Research Article

Evaluation of Maize Hybrids for Maturity and Related Traits

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Abstract | Low production of maize in Pakistan is mainly due to the unavailability of high yielding and early maturing varieties and hybrids. Earliness in maize is highly desirable as it allows plants to escape various biotic and abiotic stresses. It also makes multiple cropping possible as the land becomes available for next crop. Keeping the importance of early maturity of maize crop in view, the present study was conducted to evaluate different maize hybrids for maturity and related traits in the geographical location of Khyber Pakhtunkhwa. The experiment was conducted at The University of Agriculture, Peshawar during the cropping season of 2016. Randomized complete block design was used, having two replications and 35 genotypes, comprised of 33 hybrids and two local checks. Data were recorded on days to 50% tasseling, days to 50% anthesis, days to 50% silking, anthesis silking interval, plant height and ear eight. Analysis of variance revealed highly significant differences for all the traits except anthesis silking interval that exhibited non-significant difference among the tested genotypes. Moderate to high broad sense heritability were observed for all the traits. Hybrid, HP1097-21 showed minimum days to tasseling, anthesis, and silking (70.5, 73.0, and 76.5, respectively) and hence proved to be the earliest maturing hybrid. It also had desirable plant and ear height of 148.80 cm and 70.00 cm, respectively. The present study revealed considerable amount of variation among the tested hybrids that may be exploited in future breeding programs for developing early maturing maize hybrids accompanied with other desirable attributes.

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Introduction

Maize, botanically known as *Zea mays* L. is a diploid plant species that belongs to the grass family (*Poaceae*) (Suleiman et al., 2013). It is a monoecious and highly cross pollinated plant and is the highest yielding cereal crop in the world with significant importance in countries such as Pakistan due to the ever increasing population pressure. Maize is the third largest grown cereal after wheat and rice. The area under maize cultivation in Pakistan was 1168.5 thousand hectares with production of 4944.2 thousand tons (PBS, 2014).

Maize is a high yielding crop with tremendous yield potential than any other cereal, but its' yield in Pakistan is low as compared to other maize growing countries of the world. This low yield of maize in Pakistan can be attributed to the unavailability of high yielding and early maturing varieties and hybrids. In order to improve the yield of maize per hectare in Pakistan, there is need to develop open pollinated varieties and hybrids of maize that are high yielding, early maturing, widely adopted, having disease and insect resistance, responsive to improved production practices and adjustable in the existing cropping pattern.

In Pakistan about 65% maize is cultivated on irrigated land, while the remainder is cultivated under rain fed conditions. Maize is highly sensitive to drought;

therefore, it requires frequent irrigations for successful vegetative and reproductive growth (Rashid and Rasool, 2011). Drought affects many physiological processes and hence causes considerable reduction in yield. The yield of maize is also greatly affected by different diseases and insects that mostly appear during later stages of the crop. A recently emerging constraint to increased crop production is the change in the climatic pattern. To cope with this issue the farmers have to alter the existing cropping pattern and farming practices (Bhandari, 2013). This change in the climate is also becoming a major threat to the production of maize. Early maturing varieties and hybrids are needed in order to cope with these newly emerging constraints. The production of early maturing varieties and hybrids may prevent yield losses by escaping the terminal droughts, as well as disease and insect attacks to considerable extent. Cultivation of early maturing hybrids and varieties also promote production of two or more crops per year and adjust easily in the existing cropping pattern (Larson and James, 1993).

Keeping the importance of early maturing varieties and hybrids, the current experiment was conducted with the objectives to evaluate different maize hybrids for maturity and its associated traits, select an early maturing hybrid from a group of hybrids and to estimate heritability for various traits associated to maturity.

Materials and Methods

In order to assess different maize hybrids for maturity and related traits, the present study was conducted during spring 2016 at Malakander Research Farm, The University of Agriculture, Peshawar (340 01" N latitude, 710 35" E longitudes with altitude of 359 ft.). A set of 33 hybrids and two local checks, procured from CIMMYT were evaluated by using randomized complete block design, having two replications. Each subplot consisted of two rows, having row length of 5 m and row-to-row space of 0.75m. Sowing was done on 8th march 2016 by planting 50 seeds in each plot. The crop was raised following all the recommended farming practices.

Data were recorded on days to tasseling, anthesis, sillking, anthesis silking interval, plant height and ear height at appropriate stage. For flowering attributes the date on which more than 50% plants in a plot exhibited the trait expression was recorded while for plant and ear height, data were taken on ten randomly selected plants in each plot. Analysis of variance was used to determine significant differences among the hybrids for various parameters using the procedure of Gomez and Gomez (1984) for Randomized Complete Block Design. The data were also subjected to computer program "Statistix 10.1" for statistical analysis.

Broad sense heritability was estimated for the above listed parameters using the formula of Feher (1987).

Heritability Broad sense (h^2bs) = $\delta^2g/\ \delta^2p$
Genetic variance (δ^2g) = MSG – MSE / r
Phenotypic Variance (δ^2p) = MSG/r where as;
MSG = Genetic mean squares from the analysis of variance (ANOVA)
MSE = Error mean squares of ANOVA
r = number of replications

Results and Discussion

Days to 50% tasseling

Analysis of variance revealed highly significant ($P \leq 0.01$) differences among the hybrids for days to tasseling. Coefficient of variance (CV) was 1.92% (Table 1). Data for days to 50% tasseling ranged from 70.5 to 77.0. Minimum days to 50% tasseling (70.5) were observed for HP1097-21, HP1100-11, HP1100-6, HP1100-22, HP1097-10, local check 2 (Gulabadi) and HP1100-8, while on the other hand maximum days to 50% tasseling (77.0) were observed for the hybrids HP1097-13 and HP1100-30. LSD for mean comparison among hybrids was 2.84 days (Table 2). High broad sense heritabilty value (79.03%) was observed for days to 50% tasseling (Table 3). Days to 50% tasseling determine the maturity duration in maize crop and is an important character in maize breeding. Our results are similar to those of Muchie and Fentie (2016) who also observed highly significant ($P \leq 0.01$) differences for days to tasseling in maize hybrids. Vashistha et al. (2013) also reported highly significant ($P \leq 0.01$) differences among different maize genotypes along with high broad sense heritability value for days to 50% tasseling.

Days to 50% anthesis

Days to 50% anthesis is an important character for determining maturity period in maize crop. Pollen grains remain viable for a shorter period of time as

compared to silks and will desiccate and lose their viability, if pollination does not occur within 1-2 days of anthesis. Pollen shedding at right time and its perfect synchronization with silking will ensure high kernel filling and ultimately higher yield. Statistical analysis revealed highly significant (P ≤ 0.01) differences among the hybrids tested for days to anthesis. Coefficient of variance (CV) was 1.67% (Table 1). Days to 50% anthesis ranged between 73.0 to 80.5 days. Hybrids, HP1100-11 and HP1097-21 took minimum days to 50% anthesis (73.0), while the hybrid HP1100-30 needed maximum days to 50% anthesis (80.5). LSD for mean comparison among the hybrids was 2.58 days (Table 2). High broad sense heritability value (82.24%) was observed for days to 50% anthesis (Table 3). Muchie and Fentie (2016) also reported highly significant (P ≤ 0.01) differences among maize hybrids for days to anthesis and observed high broad sense heritabilty value for days to anthesis. Sesay et al. (2016) also reported highly significant differences among top-cross and three way cross hybrids for days to 50% anthesis, while evaluating top- cross and three-way cross maize hybrids. They also reported high broad sense heritability value for days to 50% anthesis in top-cross hybrids and moderate broad sense heritability value for days to 50% anthesis in three-way cross hybrids.

Table 1: *Mean square (MS) values and coefficient of variation (CV) for various traits of 35 maize hybrids.*

Traits	Genotype mean squares	Error mean squares	Coefficient of variation (%)
Days to tasseling	8.33**	1.95	1.92
Days to pollen shedding	8.26**	1.61	1.67
Days to silking	9.88**	2.29	1.90
Anthesis silking interval	0.91ns	0.65	21.95
Plant height	361.57**	112.10	6.39
Ear height	214.54**	35.92	7.47

*NS = non-significant; *,** significant at 5% and 1% levels of probability, respectively.*

Days to 50% silking

Days to 50% silking is recorded as a measure of maturity. Days to 50% silking along with other maturity traits are commonly used by maize breeders for determining maturity duration in maize crop and are considered important in maize breeding. Highly significant (P ≤ 0.01) differences were observed for days to 50% silking among the hybrids studied. Coefficient of variance (CV) was 1.90% (Table 1). Range for 50% silking was 76.5 to 84.5. Minimum days to 50% silking (76.5) were observed for HP1097-21. On the contrary, maximum days to 50% silking (84.5) were observed for HP1100-30. LSD for comparison among the means was 3.07 days (Table 2). High broad sense heritability value (79.25%) was observed for days to 50% silking (Table 3). Our results are similar to those observed by Muchie and Fentie (2016) while evaluating different maize hybrids in order to asses the association among yield and yield related traits. Akbar et al. (2008) also observed highly significant differences among different maize hybrids along with high broad sense heritability value.

Anthesis-silking interval

Results showed non-significant differences among the hybrids tested for anthesis-silking interval. Coefficient of variance (CV) was 21.95% (Table 1). Range for anthesis-silking was 2.5 to 6.0. Minimum anthesis-silking interval (2.5) was observed for HP1100-24, and Hp1100-14, while maximum anthesis-silking interval (6.0) was observed for HP1097-5. LSD for comparison among the means was 1.64 (Table 2). Moderate broad sense heriability value (47.40%) was observed for anthesis-silking interval (Table 3). Pollen grains are more sensitive to environmental stresses and they may lose their viability quickly under high temperature and drought conditions. For successful pollination there must be synchronization between pollen shedding and silking, as it leads to higher seed setting and finally higher yield. If asynchrony prevails in days to pollen shedding and silking, it will lead to low seed setting and ultimately low grain yield. Similar results were obtained by Rahman et al. (2010) who also reported non-significant differences for anthesis-silking interval among different maize hybrids while evaluating different maize hybrids for stability.

Plant height (cm)

Plant height is an important agronomic character that plays significant role in plant lodging. Therefore, maize breeders give special attention to this character in maize breeding. Semi-dwarf plants are desired, because such plants are more resistant to lodging and are fertilizer responsive as well. Analysis of variance revealed highly significant (P ≤ 0.01) differences for plant height among the hybrids tested. Coefficient of variance (CV) was 6.39% (Table 1). Range for plant

Table 2: *Mean values for flowering tratis, plant height and ear height of 35 maize hybrids.*

Hybrids	Days to Tasseling	Days to pollen Shedding	Days to Silking	Anthesis silking Interval	Plant height (cm)	Ear height (cm)
HP1100-46	73.00 DEFG	76.00 DEFG	79.50 DEFGH	3.50 BCD	149.70 IJK	70.00 KLMN
HP1097-21	70.50 GH	73.00 H	76.50 H	3.50 BCD	148.80 JK	70.00 KLMN
HP1097-13	77.00 A	79.00 ABC	83.00 ABC	4.00 ABCD	171.90 BCDEFG	82.70 DEFGHIJ
HP1100-11	70.50 GH	73.00 H	77.00 GH	4.00 ABCD	150.30 HIJK	79.20 EFGHIJK
HP1097-5	73.00 DEFG	76.00 DEFG	82.00 ABCD	6.00 A	163.80 CDEFGHIJK	91.10 ABCDE
HP1097-4	71.50 EFGH	73.50 GH	77.00 GH	3.50 BCD	144.90 K	65.60 MN
HP1097-15	72.50 DEFG	76.50 CDEF	80.00 CDEFG	3.50 BCD	182.90 ABCD	98.00 AB
HP1100-27	73.50 CDEF	76.00 DEFG	79.50 DEFGH	3.50 BCD	176.00 BCDEF	80.40 EFGHIJK
HP1100-34	71.00 FGH	74.00 FGH	77.00 GH	3.00 CD	180.60 ABCDE	84.40 DEFGHI
HP1100-31	74.50 ABCD	78.00 ABCD	81.50 ABCD	3.50 BCD	173.10 BCDEFG	93.00 ABCD
HP1097-8	76.00 ABC	78.00 ABCD	81.00 BCDE	3.00 CD	148.90 JK	76.00 FGHIJKLM
HP1100-28	74.50 ABCD	77.50 BCD	81.50 ABCD	4.00 ABCD	167.70 CDEFGHIJ	84.50 DEFGH
HP1100-32	76.50 AB	79.00 ABC	83.00 ABC	4.00 ABCD	159.90 EFGHIJK	71.20 JKLMN
HP1097-23	74.50 ABCD	77.50 BCD	80.50 CDEF	3.00 CD	192.10 AB	97.70 AB
HP1100-6	70.50 GH	73.50 GH	77.00 GH	3.50 BCD	158.90 FGHIJK	73.80 HIJKLMN
HP1097-3	73.00 DEFG	76.50 CDEF	80.00 CDEFG	3.50 BCD	191.90 AB	96.70 ABC
HP1100-30	77.00 A	80.50 A	84.50 A	4.00 ABCD	184.00 ABC	93.90 ABCD
HP1097-1	72.50 DEFG	75.50 DEFGH	79.50 DEFGH	4.00 ABCD	163.40 CDEFGHIJK	88.00 BCDEF
HP1097-16	74.00 BCDE	76.50 CDEF	80.50 CDEF	4.00 ABCD	170.80 BCDEFGHI	85.50 CDEFGH
HP1100-38	73.50 CDEF	76.50 CDEF	81.00 BCDE	4.50 ABC	161.40 DEFGHIJK	77.60 FGHIJKLM
HP1097-6	71.50 EFGH	74.50 EFGH	77.50 FGH	3.00 CD	173.80 BCDEFG	87.30 BCDEF
HP1100-22	70.50 GH	73.50 GH	77.50 FGH	4.00 ABCD	172.20 BCDEFG	66.80 MN
HP1097-10	70.50 GH	74.00 FGH	77.50 FGH	3.50 BCD	152.30 GHIJK	66.90 LMN
HP1100-24	74.00 BCDE	77.00 CDE	79.50 DEFGH	2.50 D	163.90 CDEFGHIJK	79.50 EFGHIJK
HP1100-35	71.00 FGH	74.50 EFGH	77.50 FGH	3.00 CD	162.50 CDEFGHIJK	69.60 KLMN
Hp1100-14	72.00 DEFGH	75.50 DEFGH	78.00 EFGH	2.50 D	159.30 EFGHIJK	72.30 IJKLMN
HP1100-25	74.50 ABCD	77.50 BCD	81.00 BCDE	3.50 BCD	159.40 EFGHIJK	68.30 KLMN
HP1097-2	71.00 FGH	74.00 FGH	77.50 FGH	3.50 BCD	171.40 BCDEFGH	80.20 EFGHIJK
HP1100-26	73.00 DEFG	75.50 DEFGH	80.50 CDEF	5.00 AB	162.10 DEFGHIJK	86.30 BCDEFG
HP1100-8	70.50 GH	74.00 FGH	77.50 FGH	3.50 BCD	148.90 JK	82.30 DEFGHIJ
HP1100-37	76.50 AB	80.00 AB	84.00 AB	4.00 ABCD	198.70 A	101.00 A
HP1097-7	72.00 DEFGH	74.50 EFGH	77.50 FGH	3.00 CD	166.50 CDEFGHIJ	74.20 GHI-JKLMN
HP1100-21	72.50 DEFG	76.00 DEFG	80.50 CDEF	4.50 ABC	161.30 EFGHIJK	79.00 EFGHIJKL
local check 1 (Azam)	71.50 EFGH	74.00 FGH	78.00 EFGH	4.00 ABCD	152.30 GHIJK	63.70 N
local check 2 (Gulabadi)	70.50 GH	73.50 GH	77.00 GH	3.50 BCD	156.60 FGHIJK	71.60 JKLMN
Range	70.50 - 77.00	73.00 - 80.50	76.50 - 84.50	2.50 - 6.00	144.90 - 198.70	63.70 - 101.00
LSD (0.05)	2.84	2.58	3.07	1.63	21.52	12.18

height was 144.90 to 198.70 cm. Short plants (144.90 cm) were observed for HP1097-4. Conversely the tallest plants (198.70 cm) were observed for HP1100-37. LSD for mean comparison was 21.52 cm (Table 2). High broad sense heriability value (73.15%) was observed for plant height (Table 3). Similar results were obtained by Hussain and Hassan (2014) also indicated highly significant differences among

maize hybrids and high broad sense heritability value for plant height. Muchie and Fentie (2016) also obtained highly significant differences among maize hybrids and high broad sense heritability value for plant height which are in conformity to our results.

Table 3: *Heritabilty (h^2_{bs}) values for various traits of 35 maize hybrids.*

Traits	Genotypic variance	Phenotypic variance	Broad sense heritability (%)
Days to tasseling	7.36	9.31	79.05
Days to pollen shedding	7.46	9.07	82.24
Days to silking	8.74	11.03	79.25
Anthesis silking interval	0.59	1.23	47.40
Plant height	305.52	417.62	73.15
Ear height	196.58	232.50	84.55

High = more than 60; Moderate = more than 30 and less than 6; Low = less than 30

Ear height (cm)

Ear height will indirectly increase yield through reduction in lodging, hence an optimum level for ear height is always desirable. Reducing the ear height below that level will decrease the yield as it becomes exposed to the rodents attack in open field. Highly significant ($P \leq 0.01$) differences were observed among hybrids tested for ear height. Coefficient of variance (CV) was 7.47% (Table 1). Range for ear height was 63.70 to 101.00 cm. Local check 1 (Azam) exhibited minimum (63.70 cm) ear height while HP1100-37 showed maximum (101.0 cm) ear height. LSD for mean comparison was 12.18 cm (Table 2). High broad sense heriability value (84.55%) was observed for ear height (Table 3). Our results are in accordance to those of Nayaka et al. (2015) who obtained highly significant differences among the different genotypes for ear height along with high broad sense heritability value.

Conclusions

The present study revealed moderate to high broad sense heritability values for all the traits. Hybrid, HP1097-21 showed minimum days to tasseling, anthesis, and silking (70.5. 73.0, and 76.5, respectively) and hence proved to be the earliest maturing hybrid. It also had plant and ear height of 148.80 and 70.00 cm, respectively, which were closer to the mean values. Due to its moderate stature and central ear placement negligible amount of lodging was observed in it. The study also revealed considerable amount of variations among the tested hybrids that may be used in future breeding programs for developing early maturing maize hybrids.

Author's Contributions

ZU conducted the experiments, collected and analysed data and wrote the manuscirpt. HR designed the experiments, provided the experimental material and revised the manuscript. NM collected the data and entered it.

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