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Potential of S_5 Lines in Test Crosses for Yield and Yield Associated Traits in Maize Variety Azam

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Abstract:

This research was conducted at The University of Agriculture, Peshawar and Cereal Crops Research Institute, (CCRI) Pirsabak, Nowshera, during spring and summer (2012-13) crop seasons. The testcrosses were developed from maize variety Azam at CCRI. All lines were de-tasseled prior to pollen shedding. At physiological maturity the test crosses were manually harvested and shelled individually. In spring (season 1) and summer (season 2) 2013, the resulting test-crosses were evaluated in a 12x12 partially balanced lattice square design at The University of Agriculture, Peshawar for different agronomical and yield related traits. Data had been taken on ear height (cm), ear length (cm), kernel rows ear^{-1}, 100 kernels weight (g), and grain yield (kg ha^{-1}). Non-significant differences were observed only for ear length, kernel rows ear^{-1} and 100 kernels weight in seasons 1 while in season 2; non-significant differences were recorded for ear

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length and kernel rows ear^{-1}. The remaining traits showed significant genetic variations among the testcrosses in both seasons. Low to moderate estimation of heritability and genetic advance was observed in both seasons. Maximum ear height was observed for TC-193 in season 1 and for TC-111 in season 2, whereas maximum kernel rows ear^{-1} was recorded for TC-226 in season 1 and for TC-251 in season 2. Test crosses TC-127 in season 1 and TC-251 in season 2, had maximum 100-grain weight, whereas TC-91 in season 1 and TC-107 in season 2, had maximum ear length. The TC-194, in season 1 and TC-95, in season 2, were observed to be the highest yielding test crosses and can be utilized as progenitors in succeeding generations of maize breeding programs.

Key words: *Zea mays*, Testcrosses progenies, Maize S_5 lines, Broad sense heritability, Genetic Advance

Introduction

Maize (*Zea mays* L.) is a universal cereal crop which is associated to group maydea and grass family, Poaceae. It has been domesticated from Mexican annual teosinte (*Zea mexicana* L.). An ancient corn was cultivated in South Mexico, Central America and N.S. America 7,000 years before. Maize does not sustain in its wild shape due to cross pollination in nature (Ram and Singh, 2003). In Pakistan during year 2012-13, maize was cultivated on 1139.4 thousand hectares with annual production of 4997.1 thousand tones and average yield was 4385.7 kg ha^{-1}. In Khyber Pukhtunkhwa maize was grown on about 497.3 thousand hectares with total annual production of 1300 thousand tons with average yield of 2614.11 kg ha^{-1} (FBS, 2012-13). Maize is cultivated as a multipurpose crop, for grain, fodder and can be utilized in manufacturing of starch, oil, etc. (Aziz *et al.,* 1992). Corn starch is used in plastic textile and sticky glue. It is also utilized as bio-mass resource of energy and ethanol fuel. Maize is also used in some other products like bio-degenerated chemical, papers, flour, and in paints and explosive materials. In food 15-20% calorie comes from maize. Maize varieties development requires formation, evaluation, selection, and recombination of genetically diverse genotypes or inbred lines and because the superior cultivars must integrate many desirable characters; the process can be complex and prolonged (Pixely *et al.,* 2006). Initially early generation testing of partial inbred lines idea was put forward by Jenken (1935). The testcross performance of experimental lines is the prime selection criterion in hybrid breeding of maize. Recognition of such beneficial lines in mixed populations is the main objective of plant breeders (Khan *et al.,* 2004). The heritability and genetic advance is the essential framework for the selection, their collective estimation is beneficial for the prediction of gain during the selection. The objectives of this research study were to evaluate test-crosses of S_5 lines obtained from Azam maize variety by mean of recurrent selection, and to identify superior testcrosses for grain yield and yield related traits.

Materials and Methods

Breeding materials

The research materials had been developed from Azam maize variety. Azam is white flint genotype having moderate average stature, and matures in 90 to 100 days. It was developed through cross among the Zia and Pir-sabak 7930, and with back cross to Pir-sabak 7930. It is acclimatized and adapted maize composite and could be grown in all regions of Khyber-Pakhtunkhwa. In this experiment commercial hybrid 30-K08 was used as a check for the comparison.

Field experimentation and procedure

During summer crop period (July- October) 2012, 143 S_5 lines, developed from maize variety Azam were test-crossed by crossing with the selected tester (FRHW-20-4) in isolation at

CCRI, Pirsabak, Nowshera. By regular rounds during flowering tassels lines were de-tasseled. The de-tasseled lines were let to open pollination by the tester. At physiological maturity (black layer establishment at hilum) the test-crosses were manually harvested and shelled individually. The best were selected and others were disposed. During 2013, in two crop seasons [spring (March-June) season 1, and summer (July-October) season 2] the test-crosses along with a check were planted in a replicated yield trial in a partially balanced, lattice square design along with 2 replications at The University of Agriculture, Peshawar. Row length was kept 5m, plant-to-plant gap was 25cm and row-to-row space was kept to be 75cm. Each genotype comprised single row plot. Standard cultural techniques were applied. Data were taken on ear height (cm), ear length (cm), kernel rows ear^{-1}, 100 kernels weight (g), and grain yield (kg ha^{-1}) in two seasons.

Statistical Analysis

The data were subjected to ANOVA (Analysis of variance) appropriate for partially balanced lattice square design; means of all parameters were also calculated.

Table: Analysis of variance format for partially balanced lattice square design.

SOV	DF	MS	Expected MS
Replication(r)	r-1		
Block(k)	r(k-1)		
Treatments(t)	k^2-1	M1	$V_E + rV_G$
Error	(k-1)(rk-k-1)	M2	V_E

Estimates of heritability and variance components (genotypic and phenotypic components) were calculated from the ANOVA by using the following formula (Fehr, 1987):

Genotypic variance (V_G) = (GMS – EMS) ⁄ r

Environmental variance (V_E) = EMS

Phenotypic variance (V_P) = $V_G + V_E$

Plot mean basis (h^2_{BS}) = $V_G / V_G + V_E$
Genetic Advance (GA) = $i \times \sqrt{V_P} \times h^2$
Where,
i at 20 % = 1.40

Results and Discussion

Ear height (cm)

The analysis of variance pertaining to ear height displayed significant ($P<0.05$) differences among the test-crosses in season 1 and highly significant ($P<0.01$) variations in season 2. The co-efficient of variation was 11.12% and 6.67% in season 1 and season 2, respectively (Table 1). Maximum ear stature of 93.67 cm was recorded for test-crosses (TC)-193 and lowest ear stature of 50 cm was recorded for TC-240 in season 1, while for the check 68 cm ear height was computed (Table 2). Similarly in season 2, highest ear height of 79.16 cm was noted for TC-111, while minimum (53 cm) height was observed for TC-152 and for the check 73.3 cm of ear stature was observed (Table 3). The estimates of heritability, genetic advance, environmental variance and genotypic variance, were observed to be 0.17, 2.11, 65.08, and 13.65, respectively in season 1 (Table 4). In season 2, calculated Ve was 17.33, Vg was 14.13, h^2_{BS} was 0.45 and genetic advance (GA) was noted to be 3.53 (Table 5). The calculated over all mean ear height (72.53 cm) was observed in season 1, and 62.29 cm was observed in season 2 (Table 6). The location of ear in maize is essential for lodging resistances; if the ear locates over the middle the ear will be affected by lodging and if it situates below the middle, animals will damage the crop. The placement of ear on height from soil level apply pressure on plant during maturity and grain filling time that cause lodging by which yield could be affected. So the ear should be at the center and optimal position. Gentar and Alexandar (1965) found highly significant variation for ear stature between test crosses of 2 groups of maize with single cross tester. Similarly significant results were also found by Abal and Pollak (1991). The heritability estimation was low to moderate in both seasons. Salami *et al.,* (2007) observed low estimation of heritability while analyzing the genetic variability between the maize genotypes. High heritability and genetic advance was observed for ear stature by Bello *et al.,* (2012).

Ear length (cm)

Analysis of variance for ear length revealed non-significant (P>0.05) variation among the test crosses in both seasons. Co-efficient of variation was recorded to be 10.91% in season 1 and 31.40% in season 2 (Table 1). The highest cob length of 16.83 cm was recorded for TC-91 and lowest 11.28 cm was observed for TC-105, ear length of 15.2 cm was observed for the check 30-K08 (Table 2). In season 2, the maximum cob length (15.48 cm) was recorded for TC-107 and minimum (8.9 cm) was recorded for TC-253, while the check showed 11.9 cm cob length (Table 3). From Table 4, it is indicated that heritability observed was very low (0.04) and genetic advance, environmental variance, and genotypic variance, were recorded to be 0.09, 2.35 and 0.10, respectively in season 1. In season 2, the variance components Ve, Vg were 16.33 and 0.72, while heritability and genetic advance were recorded to be 0.04 and 0.23 (Table 5). The mean cob length was 14.06 cm and 12.87 cm in season 1 and season 2, respectively (Table 6). The ear length or cob length also influences the production like other yields related parameters, as ear length and kernel rows ear^{-1} are positively and significantly correlated to kernel yield (Mannivanan, 1998). Contrasting results were observed by Carlone and Russell (1989) who recorded significant variations for ear length between test crosses of S_2 lines. Low estimation of h^2 was recorded by Beyene (2005) for ear length while studying phenotypic diversity for agronomical and morphological parameters in Ethiopian upland accessions. High to moderate GA was observed by Badawy (2012) for ear length while studying the genetic traits in 3 maize crosses for yield and its related characters.

Number of kernel rows ear^{-1}

The statistical analysis among the test crosses for the kernel rows per ear showed non- significant (P>0.05) variation in both seasons. In season 1 and season 2 the CV was 6.86% and 16.10%, respectively (Table 1). Maximum kernel rows cob^{-1} (16 rows) were observed for TC-226 and minimum (11 rows) were observed for TC-256 and for the check 13 rows cob^{-1} were calculated in season 1 (Table 2). In season 2, maximum (14 rows) were recorded for TC-171, minimum (10 rows) were recorded for TC-85, while 12.3 rows were noted for the check 30-K08 (Table 3). The environmental variance and genotypic variance were recorded to be 0.89, 0.09, respectively while heritability and genetic advance were observed to be 0.10 and 0.13 in season 1 (Table 4). In season 2, the Ve, Vg, h^2_{BS}, and GA were computed to be 4.16, 0.34, 0.08 and 0.23, respectively (Table 5). The overall mean of kernel rows ear^{-1} was observed to be 13.79 in season 1 and 12.67 in season 2 (Table 6). Kernel rows ear^{-1}, ear length, ear diameter, and kernels weight has important contribution in yield production. According to Mannivanan (1998) preferences should be given to kernel rows ear^{-1} and ear girth (circumference). The heritability estimation was recorded very low which was an indication of high environmental influence in breeding materials under observation. Low estimation had been recorded by Beyene (2005) for kernel rows ear^{-1}. High heritability and genetic advance was observed for no of kernel rows ear^{-1} by Bello *et al.,* (2012). Kernel or grain weight is main yield element which has significant contribution to final yield. The 100 grains weight as well as plant height and cob length are the main components that have contribution to final grain yield, so the selection should be carried out on these basis (Dash, 1992). Statistical analysis revealed highly significant (P<0.01) differences among the test crosses of S_5 lines in season 2, while non- significant

(P>0.05) variations were observed in season 1. Rahman *et al.,* (2007) had been observed significant variations for 1000 seeds weight while comparing the original and selected maize population for kernel yield characters. High to moderate GA was observed by Badawy (2012) for 100 seeds weight while estimating the genetic traits in 3 maize crosses for yield and its characters.

100 kernels weight (g)

The statistical analysis revealed highly significant (P<0.01) differences among the test crosses of S_5 lines in season 2, while non- significant (P>0.05) variations existed in season 1. Co-efficient of variations was observed to be 10.02% and 8.57% in both the seasons, respectively (Table 1). Maximum 100 grains weight of 40.28g was recorded for TC-127 and minimum (26g) was observed for TC-237 while for the check 36.4g of weight was observed in season 1 (Table 2). Similarly in season 2, maximum 100 grains weight (42.5g) was noted for TC-251, and minimum weight 27g was observed for TC-179. For the check (30-K08) 42.3g of weight was observed (Table 3). In season 1, the genotypic variance was 1.79, environmental variance was 11.7, genetic advance was 0.66 and broad sense heritability was observed to be 0.13 (Table 4). In season 2, the genotypic variance was 9.47, environmental variance was 8.61, genetic advance was 3.09 and broad sense heritability was noted to be 0.52 (Table 5). The grand mean was calculated as 34.10 g in season 1 and 34.16 g in season 2 (Table 6). Kernel or grain weight is main yield element which has significant contribution to final yield. The 100 grains weight as well as plant height and cob length are the main components that have contribution to final grain yield, so the selection should be carried out on these basis (Dash, 1992). Rahman *et al.,* (2007) observed significant variations for 1000 seeds weight while comparing the original and selected maize population for kernel yield characters. The heritability estimation was low to moderate in both seasons, which showed high environmental effect on the parameter. Mahmood *et al.,* (2004) and Alvi *et al.,* (2003) reported high estimated heritability for kernels weight. High to moderate GA was observed by Badawy (2012) for 100 seeds weight while estimating the genetic traits in 3 maize crosses for yield and its characters.

Grain yield (kg ha^{-1})

Statistical analysis of variance indicated highly significant (P<0.01) differences among the test-crosses for grain-yield during the two seasons. Co-efficient of variations was recorded to be 15.81% for season 1, and 13.48% for season 2 (Table 1). Maximum grain yield of 10213 kg ha^{-1} was recorded for TC-194 and minimum (3456 kg ha^{-1}) was observed for TC-203 while for the check grain yield of 7201.7 kg ha^{-1} was observed in season 1 (Table 2). Similarly in season 2, highest grain yield of 8890 kg ha^{-1} was observed for TC-95, while minimum yield of 3317 kg ha^{-1} was observed for the check 30-K08 (Table 3). The variance components of both seasons are presented in tables 4 and 5, respectively. The heritability and genetic advance were observed to be 0.38 and 687.58 in season 1 (Table 4). In season 2, the genetic advance was 950.55 and broad sense heritability was recorded to be 0.57 (Table 5). The test-crosses mean was 6450 kg and 5839 kg in season 1 and season 2, respectively (Table 6). Generally kernel (grain) yield in maize is a major and significant economic component in crop production. It is usually the topmost priority and major interest of plant breeders. Kernel yield is the basic and fundamental objective of every plant breeding scheme (Welsh, 1981). Statistical analysis of variance indicated highly significant (P<0.01) differences in both seasons. Significant differences in yield potential of test-crosses have been reported by Rahman *et al.,* (2007). These variations in yield parameters could be attributed to the different genetic back ground of materials used in various studies as the maize germplasm differed in yield attributes and components. Moderate heritability estimation was observed for yield in both seasons. Similar moderate heritability was observed by Weyhrich *et al.,* (1998) and by Betrin and Hallauer (1996) and high estimation was reported by Santos *et al*., (2005). Ali *et al.,* (2011) also recorded high heritability approximation for the kernel yield. High to moderate GA was also observed by Badawy (2012) for kernel-yield while estimating the genetic traits in 3 maize crosses for yield and its characters. Gnanamurthy *et al.,* (2013) recorded high genetic advance for kernel yield, in their research experiment.

Table 1: Genotype mean squares (GMS), error mean squares (EMS) and co-efficient of variation (CV) for various parameters of test crosses derived from S_5 lines of Azam maize variety during two seasons.

	Spring (Season 1)			**Summer (season 2)**		
Parameters	**GMS (M1) DF= 143**	**EMS (M2) DF= 121**	**CV (%)**	**GMS (M1) DF= 143**	**EMS (M2) DF= 121**	**CV (%)**
Ear height	92.38*	65.08	11.12	45.59**	17.33	6.67
Ear length	2.56^{NS}	2.35	10.91	17.78^{NS}	16.33	31.40
Number of kernel rows	1.08^{NS}	0.89	6.86	4.84^{NS}	4.16	16.10
100 kernels weight	15.28^{NS}	11.7	10.02	27.565**	8.61	8.57
Grain yield	2298033.52**	1042823.5	15.81	2221734.29**	616042.8	13.48

Ns=Non-Significant, *=Significant at 5% level of probability, **=Significant at 1% level of probability

Table 2: Minimum and maximum means (range) for various parameters of test-crosses derived from S_5 lines of Azam maize variety during season 1.

	Spring (Season 1)				
	Range				
Parameters	**Entry no**	**Minimum**	**Entry no**	**Maximum**	**Check 30 K-08**
Ear height	240	50	193	93.67	68.3
Ear length	105	11.28	91	16.83	15.2
Number of kernel rows	256	11	226	16	13.3
100 kernels weight	237	26	127	40.28	36.4
Grain yield	203	3456.8	194	10213.8	7201.7

Table 3: Minimum and maximum means (range) for various parameters of test crosses derived from S_5 lines of Azam maize variety during season 2.

Parameters	Summer (Season 2)				
	Range				Check 30 K-08
	Entry no	Minimum	Entry no	Maximum	
Ear height	152	53	111	79.16	73.3
Ear length	253	8.9	107	15.48	11.7
Number of kernel rows	85	10	171	14.33	12.3
100 kernels weight	179	27	251	42.5	42.3
Grain yield	30 K-08	3317.1	95	8890.5	3317.1

Table 4: Environmental variance (Ve), genotypic variance (Vg), broad-sense heritability (h^2_{BS}) and genetic advance (GA) for various parameters of test crosses derived from S_5 lines of Azam maize variety during season 1.

Parameters	Spring (Season 1)			
	Ve	Vg	h^2_{BS}	GA
Ear height	65.08	13.65	0.17	2.11
Ear length	2.35	0.10	0.04	0.09
Number of kernel rows	0.89	0.09	0.10	0.13
100 kernels weight	11.7	1.79	0.13	0.66
Grain yield	1042823.5	627604.9	0.38	687.58

Table 5: Environmental variance (Ve), genotypic variance (Vg), broad-sense heritability (h^2_{BS}) and genetic advance (GA) for various parameters of test crosses derived from S_5 lines of Azam maize variety during season 2.

Parameters	Summer (Season 2)			
	Ve	Vg	h^2_{BS}	GA
Ear height	17.33	14.13	0.45	3.53
Ear length	16.33	0.72	0.04	0.23
Number of kernel rows	4.16	0.34	0.08	0.23
100 kernels weight	8.61	9.47	0.52	3.09
Grain yield	616042.9	802845.7	0.57	950.55

Table 6: Mean values for ear height (EH), ear length (EL), kernel rows ear^{-1} (KR), 100 kernels weight (100 KW) and grain yield (GYLD) in season 1 and season 2.

	Test crosses Mean values	
Parameters	**Season 1**	**Season 2**
Ear height	72.53	62.29
Ear length	14.06	12.87
Number of kernel rows	13.79	12.67
100 kernels weight	34.10	34.16
Grain yield	6450	5839

Conclusion

On the basis of the results of the present study, different testcrosses manifested potential for selection of the desired traits. In season 1, TC-148, TC-159 and TC-175, while TC-122, TC-107, and TC-103 in season 2, had the central location for the ear, which showed the potential for lodging resistance. Test-crosses TC-127 in season 1 and TC-251 in season 2 showed the highest values for 100 grain weight. Estimation of heritability and genetic advance for all the parameters were low to moderate which displayed comparatively high environmental influences on the traits expression in the breeding materials. The test-crosses which had low heritability estimation could be evaluated in multiple-location zones. The TC-194, in season 1 and TC-95, in season 2, were observed the highest yielding test-crosses and are suggested for future evaluation in the maize breeding programs of Pakistan.

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