Research Article

Evaluation of Maize Hybrids for Yield and Maturity Traits

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Abstract | Evaluation of genotypes for yield and its associated traits is an essential step towards the development of a crop variety. Crop breeders mostly practice selection for the desired traits to identify superior genotypes. This research was conducted to assess the performance of 20 maize hybrids along with two checks at The University of Agriculture Peshawar during spring 2017 crop growing season. The experimental material was planted in randomized complete block design with three replications. Significant differences among the hybrids were observed for plant height, ear height, days to tasseling, days to anthesis, days to silking, cob length, cob diameter, kernel rows cob^{-1}, 100-kernel weight and grain yield. Among the hybrids, ZH1610 was observed as the earliest maturing hybrid with minimum days to tasseling (91.7), days to anthesis (93.7) and days to silking (96). Hybrid ZH169 showed maximum cob length (19.5 cm) while ZH1621 produced maximum kernel rows cob^{-1} (15.7). Maximum 100-kernel weight (35.0 g) was recorded for CAH153 while hybrid ZH1620 gave maximum grain yield (12412.8 kg ha^{-1}). The present study revealed ample variation among the hybrids for yield and yield related traits. On the basis of superior performance for maturity, yield and associated traits, hybrids ZH610, ZH169, ZH1621, CAH153 and ZH1620 are recommended for commercial cultivation after multi-location trials and onward utilization in maize breeding programs.

Received | March 07, 2018; **Accepted** | November 22, 2018; **Published** | January 06, 2019
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Citation | Khan, M.U., S.M.A. Shah, H. Rahman, A. Iqbal and E. Aslam. 2018. Evaluation of maize hybrids for yield and maturity traits. *Sarhad Journal of Agriculture,* 35(1): 7-12.
DOI | http://dx.doi.org/10.17582/journal.sja/2019/35.1.7.12
Keywords | Maize hybrids, Genetic variation, Heritability, Maturity traits, Yield and yield related traits

Introduction

Maize (*Zea mays* L.) belongs to the family of grasses (Poaceae) and is the one of the most important cereal crops worldwide after wheat and rice. The word maize has been derived from a Spanish word "Maiz" and is the domesticated variant of teosinte (*Zea mexicana*). The natives of Mesoamerica first domesticated this crop while the most diversity has been reported in Mexico. In Pakistan, maize is the 4th prime growing crop after wheat, rice and cotton. In Pakistan the area under maize cultivation was 1334 thousand hectares with the production of 6130 thousand tons (FAOSTAT, 2016). Peshawar, Kohat, Malakand, Hazara, and D.I Khan are the main maize growing regions of the province of Khyber Pakhtunkhwa.

In Pakistan, maize is used as a short duration food crop and provides two crops per year. This aspect of maize crop could play a vital role to ensure food security. It is cultivated in two seasons i.e. spring and autumn. Spring maize is planted from first week of February up to first week of March whereas planting time for autumn maize begins from first week of July to the middle of August. Apart from the use of maize as a cereal, it also serves as a multi-purpose crop. It is used as fodder, feed for livestock and generating silage later fermentation of corn-stocks. The demand for maize has been extensively enhanced on account of its extensive use in the poultry and livestock feed industry.

Maize production in Pakistan is lower than the other developed countries of world. It is imperative for the maize breeders to identify and develop early maturing and high yielding maize hybrids and synthetic cultivars (Hussian et al., 2016). Assessment of the genotypes for grain yield and morphological traits is one of the crucial steps towards the development of crop varieties. Maize breeders mostly assess newly developed hybrids/superior cross combinations for identification the genotypes with desired traits either for commercial release or for onward use in breeding programs. The present study was conducted to assess the performance of different maize hybrids for yield, yield associated and maturity traits and to identify early maturing and high yielding maize hybrid(s).

Materials and Methods

This field research was performed at The University of Agriculture, Peshawar (340 01 N latitude, 710 35 E longitudes with altitude of 359 ft.) during spring maize crop season of 2017. A set of 18 hybrids provided by International Maize and Wheat Improvement Center (CIMMYT) along with two local checks was planted in randomized complete block design with three replications. The list of the genotypes used in the study is given in Table 1. Each genotype was planted in 2 rows with row length of 5m and row-row spacing 0.75m. Five randomly selected plants in each entry were used to collect the data on days to 50% tasseling, days to 50% anthesis, days to 50% silking, anthesis silking interval, plant height (cm), cob diameter (cm), cob length (cm), kernel rows cob^{-1}, 100-seed weight (g) and grain yield (kg ha^{-1}).

Table 1: *List of the maize genotypes used in the study.*

Maize genotypes			
1	CAH151	11	ZH138088/ZH11953
2	CAH153	12	ZH141592
3	VH12333	13	ZH15381
4	VH12337	14	ZH15445
5	ZH169	15	ZH1610
6	ZH111755	16	ZH1619
7	ZH111948/ZL11953	17	ZH1620
8	ZH114228	18	Azam (Check-I)
9	ZH1621	19	Jalal (Check-II)
10	ZH138088	20	ZH116128

Statistical analysis

Data were subjected to analysis of variance (ANOVA) technique as outlined by Singh and Chaudhary (1985) while Least Significant Difference (LSD) test was used for means separation and comparison. Broad sense heritability for the studied traits was estimated as:

$$h^2\,(BS) = \frac{Vg}{Vp}$$

where; Vp = Phenotypic variance for a particular trait; $h^2\,(BS)$ = Broad sense heritability for a particular trait; Vg = Genetic variance.

Results and Discussion

Days to tasseling

Days to tasseling along with days to anthesis and silking regulate the ripening duration in maize crop and are considered important characters in maize from maturity perspective. Highly significant ($P \leq 0.01$) differences among the hybrids were observed for days to 50% tasseling (Table 2). Days to 50% tasseling among the hybrids ranged from 91.7 to 95.0. Hybrids ZH1610 and ZH114228 showed minimum days to tasseling (91.7) while hybrid ZH111948/ZL11953 displayed maximum days to 50% tasseling (95) (Table 3). Moderate broad sense heritabilty (39.2%) was observed for days to 50% tasseling (Table 5).

Table 2: *Mean squares of maize genotypes for various morphological traits at Peshawar during spring 2017.*

Character	Means Squares		
	Replica-tions df=2	Genotypes df=19	Error df=38
Days to tasseling	10.4	3.4**	1.19
Days to anthesis	8.8	4.7**	1.48
Days to silk	7.8	3.1**	1.09
Anthesis-silking interval	2.8	0.2^{NS}	0.43
Plant height	990.3	2613.8**	205.1
Ear height	572.1	1042.9**	82.02
Cob length	1.38	11.7^{NS}	8.21
Cob diameter	0.19	0.21**	0.07
Kernel rows per cob	22.3	4.65*	2.05
Hundred kernal weight	11.85	45.25**	16.17
Grain yield	2635047	25986205**	7921836

Earliness is considered as a desirable trait in maize crop allowing the plants to escape various biotic and abiotic stresses. Significant differences among the hybrids for days to tasseling indicated the presence of sufficient genetic variation among the hybrids for this trait. Our results are similar to the findings of Munchie and Fentie (2016) who also reported significant dissimilarities among maize hybrids for days to tasseling. Vashistha et al. (2013) similarly reported significant differences among the maize genotypes for days to tasseling.

Days to anthesis

Mean squares showed highly significant (P ≤ 0.01) differences among the hybrids for 50% anthesis (Table 2). Days to 50% anthesis among the hybrids varied between 93.7 and 99.0 days. Minimum days to anthesis (93.7) was manifested for hybrid ZH1610 while maximum days to 50% anthesis (99.0) was displayed by VH12337 (Table 3). Moderate broad sense heritability value (42.5%) was observed for days to 50% anthesis (Table 5).

Table 3: *Means of maize genotypes for days to tasseling, days to anthesis, days to silking, anthesis-silking interval (ASI) and plant height at Peshawar during spring 2017.*

Hybrids	Days to tasseling	Days to anthesis	Days to silking	ASI (Days)	Plant height (cm)
ZH5381	93.0	95.3	96.7	1.3	299.9
ZH138088	92.7	95.7	97.7	2.0	209.3
VH12333	94.7	97.0	98.0	1.7	212.8
ZH141592	93.3	96.3	98.3	1.3	240.5
CAH151	92.3	96.3	98.0	1.3	237.7
ZH169	94.0	94.7	98.3	2.0	278.3
ZH1621	94.3	96.3	98.0	1.7	234.6
CAH153	92.3	97.0	98.0	1.7	269.1
VH12337	93.3	99.0	99.7	1.7	213.8
ZH1620	92.0	95.7	98.3	1.3	212.0
ZH15445	94.7	96.7	98.3	2.0	276.5
ZH1610	91.7	93.7	96.0	1.7	263.5
ZH114228	91.7	95.3	97.7	1.0	241.3
ZH111948	95.0	98.3	100.0	1.7	191.4
ZH11755	94.3	96.7	98.0	1.3	228.5
ZH1619	93.0	95.0	98.0	2.0	241.9
ZH116128	93.0	95.3	97.3	1.3	246.7
ZH138088	94.0	95.7	97.3	1.7	194.3
Azam	92.0	94.7	96.0	1.3	207.3
Jalal	94.3	97.0	99.3	1.3	227.5
LSD(0.05)	1.80	2.01	1.73	1.08	23.67
CV (%)	1.17	1.27	1.07	41.8	6.06

Days to anthesis is an another important character which determines the maturity period of maize crop. During the pollination, pollen grains are associated with silks for a shorter duration of time and are susceptible to to dryness and harm of viability if the pollination fails to occur within 1-2 days of anthesis. Pollen shed at appropriate timings and their synchronization with silking results in high kernel filling and eventually greater yield. Our results are in agreement with the findings of Muchie and Fentie (2016) who also reported highly significant differences among maize hybrids for anthesis. Sesay et al. (2016) also observed significant differences among three way cross hybrids and top cross hybrids for days to anthesis. They also reported moderate broad sense heritability value for this trait.

Table 4: *Means of maize genotypes for ear height, cob length, cob diameter, kernel rows per cob, 100-kernal weight and grain yield at Peshawar during spring 2017.*

Hybrids	Ear height (cm)	Cob length (cm)	Cob diameter (cm)	Kernal rows cob^{-1}	100 kernal weight(g)	Grain Yield (kg ha^{-1})
ZH5381	158.9	15.9	3.4	13.0	32.6	9634.9
ZH138088	89.9	15.6	3.6	13.3	28.7	8149.9
VH12333	95.8	10.1	3.0	9.3	31.7	1660.2
ZH141592	100.7	14.3	3.4	13.7	27.9	8105.9
CAH151	97.1	11.7	3.7	13.0	27.6	4071.7
ZH169	122.3	19.5	3.1	13.7	26.3	6544.7
ZH1621	95.7	15.2	3.8	15.7	27.3	9502.8
CAH153	120.7	14.1	4.0	14.0	35.0	6309.6
VH12337	72.3	11.3	3.5	14.3	25.7	2824.0
ZH1620	84.5	18.6	3.7	13.7	30.1	12412.8
ZH15445	121.4	14.5	3.9	13.7	28.4	6221.6
ZH1610	108.1	17.8	3.4	14.3	28.3	11713.4
ZH114228	96.3	14.3	4.0	14.3	31.5	4300.2
ZH111948	80.1	14.6	3.5	14.7	24.2	7717.2
ZH11755	100.2	14.9	3.8	14.7	28.4	9207.3
ZH1619	99.8	14.0	3.7	12.7	34.0	5415.3
ZH116128	104.6	13.1	3.4	13.7	29.6	2854.8
ZH138088	90.3	11.4	3.5	13.0	22.4	7556.0
Azam	93.3	13.2	3.6	13.3	22.5	4909.1
Jalal	97.7	12.1	3.3	12.7	20.2	4446.7
LSD(0.05)	14.9	4.73	0.43	1.83	6.64	4652.2
CV (%)	8.92	20.1	7.43	10.5	14.2	42.14

Days to silking

Highly significant (P ≤ 0.01) differences among the hybrids were observed for days to 50% silking (Table 2). Days to 50% silking among the genotypes ranged from 96 to 100. Hybrid ZH1610 showed minimum days to 50% silking (96) while maximum days to silking were observed for hybrid ZH111948/ZL11953 (Table 3). Moderate broad sense heritability (38.2%) was observed for days to silking (Table 4).

Days to 50% silking is an indicator of degree of ripeness. Days to silking along with other associated maturity traits are used by plant breeders to assess ripeness duration in maize crop. The results of the present study are compatible with the findings of Muchie and Fentie (2016). They also observed significant differences among the hybrids for this trait. Akbar et al. (2008) also reported significant variation among different maize hybrids for days to silking.

Anthesis-silking interval

Results showed non-significant (P>0.05) differences among the hybrids for anthesis-silking interval (Table 2). Anthesis-silking interval among the genotypes ranged from 1.0 to 2.0 days. Minimum anthesis-silking interval (1.0) was observed for ZH114228, while maximum anthesis-silking interval (2.0) was observed for ZH138088, ZH169, ZH15445 and ZH1619 (Table 3). During pollination, pollen grains sticking with silks are sensitive to ecological strains and high temperature and water scarcity situations result in low pollen viability. In case of pollen-silk asynchrony, the silk would not available to pollen for pollination resulting in reduced grain-yield. Synchronization between anthesis and silking leads to higher seed setting and ultimately higher grain yield. Rahman et al. (2010) also reported similar results and observed non-significant differences for anthesis-silking interval among different maize hybrids.

Plant height (cm)

Highly significant (P ≤ 0.01) differences among the studied hybrids were observed for plant height (Table 2). Plant height among the hybrids ranged from 191.4 to 299.9 cm. The shortest plants (191.4 cm) were observed for ZH111948 while the tallest plants (299.9 cm) were observed for ZH15381 (Table 3). High broad sense heriability value (72.5%) was observed for plant height (Table 5). Plant height is an important agronomic character, which plays a vital role to avoid lodging. Maize breeders pay special attention to this character in maize breeding programs. Semi-dwarf plants are preferred since such plants are resistant to lodging and are fertilizer responsive. Muchie and Fentie (2016) and Hussain and Hassan (2014) also reported highly significant differences among maize hybrids and high broad-sense heritability value for plant height.

Ear height (cm)

The analysis of variance revealed highly significant (P ≤ 0.01) differences among the genotypes for ear height (Table 2). Range for ear height among the genotypes varied from 72.3 to 158.9 cm. Hybrid VH12337 exhibited minimum ear height (72.3 cm) while ZH15381 showed maximum (158.9 cm) ear height (Table 4). High broad sense heriability value (65.7%) was observed for ear height (Table 5). The results are compatible with the findings of Nayaka et al. (2015) who also obtained highly significant differences among different maize genotypes for ear height. They also reported high broad sense heritability value for this trait.

Table 5: *Heritability estimates for different morphological traits of maize hybrids at Peshawar during spring 2017.*

Parameters	Genotypic variance	Phenotypic variance	Heritability (h^2_{BS})
Days to tasseling	0.77	1.95	39.2
Days to anthesis	1.09	2.58	42.4
Days to silking	0.68	1.78	38.2
Plant height	541.1	746.3	72.5
Ear height	156.9	238.9	65.6
Cob length	3.30	11.51	28.6
Cob diameter	0.02	0.07	10.0
Kernal rows cob^{-1}	0.86	2.91	29.5
100-kernal weight	11.13	27.3	40.7
Grain yield	7783719	850555	91.5

Cob length (cm)

Cob length is a direct grain yield contributing factor in maize. Highly significant (P ≤ 0.01) differences among the hybrids were observed for cob length (Table 2). Cob length among the genotypes ranged between 10.1 and 19.5 cm. Hybrid VH1233 showed minimum (10.1cm) cob length, while ZH169 showed maximum (19.5cm) cob length (Table 4). Low broad sense heriability value (28.67%) was observed for cob length (Table 5). Maruthi and Rani (2015) also obtained highly significant differences among maize genotypes for cob length along with high broad sense heritability.

Cob diameter

Mean squares revealed highly significant (P ≤ 0.01) differences among the maize genotypes for cob diameter (Table 2). Cob diameter among the maize hybrids fluctuated between 3.1 to 4.0 cm. Minimum cob diameter (3.1 cm) was observed for hybrid ZH169. On the other hand, maximum cob diameter (4.0 cm) was observed for hybrids CAH153 and ZH114228 (Table 4). Low broad sense heritability value (10%) was observed for cob diameter (Table 5). Cob diameter is also an important yield attribute in maize crop. The results of the present study are in accordance with those of Maruthi and Rani (2015). They evaluated different maize genotypes for yield and yield contributing traits and observed significant differences among the genotypes with high heritability value for this trait.

Kernel rows cob^{-1}

The analysis of variance revealed significant ($P \leq 0.05$) differences among maize hybrids for kernel rows cob^{-1} (Table 2). The value for this trait among the genotypes ranged from 9.3 to 15.7. Minimum kernel rows cob^{-1} (9.3) were observed for hybrid VH12333, while maximum kernel rows cob^{-1} (15.7) were observed for hybrid ZH1621 (Table 4). Relatively moderate broad sense heritability value (29.5%) was observed for kernel rows cob^{-1} (Table 5).

Higher number of kernel rows cob^{-1} enhances grain weight and is thus an important yield-contributing trait. Manivannan (1998) recommended that the ear diameter and kernel rows ear should be given more attention while practicing selection for enhanced grain-yield in maize. Sesay et al. (2016) also observed highly significant differences among different hybrids for kernel rows cob^{-1}.

100-kernel weight (g)

The grains weight has an extraordinary role to achieve the goal of high grain yield (Minivanan, 1998). The analysis of variance revealed highly significant ($P \leq 0.01$) differences among maize hybrids for 100-kernel weight (Table 2). The value for this trait among the genotypes ranged 20.2 to 35.0 g. Minimum 100-kernel weight (20.2 g) was recorded for Jalal, while maximum 100-kernel weight (35.0 g) was observed for hybrid CAH153 (Table 4). Moderate broad sense heritability value (40.76%) was observed for 100-kernel weight (Table 5).

The results of the present study are compatible with the findings of Sesay et al. (2016) and Vashistha et al. (2013). These researchers observed highly significant differences among maize genotypes and high broad sense heritability value for 100-kernel weight.

Grain yield (kg ha^{-1})

Significant ($P \leq 0.01$) differences among the maize genotypes were observed for grain yield (Table 3). Grain yield among the genotypes ranged from 3849.3 to 7478.9 kg ha^{-1}. Minimum grain yield of 1660.0 kg ha^{-1} was manifested for VH12333, while ZH1620 produced maximum grain yield of 12412.8 kg ha^{-1} (Table 4). Broad sense heritability value of 91.51% was observed for grain yield (Table 4).

Grain yield enhancement is one of the main objectives of maize-breeding programs and is the result of complex interaction of both the inherent potential of the genotypes and environmental conditions (Hussain et al., 2004). Vashistha et al. (2013) also reported highly significant differences among maize genotypes and high broad sense heritability value for grain yield.

Conclusions and Recommendations

Significant genetic variation among the studied hybrids was observed for maturity, yield and yield associated traits. Hybrids ZH1610 and ZH114228 were manifested as the early maturing maize genotypes. Hybrid ZH1620 appeared as the top most producer of the grain yield and could be recommended for commercial cultivation after multi-location trials. The superior hybrids for yield and yield associated traits could also be used in future maize breeding programs for development of maize germplasm with superior attributes.

Author's Contributions

Masab Umair Khan: Field lay-out, experiment execution, data collection and wrote the manuscript.
Syed Mehar Ali Shah: Designed the experiment, data alanysis and interpretation, helped in writing up the manuscript.
Hidayat-ur-Rahman: Overall research supervision, provision of genetic material and data interpretation.
Arshad Iqbal: Helped in writing and editing the paper, reviewed the literature and data analysis.
Ezaz Aslam: Helped in writing and editing the paper, collected and analysed the data.

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