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MORPHOLOGICAL VARIATION IN MAIZE INBRED LINES

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Abstract

In order to identify morphological variation in maize inbred lines, one hundred five inbred lines were planted under randomized complete block design with two replications at research field of National Maize Research Program, Rampur, Chitwan, Nepal during summer season (March to June), 2010. Descriptive statistics and cluster analysis were done. The results revealed a wide range of morphological variation among the tested inbred lines. The inbred lines grouped in cluster 4 namely PUTU-13, L-9, RL-105, RL-197, RL-103, RML-9, RML-41, RL-165, RL-36, RL-76, RL-125, RL-30-3, L-6, RL-107, RL-174, RL-41, L-13, RML-76 and L-5 had 0.833 days anthesis-silking interval and earlier in flowering (tasseling in 54.50 days and silking in 55.33 days). Moreover they consisted of 1.16 plant aspect, 1.25 ear aspect, 33.08 cm tassel length and 13.5 tassel branch number. Among tested lines, the above inbred lines had better morphological traits, so it was concluded that they were good candidates for development of hybrids and synthetic varieties.

Key words: Maize inbred lines, morphological variation and cluster

Introduction

Two major sources of variation occur in field experiments: the first and most important is soil heterogeneity and the second one, is the genetic variability of the experimental material (Le Clerg, 1967). The variation in anthesis-silking interval (ASI) gives an opportunity to select inbred lines for hybrid seed production. Inbred lines having similar plant height, ear height can be used for development of synthetic varieties. The inbred lines consisting of characters like long tassel having large number of branches can be selected as parents for hybrid development. The Highland Maize Germplasm Collection Mission was launched throughout the highlands of Ethiopia in 1998 in collaboration with CIMMYT (Twumasi-Afriyie *et al.*, 2001). As part of this project, 287 maize accessions were collected from farmers' fields throughout the highland regions of Ethiopia. The field study of 180 of 287 maize accessions revealed that these accessions are highly variable for morphological and agronomic characteristics and thereby generated baseline data for future breeding and molecular studies. However, morphological variation does not always reflect real genetic variation because of genotype X environment interaction and the largely unknown genetic control of polygenic morphological and agronomic traits (Smith and Smith, 1992).

There is an important role of morphological data in the management of genetic resources that are conserved in ex situ gene-banks (Sanchez *et al.*, 2000). Many tools are now available to study relationships among cultivars, including various types of molecular markers; however, morphological characterization is the first step in the description and classification of germplasm (Smith and Smith, 1989).The characterization of morphological variability is useful tool to identify accessions with desirable characteristics such as earliness, disease resistance, or improved ear trait.

Cluster analysis is done for organizing data sets so that information can be retrieved more efficiently and be easily understood without the need for complicated mathematical techniques. It is frequently used to classify maize accessions and can be used by breeders and geneticists to identify subsets of accessions which have potential utility for specific breeding or genetic purposes (Rincon *et al.*, 1996). The main aim of using a cluster technique in the analysis of data from plant breeding trials is to group the varieties into several homogeneous groups such that those varieties within a group have a similar response pattern across the locations. It is reasonable that all the varieties in the trials will not behave completely independently of one another. For instance, those with similar genetic make-up would be expected to behave similarly. Information on morphological variation of inbred lines is not sufficient in Nepal. This study was conducted to provide information about the performance of maize lines in terms of morphological parameters, which will be helpful to maize breeders for further manipulation in subsequent hybrid and synthetic varieties development programs.

Materials and Methods

Study Site and Experiment Details

One hundred five inbred lines during summer season of 2010 (March to June) were planted using randomized complete block design with two replications at research field of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal to assess their morphological variations. The geographical location of this experimentation was 27°40'N latitude, 84°19' E longitude at an altitude of 228 m above sea level and the soil was generally acidic, light textured and sandy loam (NMRP, 2011). The total rainfall during the crop season was 934.98 mm, average maximum 34.04°C and minimum 20.78°C temperature and average relative humidity was 79.10% (NMRP, 2011). The Inbred lines were planted in fields at plot size of 4 rows of 5 m in length (15 m^2) with 75 x 25 cm spacing. Two seeds per hill were planted and thinned to a single plant per hill at first weeding. Fertilizers were applied at the rate of 120:60:40 kg/ha N_2: P_2O_5: K_2O respectively along with to 15 tones farmyard manure per hectare. Half dose of N and full doses of P and K were applied basally. The remaining half of N was applied as side dressing at knee-high stage. Irrigations were provided on weekly basis or as required during the entire crop season. The plots were kept free of weeds manually.

Data Collection and Analysis

Data on plant traits from centre two rows were recorded for five plants per inbred in each plot (randomly selected). Traits included days to 50% tasseling, days to 50% silking, anthesis silking interval (ASI), plant height, ear height, plant aspect, ear aspect, tassel length and tassel branches number. The plant and ear height were recorded 3-4 weeks after flowering. Data on plant aspects (plant and ear height, uniformity of plants, disease and insect damage and lodging) in each plot were recorded before the brown husk stage (before harvesting) on a scale of 1 to 5, where 1 and 5 represent excellent and poorest respectively. Before harvest, all ears from a plot were observed closely and ear aspects (size, disease and insect damage, grain filling and uniformity) were recorded on a scale of 1 to 5, where 1 and 5 signify the excellent and poorest respectively. Collected data were subjected to descriptive statistics and cluster analysis was carried out using MINITAB Ver. 14 statistical software.

Results and Discussion

The findings of this field study (Table 1) showed that tassel branches number had the greatest variation (44.21%), followed by plant aspect (43.75%) and ear aspect (40.74%). Among the traits, days to 50% tasseling showed the lowest variation (9.38 %). Sokolov and Guzhva (1997) also reported significant amount of variability for different morphological traits in maize inbred line populations. The morphological variation is due to mainly genetic factors and also subjected to environmental factors. The mean values of days to 50% tasseliing, days to 50% silking, plant height, ear height, plant aspect, ear aspect, tassel length and tassel branches number were 62.56, 64.54, 108.88, 48.61, 2.65, 2.8, 25.28 and 9.01 respectively.

Table 1: Descriptive statistics of average agromorphological characters of 105 maize inbred lines at NMRP, Rampur in 2010 summer season

Items	Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plant aspect (1-5)	Ear aspect (1-5)	Tassel Length (cm)	Tassel branch (No.)
Mean	62.56	64.54	108.88	48.61	2.65	2.8	25.28	9.01
SEMean	0.57	0.70	2.78	1.59	0.11	0.11	0.61	0.38
StDev	5.86	7.21	28.49	16.27	1.16	1.14	6.34	3.98
CoefVar	9.38	11.18	26.17	33.48	43.75	40.74	25.1	44.21
Range	32	32	134.5	71.5	4	4	28	19

SE: standard error, StDev: standard deviation, CoefVar: coefficient of variation

The findings of this field study (Table 2) showed that among the tested inbred lines the days to 50% tasseling was highest 82 days in L-9 and lowest 50 days in RML-7. Similarly 50% silking was highest 82 days in L-9 and lowest 52 days in RML-7. This variability may be attributed to their differential genetic constitution. Previously, Shah *et al.* (2000) have also reported similar results for different maturity traits among maize populations. Anthesis-silking interval (ASI) varied from 15 days (RL-197) to -8 days (RML-18). Ihsan *et al*. (2005) have also reported significant amount of variability for days to anthesis among different maize genotypes.

Table 2: Mean data of morphological traits of 105 maize inbred lines at NMRP, Rampur in 2010 summer season

*Code No.	Genotypes	Flowering 50% (days)		ASI (days)	Average height (cm)		Aspect (1-5)		Tassel length (cm)	No. of Tassel branch
		Tasseling	Silking		Plant	Ear	Plant	Ear		
1	RL-114	58	60	2	120	50	4	4.5	28.55	8
2	RL-103	73	80	7	75	35	3.5	5	29.8	6
3	RL-12	59	58	-1	85.5	40	3.5	2.5	22.7	19
4	RL-129	60	58	-2	120.5	50	3	2	24.42	7
5	RL-28	58	61	3	132	50	2	4	32	13
6	RL-31	66	68	2	110.5	50	2.5	2.5	28	17
7	RL-80	61	62	1	162	81	1	1	33.5	15
8	RL-117	64	70	6	119	51	2.5	2.5	26	6
9	RL-36	63	68	5	81.5	34	2	2	22.75	6
10	RL-85	52	53	1	173.5	75.5	1	1	29.25	20
11	RL-100	63	69	6	140	50	3	3	32	9
12	RL-118	55	59	4	117	37.5	3	3.5	24	9
13	RL-116	54	56	2	171	60	2	2	41	9
14	RL-112	52	54	2	133	66	2	1.5	26	15

15	RL-140	58	60	2	147.5	65.5	1.5	1.5	30	22
16	RL-25	57	60	3	138	66.5	1.5	2	32	12
17	RML-41	70	80	10	80	30	4.5	4.5	22	6
18	RML-12	59	61	2	142.5	56	2	1.5	24	14
19	RML-9	72	80	8	75	25	2.5	3.5	25	9
20	RL-177	60	62	2	119.5	56.5	2.5	2.5	25	10
21	RML-6	59	61	2	140	65	1	1	42	11
22	RL-29	66	62	-4	85	48	4	3.5	23	13
23	RL-153	68	71	3	90.5	35.5	2.5	2.5	27	6
24	RL-1	59	62	3	122.5	55	1	2	35	13
25	RL-101	57	60	3	121.5	54.5	2	2.5	29	10
26	RL-161	59	62	3	111	51	3	2.5	27	8
27	RL-41	67	69	2	78.5	25	3.5	3	18	5
28	RL-166	67	62	-5	112	45	4	3	27	8
29	RML-7	51	54	3	113.5	53	2	2.5	26.2	16
30	RL-97	59	60	1	66.5	30	5	5	14.4	13
31	RL-197	65	80	15	85	27.5	4.5	4.5	23	9
32	RL-30-1	66	62	-4	70	27.5	4	4	23.6	7
33	RL-159	62	63	1	116.5	46	2.5	3.5	23.35	7
34	RL-170	66	69	3	140.5	56	1.5	1.5	33	10
35	RL-165	73	80	7	78	30	5	5	19.34	5
36	RL-108	55	57	2	117.5	50	2	2	23	12
37	RL-76	62	67	5	84	32	3.5	4	25.5	15
38	RL-94	57	59	2	148.5	75	1.5	2	32.25	19.5
39	RL-95	63	65	2	95	43.5	3	3	32.5	6
40	RL-160	56	57	1	122.5	53	2	2	25.5	10.5
41	RML-54	60	61	1	118	42.5	2	1.5	14.3	5
42	RL-137	61	59	-2	95.5	32.5	3.5	3.5	24.75	10.5
43	RML-68	66	61	-5	125	45	3.5	3	22.5	12.5
44	RML-18	78	70	-8	39	11	2	2	15.5	5
45	RML-7	50	52	2	173	77.5	1	1.5	28.75	16
46	RML-76	60	56	-4	135	49.5	2.5	2	30.5	11
47	RL-154	66	59	-7	103	56	2.5	2.5	33.75	9.5
48	RL-84	59	61	2	122.5	60	2.5	2	32.5	7.5
49	RL-105	63	66	3	80.5	30	2	2.5	41	6
50	RL-194	74	78	4	50	27	4	2	24	5
51	RML-17	63	60	-3	140	75	1	1	37.5	14
52	RML-40	72	80	8	51	15	4.5	5	17.2	9
53	RML-74	55	56	1	173	82.5	1	1	28	10
54	RL-107	70	74	4	90	25	4.5	5	20	5
55	RL-13-2	66	70	4	95	30	2.5	3	23	7
56	RL-96	59	60	1	105.5	52.5	2	2.5	24	9
57	RL-17	63	66	3	130.5	50	2.5	2	29	8
58	RL-150	62	66	4	93	40.5	5	5	14	4

59	NML-2	62	59	-3	97.5	48	2	2	28	10
60	RL-189	55	53	-2	157.5	63	1	1	38	11
61	RL-167	63	66	3	72.5	30	5	5	14	4
62	RML-8	52	50	-2	148.5	73.5	1	3	32	8
63	RL-143	63	70	7	93.5	45	3.5	4	20	6
64	RL-86	62	70	8	91	46	5	5	15	5
65	RL-174	71	75	4	90	21	5	2	18	6
66	RL-30-3	70	73	3	90	35	4.5	4.5	15	4
67	RML-76	70	73	3	80	25	3	4	14	6
68	RL-125	65	67	2	86	30	4.5	4.5	16	5
69	L-12	62	62	0	129	67.5	1.5	3	25	13
70	L-11	70	73	3	120.5	61	1.5	2.5	28	6
71	PUTU-13	71	73	2	80	50	4.5	4.5	22	6
72	PUTU-22	62	66	4	85.5	48	4	4.5	26	7
73	PUTU-15	70	72	2	127.5	57.5	3	3.5	25	4
74	PUTU-17	62	61	-1	109	51	3	2	28	9
75	L-9	82	82	0	82.5	40	2.5	2.5	20	5
76	L-8	66	70	4	91	40	1.5	1.5	25	9
77	L-7	63	66	3	95	51	1.5	2	26	6
78	L-6	69	72	3	82.5	37.5	2	4.5	18	8
79	L-5	70	73	3	80	25	3.5	3.5	14	3
80	L-4	56	58	2	132	80	3.5	3.5	22	12
81	L-3	64	60	-4	96	38.5	2	2.5	17	4
82	L-2	57	56	-1	150	75	1	1	28	13
83	L-1	64	69	5	88.5	46	1.5	2	25	9
84	AG-20	57	57	0	131	60	1.5	2	30	6
85	PUTU-19	60	62	2	127	75.5	1	1	31	13
86	PUTU-12	59	61	2	94	50	3.5	3	20	3
87	PUTU-8	65	70	5	97.5	40	3.5	3	25	8
88	PUTU-18	58	59	1	139	69.5	1.5	1.5	28	17
89	PUTU-4	56	57	1	150	78	2.5	3	30	7
90	PUTU-14	63	62	-1	110	47.5	1.5	2	34	7
91	L-24	64	62	-2	118.5	60	1.5	2.5	30	9
92	L-20	59	60	1	142.5	73	1.5	2	29	9
93	L-19	59	60	1	117.5	64.5	2	2.5	26	7
94	L-18	62	70	8	96.5	40.5	2	3	18	9
95	L-17	58	61	3	95	37.5	2.5	3	22	9
96	L-16	64	66	2	60	25	4.5	5	14	5
97	L-25	57	58	1	140	60	1.5	2	16	6
98	PUTU-3	61	59	-2	106	55	2	2	26	9
99	PUTU-21	70	73	3	95	45	3.5	3.5	18	4
100	PUTU-16	58	57	-1	122.5	70	2.5	2.5	22	8
101	PUTU-7	64	71	7	93	42.5	2.5	2.5	26	13
102	L-15	69	71	2	98	57.5	2.5	3	26	9

103	L-14	62	66	4	90	37.5	2.5	2.5	27	8
104	L-13	66	70	4	75	30	3.5	3.5	19	5
105	PUTU-20	59	60	1	117.5	67.5	2.5	2.5	31	7

**The name of inbred lines were assigned as code no. for their clustering in dendrogram*

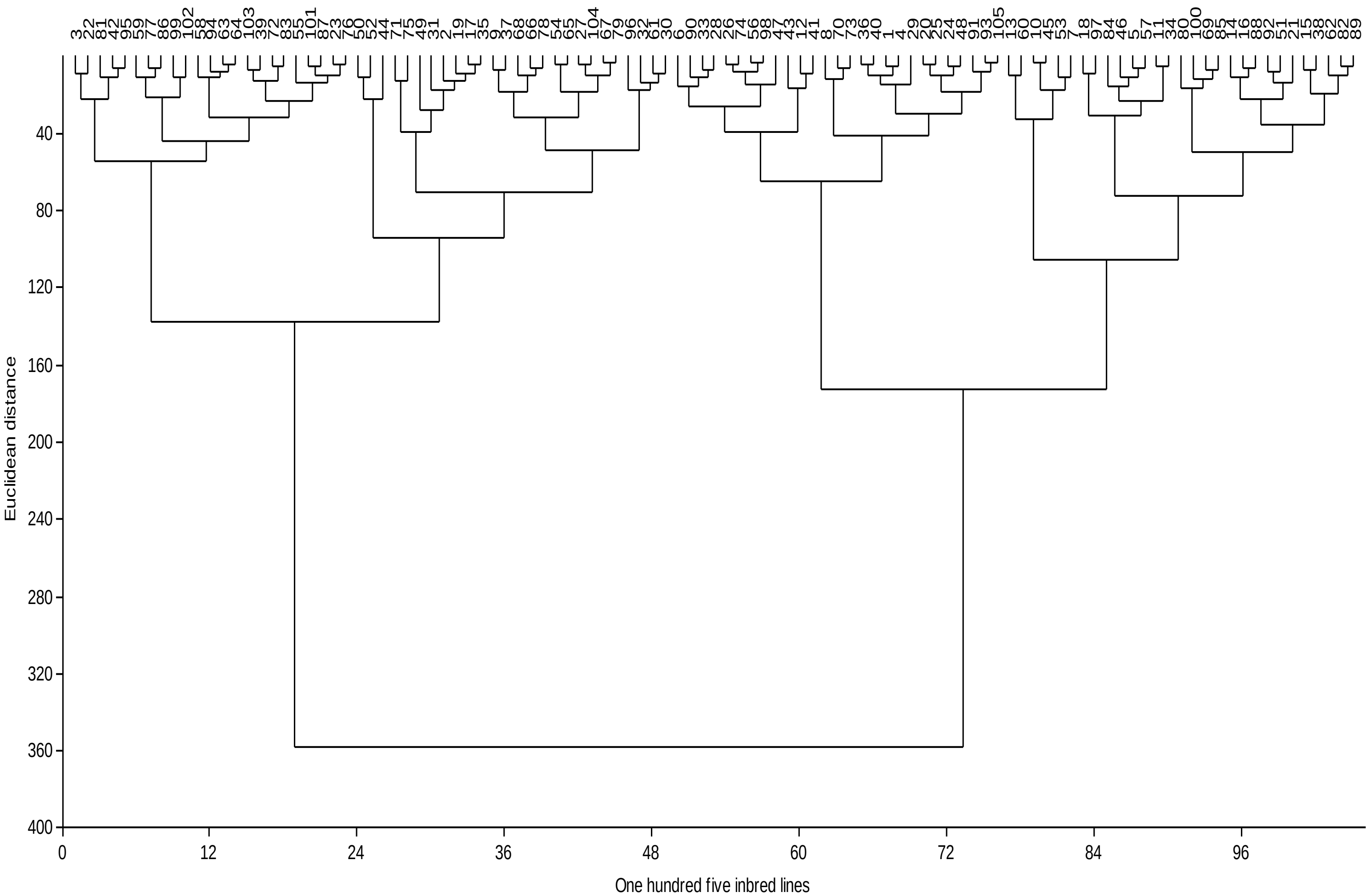

Figure 1: Dendrogram (algorithm: Ward's method and similarity measure: Euclidean distance) depicting relationship among 105 inbred lines based on morphological traits at NMRP, Rampur in 2010 summer season

Plant height ranged from 173.5 cm (RL-85) to 39 cm (RML-18). This variation may be attributed to their genetic background. These results are in conformity with those of Ihsan *et al.* (2005) who also reported significant amount of variation among different maize populations for morphological traits. Similarly ear height ranged from 82.5 cm (RML-74) to 11 cm (RML-18). These results are in line with those of Ullah (2004) and Shah *et al.* (2000) who had reported significant amount of variability for ear height among different maize populations. Generally medium type of ear height is preferred, having ear in the middle. The observed variation in plant and ear height may be attributed to differences at the genotypic level. Dijak *et al.* (1999) who also reported significant amount of variability among long and short stature maize populations for ear and plant height. Tassel length was highest 42 (RML-6) to lowest 14 (RL-150, RL-167, RML-76, L-16 and L-5). Number of tassel branches was highest 22 (RL-140) to lowest 3 (L-5 and PUTU-12).

Similarly plant aspect was poorest (highest) 5 (RL-167, RL-86, RL-174, RL-150 and RL-165) to excellent (lowest) 1 (RL-80, RL-85, RML-6, RL-1, RML-7, RML-17, RML-74, RL-189, RML-8, L-2, and PUTU-19). Ear aspect was poorest (highest) 5 (RL-103, RL-165, RML-40, RL-107, RL-150, RL-167, RL-86, and L-16) to excellent (lowest) 1 (RL-80, RL-85, RML-6, RML-17, RML-74, RML-189, L-2 and PUTU-19).

Clustering pattern of inbred lines under this study reveals that the inbred lines showed considerable genetic diversity among themselves by occupying eight different clusters (Table 3). Similar results were reported by Singh *et al.* (2005) in maize.

Table 3: Agro-morphological traits of 105 inbred lines within and among 8 clusters recorded at NMRP, Rampur in 2010 summer season

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8
Days to 50%tasseling	61	66	58.56	54.50	63	78	63	73
Days to 50 Silking	61.66	69.66	59.65	55.33	62.66	70	66	79
ASI (days)	0.66	3.66	1.08	0.83	-0.33	-8	3	6
Plant height (cm)	116.44	87.66	138.217	168.33	65.5	39	80.5	50.5
Ear height (cm)	52.68	37.38	65.5	73.25	27.5	11	30	21
Plant aspect (1-5)	2.42	3.309	1.783	1.16	4.5	2	2	4.25
Ear aspect (1-5)	2.53	3.45	2.065	1.25	4.66	2	2.5	3.5
Tassel length (cm)	26.92	21.57	29.272	33.08	17.33	15.5	41	20.6
No. of tassel branches	9	7.20	11.761	13.5	8.33	5	6	7

These inbred lines were grouped based on mainly tasseling and silking days, ASI, plant height, ear height, plant aspect, ear aspect, tassel length and tassel branches numbers. The values fall within clusters are presented in following Table 4.

Table 4: Grouping of 105 inbred lines into 8 clusters based on agro-morphological traits recorded at NMRP, Rampur in 2010 summer season

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8
RL-12, RL-29, L-3, RL-137, L-17	NML-2, L-7, PUTU-12, PUTU-21, L-15, RL-150, L-18, RL-143, L-14, RL-95, PUTU-22, L-1, RL-13-2, PUTU-7, PUTU-8, RL-153, L-8	RL-194, RML-40, RML-18	PUTU-13, L-9, RL-105, RL-197, RL-103, RML-9, RML-41, RL-165, RL-36, RL-76, RL-125, RL-30-3, L-6, RL-107, RL-174, RL-41, L-13, RML-76, L-5	RL-31, PUTU-14, RL-159, RL-166, RL-161, PUTU-17, RL-96, PUTU-3, RL-154, RML-68, RL-118, RML-54	RL-117, RL-11, PUTU-15, RL-108, RL-160, RL-114, RL-129, RML-7, RL-177, RL-101, RL-1, RL-84, L-24, L-19, PUTU-20	RL-116, RL-189, RL-85, RML-7, RML-74, RL-80	RML-12, L-25, AG-20, RML-76, RL-28, RL-17, RL-100, RL-170, L-4, PUTU-16, L-12, PUTU-19, RL-112, RL-25, PUTU-18, L-20, RML-17, RML-6, RL-140, RL-94, RML-8, L-2, PUTU-4

Conclusion

The morphological variation in traits like flowering (tasseling and silking), anthesis-silking interval (ASI) , plant height, ear height, plant aspect, ear aspect, tassel length and tassel branches number provides an opportunity to select inbred lines for hybrid and synthetic varieties development and their seed production. The inbred lines grouped in cluster 4 namely PUTU-13, L-9, RL-105, RL-197, RL-103, RML-9, RML-41, RL-165, RL-36, RL-76, RL-125, RL-30-3, L-6, RL-107, RL-174, RL-41, L-13, RML-76 and L-5 had 0.833 days anthesis- silking interval. These inbred lines were earlier in flowering (tasseling in 54.50 days and silking in 55.33 days) and also had better values in terms of ASI, plant aspect, ear aspect, tassel length, tassel branches number. They had 0.83 days ASI, 1.16 plant aspect, 1.25 ear aspect, 33.08 cm tassel length and 13.5 tassel branch number. Thus morphological performances of these inbred lines were better, so they can be used for development of hybrids and synthetic varieties.

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