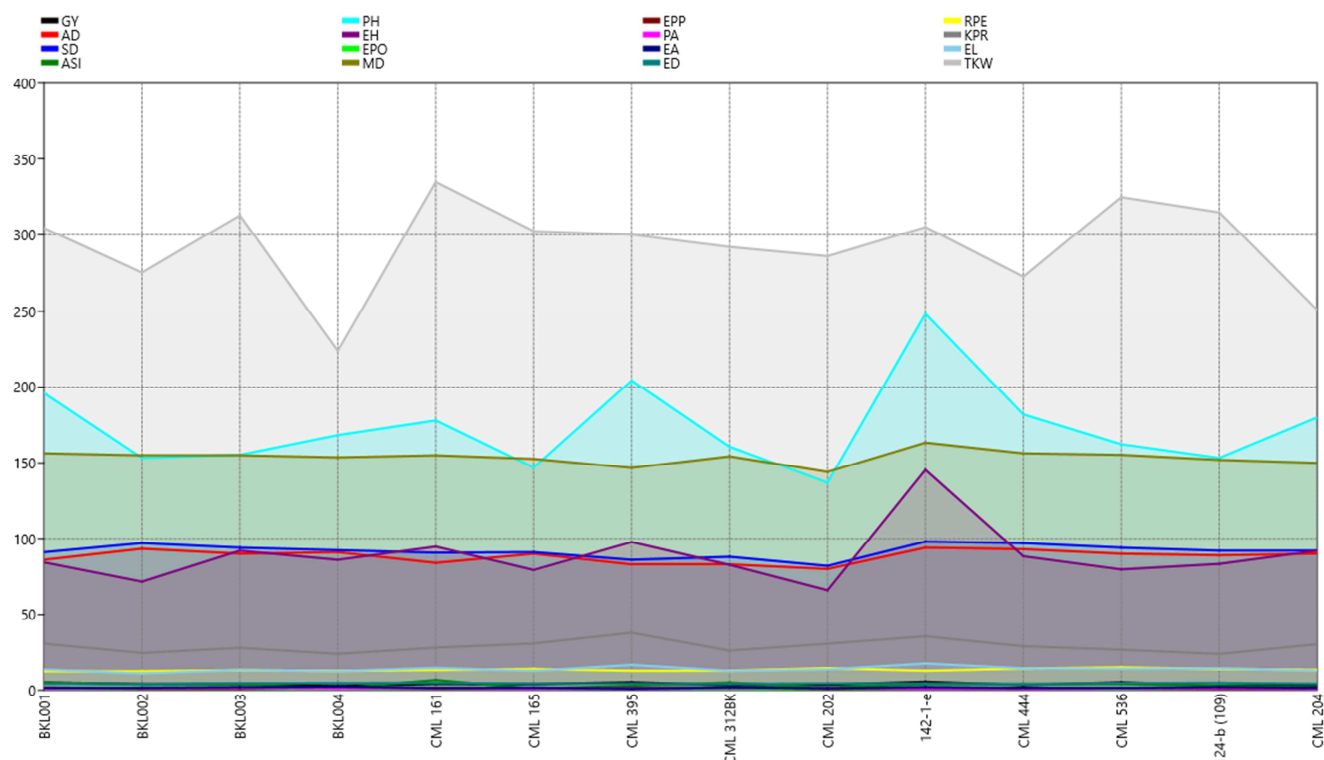


Figure 1. Trait distribution for 14 inbridlines maize.

### 3.3. Principal Components Analysis for Agronomic Traits

Principal Component Analysis (PCA) has been proposed as an alternative to Structure analysis for studying population structure of genotypic data according to Patterson *et al.*, (2006). Analysis of PCA performed were shown as follow.

Table 3. Eigenvalues, percent of variation and cumulative percentage of sixteen morphological traits.

PCA	Eigenvalue	Percentage (%) of variance it Contributed
1	1158.45	54.794%
2	846.857	40.056%
3	62.9846	2.9791%
4	33.7834	1.5979%
5	7.91322	0.37429%
6	2.34841	0.11108%
7	0.942068	0.044559%
8	0.568293	0.02688%
9	0.175735	0.008312%
10	0.123667	0.005849%
11	0.033882	0.001603%
12	0.021255	0.001005%
13	0.003664	0.000173%

Table 3 shows the Eigenvalues, percent of variation and cumulative percentage of sixteen morphological traits. The three principal components had Eigenvalues greater than or equal to 1.0. Together they account for 99.43% of the variability among the 14 inbred lines. PC1 with Eigenvalue of 1158.45 explained 54.79% of the total

observed variation and PC2 with Eigenvalue of 846.85 accounted for 40.06% of the total observed phenological variation while PC3 had Eigenvalue of 62.98 and accounted for 2.9791% PC4 had Eigenvalue 33.7834 account for 1.5979% of the total variation. In PC1 the predominant traits that contributed to most of the variation among the inbred lines were plant height, Ear height. The most predominant traits contributing to PC2 were thousand kernel weight. The traits that dominated PC3 were number of rows per cob, ear height and plant height.

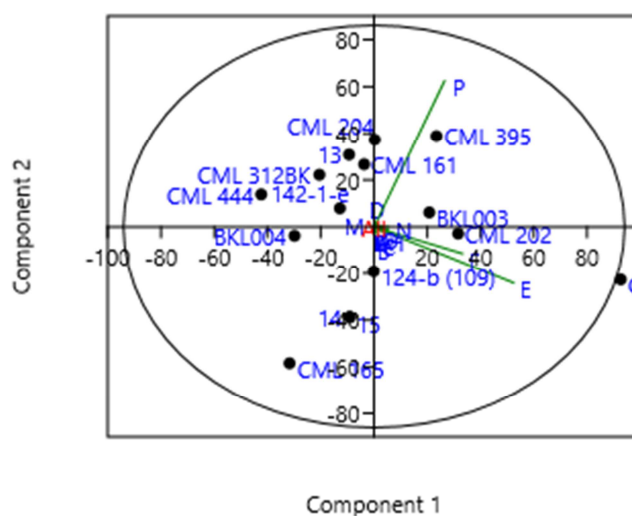
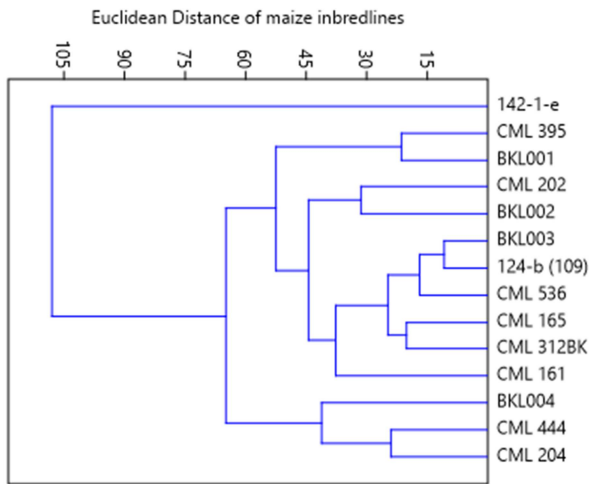


Figure 2. Principal component coordinates for each parents.



**Figure 3.** A dendograms showing the relationship among 14maize inbridlines based on their 16 morphological traits using Euclidean coefficient single link similarity matrix.

Based some morphological characters these inbridlines were clustered in to three main groups and 1421-e were in

cluster I alone due to its unique behavior for all traits evaluated, CML202, BK001, CML395, BKL002, BKL003, 124-b (109), CML312BK, CML165 and CML536 were in cluster II and BKL004, CML444 and CML 204 were became cluster III. Crossing of inbridlines under one cluster may not be effective due there morphological similarity. While the cross combination of 1421-e with all parents and cross combination of inbridlines with different cluster can create heterozygous F1 parents.

### 3.4. Phenological Diversity Analysis

Plant height is the trait with highest divergent character among all traits which differ each inbred lines. This could be due to Evolutionary divergence among the inbred lines or accession of the material which might governed by poly genes.

Similarly different author at different year and different countries reported that importance maize Phenological diversity for feature creation of hybrid maize [9-15].

**Table 4.** Diversity test results for major traits of 14 maize inbred lines.

Div.of traits	GY	AD	SD	PH	EH	MD	EPP	PA	EA	ED	RPE	KPR	EL	TKW
No	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Min	2.8	80.0	82.0	137.0	66.0	144.0	1.0	1.0	1.0	4.0	12.5	23.9	11.0	224.0
Max	5.5	94.0	98.0	248.3	145.3	163.3	2.0	1.7	2.3	4.8	15.1	37.8	17.6	334.7
Sum	56.0	1236.3	1285.0	2426.0	1243.0	2149.7	18.7	16.8	23.3	61.5	188.1	405.5	194.5	4099.3
Mean	4.0	88.3	91.8	173.3	88.8	153.5	1.3	1.2	1.7	4.4	13.4	29.0	13.9	292.8
Std. error	0.2	1.2	1.2	7.7	4.9	1.2	0.1	0.1	0.1	0.1	0.2	1.1	0.5	7.9
Stand. Dev	0.9	4.4	4.4	28.7	18.4	4.6	0.3	0.2	0.3	0.3	0.8	4.1	1.7	29.5
Coeff. Var	23.0	4.9	4.8	16.5	20.7	3.0	25.8	18.2	20.5	6.3	6.0	14.2	12.1	10.1

TKW were highly deviated with the value of (29.5) followed by PH with the value of (28), EH (18) and MD with the deviation value of (4.6) knowing these traits variability help the plant breeder to make cross

combination for maximizing heterogeneity. Selecting of parents having differ in a targeted trait will be serve as opportunity for creation of new variety to overcoming a given stress.

**Table 5.** Similarity and distance indices.

[illegible]

Trait combination comparison among 14 inbred lines were made to evaluate the similarity and dissimilarity and these of marked in astrix (\*) table above are inbred lines with more than 50 values for dissimilarity. The cross combination of these inbred line will be success full for creation of new variety. Hence plant breeders can use the inbred lines based on specific combining ability and General combining ability of the inbred lines. These of inbred lines having value less than 50 value might not be important for creation for new variety due to homogeny of the main yield contributing traits. Additionally the cross combination of the inbridlines with less than 50 values of dissimilarity might susceptible to the same pathogen or affect by inbreeding depression.

4. Summary and Conclusion

Identifying the DUS of a given crop is the crucial point for production of highly qualified seed by preventing genetic contamination and enhance the continuity of initial composition without losing its originality. Beside these importance it serve as registry verification to fit legally guaranteed. This study help the seed producers and different stake holders to easily identify the character of inbred lines so that they produce highly qualified seed

fitting both international and national seed standard. In addition it could provide planting time information as the maturity date and other important traits are discussed detail which are directly connected with Agro ecology selection. Finally the diversity among different traits and inbred lines were mentioned which could be helpful input for feature plant breeders to make cross combination of parents so that improving target traits will made. To know which alleles were involved for the variation among the traits further molecular marker assisted research will be required.

Conflicts of Interest

The authors declare no conflict of interest.

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Appendix: Meteorological Data of the Research Station

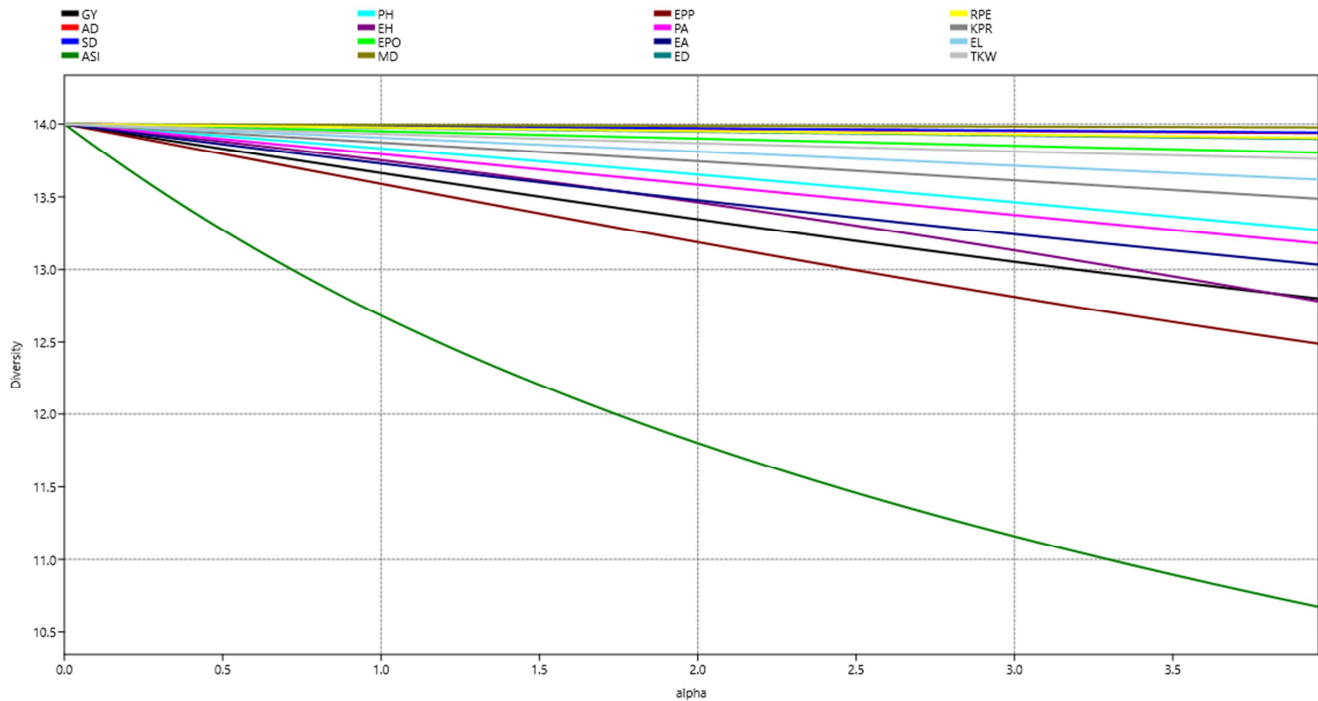


Figure 4. Alpha diversity profiles for 16 morphological traits of Maize.



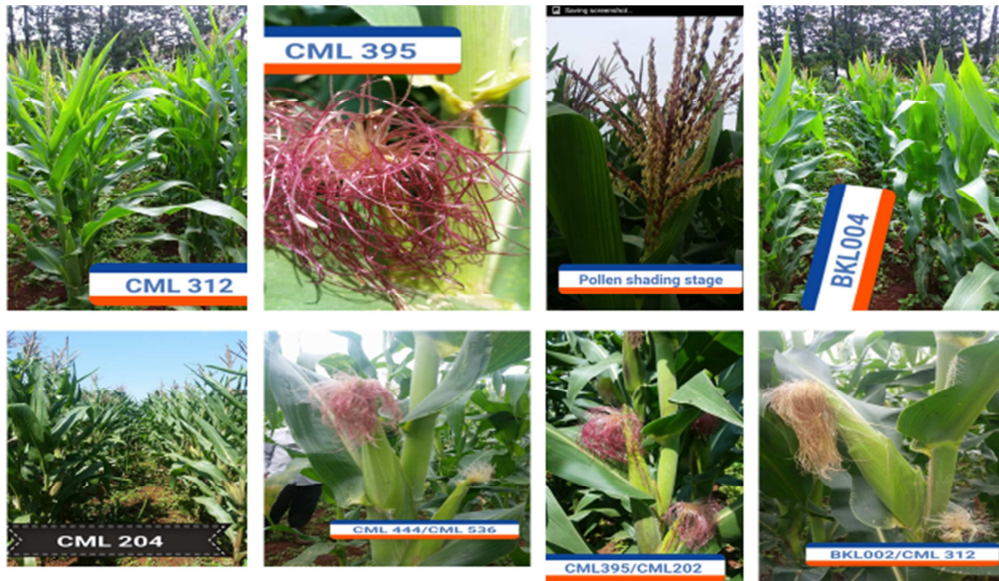


Figure 5. Some field photos of parental lines during data collection.



Figure 6. Some field photos of parental lines at Harvesting.

Table 6. Long-term (2010-2020) mean monthly field temperature, relative humidity and rainfall of Bako Agricultural research center.

Months	Rain fall (mm)	Air Temperature (°C)			Relative humidity (%)
		Minimum	Maximum	Average	
January	5.02	15.01	31.44	23.22	46.7
February	9.98	19.53	32.53	22.83	46.1
March	31.95	19.95	33.53	26.74	46.06
April	59.82	22.43	32.15	34	46.75
May	166.08	20.38	31.52	25.95	49.5
June	264.73	14.68	26.89	20.78	52.66
July	150.18	14.72	25.58	20.15	55.92
August	197.53	14.48	24.84	19.66	56
September	156.5	14.53	26.32	20.42	53.31
October	64.8	14.62	27.79	21.2	52.45
November	27.13	14.26	29.4	21.83	50.49
December	5.95	17.28	30.53	21.43	49.22
Total	1139.68	201.86	352.52	278.22	605.17
Mean	-	16.82	29.38	23.19	50.43

Source: Bako Agricultural Research Center, Weather Data (unpublished).

**Table 7.** Mean monthly field temperature, relative humidity (%) and rainfall of Bako during the study period (2019).

Months	Rain fall (mm)	Air Temperature (°C)			R.H (%)
		Minimum	Maximum	Average	
January	0	14.1	32.2	23.15	49
February	19.8	14.2	32.4	23.3	45
March	69.2	13.6	30.9	22.25	48.4
April	115.3	13.8	31.6	22.7	53
May	101.1	14.3	31	22.65	52
June	384.9	14.45	27.03	20.74	54.26
July	149.9	14.7	25.7	20.2	53.64
August	224.2	14.24	25.18	19.71	53.58
September	192.4	14.46	25.58	20.02	54.66
October	67.3	14.32	26.98	20.65	52.38
November	90	13.76	29.46	21.61	51.26
December	0	14.46	29.46	22.65	49
Total	1414.1	170.39	347.49	259.63	616.18
Mean	-	14.1992	28.9575	21.6358	51.3483

Source: Bako Agricultural Research Center, Weather Data (unpublished).

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