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EFFECTS OF GENETIC COMPONENTS BY ENVIRONMENTAL INTERACTIONS OF MAIZE HYBRIDS ACROSS THE DIFFERENT LOCATIONS OF KHYBER PAKHTUNKHWA, PAKISTAN

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ABSTRACT

The effect on genetic constitution by the environment interaction was studied for 13 maize genotypes, during 2012 over four different location of Khyber Pakhtun Khwa i.e. KPK Agricultural University Peshawar, Agricultural Research Station Baffa (Mansehra), Agricultural Research Station, Jamra (Mardan) and Cereal Crops Research Institute, Pirsabak. These experiments were carried out in randomized complete block design with three replication at each location during (July-October) 2012. Data were recorded on different morphological and yield parameters. Analysis of variance indicated significant differences among the four locations for followings traits, such as days to 50% silking, days to 50% pollen shedding, anthesis silking interval (ASI), plant height, ear height, grain moisture at harvest and grain yield per hectare. All the genotypes showed significant differences for almost parameters except anthesis silking interval (ASI), which was non significant across the four different locations. The genotypes x locations interactions also showed significant differences for days to 50% silking, days to 50% pollen shedding, height of plant, height of ear, grain moisture at harvest and grain yield per hectare, while non significant difference was observed for anthesis silking interval (ASI). Based on yield performance of genotypes across the four locations, Baffa ranked first as compared to the other three locations. Hybrid WD-2x8 was the highest yielding across the four locations followed by hybrid Hi-corn, while the lowest yield was observed in hybrid CS-King at all the four locations.

Key-words: Maize, Genotype, Environment, Yield associated traits.

INTRODUCTION

Maize is one of the most important and high yielding cereal crop in the world, it is considered as a queen of cereal crop. Maize is more significant and importance food supplies those countries, where population is rapidly increasing available. Maize is one of the three important cereal crops after wheat and rice in Pakistan (Anonymous 2012a). It contributes about 5.44% of the total cultivated area and 3.5% of the value of agricultural output. It is grown on an average area of 1.02 million ha with an annual production of 3.1 million tons. The bulk (97%) of the total production comes from two provinces i.e., KPK, accounts for 57% of the total area and 68% of total production and Punjab contributes 38% acreage with 30% of total maize grain production., while on very small areas of maize is planted, which accounts for (2-3%) in the province of Sindh and Balochistan (Anonymous 2012b). The phenotype of an individual is determined by both the genotype and the environment. These two effects are not always additive which indicates that genotype x environment interactions (GEI) are present. The GEI results in inconsistent performances among the genotypes across environments. Significant GEI results from the changes in the magnitude of differences among genotypes in different environments or changes in the relative ranking of the genotypes (Crossa, 1990). The genotype x environment interaction is an important aspect of plant breeding programs. It may arise when certain genotypes are grown in diverse set of environments. A significant G x E interaction for a quantitative trait such as seed yield can seriously limit the efforts on selecting superior genotypes for both new crop production and improved cultivar development (Kang and Gorman, 1989). Genotype x environment interaction for any variety reduces the usefulness of genotype mean over all locations for selecting and advancing superior genotypes. Genotype by environment (G x E) interactions is almost unanimously considered to be among the major factors limiting response to selection and also decreases the efficiency of breeding programs. G x E interactions become important when the rank of breeding lines changes in different environments. This change

in rank is called crossover G x E interaction (Baker 1988). Genotypes by environment interactions (G x E) are a known fact in cultivar evaluations. The G x E is composed of G x Location, G x Year, and G x L x Y constituents. In general G x Y is larger than G x E, although both were observed to be nearly equivalent for switch grass biomass yield (Hopkin *et al*., 1995). If the G x Y component is larger, then multiple year tests are needed. It is usually not considered during the early stages of testing. Later, as the cultivar/hybrid testing program becomes focused on few potential releases, testing in multiple years is essential for selecting the best and most stable entries. Therefore the aimed of this study was to evaluate 13 maize genotypes for their adaptability (G X E) of performance for yield and yield components at four different locations of KPK.

MATERIAL AND METHODS

A series of experiments were conducted at four locations of Khyber Pakhtun Khwa i.e. KPK Agricultural University (AU) Peshawar, Cereal Crops Research Institute (CCRI) Pirsabak, Agriculture Research Station (ARS) Baffa (Mansehra) and Agriculture Research Station (ARS) Jamra (Mardan). For this purpose 10 maize hybrids along an open pollinated variety (OPV) and two populations were used (Table 1).

Table 1. Maize genotypes, origin and source used in experiment during crop season 2008.

S.No.	Genotypes	Origin	Source
1	974 (w)	Hybrid	Pioneer
2	P – 3025(w)	Hybrid	Pioneer
3	Opener (w)	Hybrid	Pioneer
4	CS – King	Hybrid	Ginocrm
5	Hi – Corn	Hybrid	Ginocrm
6	CS – 201	Hybrid	Ginocrm
7	WD -2 x 8	Hybrid	CCRI
8	WD – 3x 6	Hybrid	CCRI
9	P – 30k08	Hybrid	Pioneer
10	R – 4210	Hybrid	Rafhan
11	SW C4	Population	AUP
12	AZ C4	Population	AUP
13	Jalal	OPV	CCRI

The experiment at each location was conducted in a randomized complete block design (RCBD) and was replicated three times. Sowing was done on 20th June 2008 at KPK AU, Peshawar, 24th June 2008 at ARS Baffa, 30th June 2008 at ARS Jamra (Mardan) and on 5th July 2008 at CCRI Pirsabak. Each genotype was planted in a plot of four rows having five meters length. The plant to plant distance was 25 cm and row to row distance was of 75 cm. A basal fertilizer dose of 50 kg urea and 200 kg SSP per acre was applied. Before sowing, seeds were treated with Confidor and Imkan fungicides. Standard cultural practices essential for crop management were practiced at all locations through out the season. Data were recorded on the following parameters; Days to 50% silking, Days to 50% pollen shedding Anthesis silk interval, Plant height Ear height, Fresh ear weight at harvest Grain moisture at harvest

Grain yield per hectare . (Grain yield (kg ha^{-1}) = fresh ear wt. x (100 – grain moisture content) x 0.8 x 10000).

RESULTS

Flowering traits

Mean square values for days to 50 % silking, days to 50% pollen shedding and anthesis silking interval (ASI) are given in the Table 2, 3,4,5,6 indicated that highly significant differences were observed among the four locations for days to 50 % silking, days to 50% pollen shedding and anthesis silking interval (ASI). Highly significant differences were observed among hybrids as well across four locations for days to 50 % silking and days to 50% pollen shedding while differences were non significant for anthesis silking interval (ASI). The interaction between genotypes and locations was also highly significant for days to 50% silking and days to 50% pollen shedding. The mean values for days to 50% silking and days to 50% pollen shedding of maize genotypes at four locations are given in Table 2. It was noted that hybrid P-30K08 had the highest mean value of 58.5 days followed by Jalal (OPV) with 58.4 days for 50% silking. The shortest duration for days to 50% silking was observed for hybrid WD-3x6 with

mean value of 54.3 days. The highest mean value of 57.8 for days to 50% pollen shedding was observed for hybrid P-30K08, followed by Jalal (OPV) with mean value 57.5 days. The minimum value for days to 50% pollen shedding was observed for hybrid WD-3 x 6 i.e. 53.5 days.

Plant height (cm)

Statistical analysis of the data regarding plant height indicated highly significant differences among the four locations used in this study. The hybrids also exhibited significant variations across the four locations. The interaction between genotype and locations (G X L) was significant (Table 7).The mean values for plant height given in Table 7, indicated that hybrid P-30K08 showed highest mean value for this trait i.e. 213.9 cm while lowest mean value was expressed by hybrid WD-3X6 having a value 150.3 cm. Other hybrids showed their mean values for plant height with in this range.

Table 2. Mean values for days to 50% silking, and pollen shedding plant height and ear height of maize genotypes across four locations of KPK.

Maize genotypes	Days to 50% Silking	Days to 50% Pollen shedding	Plant height (cm)	Ear height (cm)
974 (W)	55.83 d-g	55.92 bc	180.36 b	85.03 de
P-3025(W)	56.83 b-d	56.08 bc	173.44 b-e	77.39 f
Opener (W)	54.83 fg	54.42 de	176.97 bc	82.31 ef
CS King	57.42 a-c	57.17 ab	163.55 ef	81.09 ef
Hi Corn	57.83 ab	56.75 a-c	178.90 bc	94.41 b
CS-201	57.75 ab	56.75 a-c	168.79 c-e	85.80 c-e
WD-2X8	55.00 e-g	54.00 e	177.16 bc	92.62 bc
WD-3X6	54.33 g	53.50 e	150.34 g	79.64 ef
P-30K08	58.50 a	57.75 a	213.91 a	107.60 a
R-4210	57.50 a-c	56.58 a-c	173.38 b-e	84.90 de
SW-C4	56.17 c-f	55.42 dc	164.52 d-f	76.24 f
AZ-C4	56.42 c-f	55.42 dc	157.81 fg	77.17 f
JALAL	58.42 a	57.50 a	175.39 b-d	91.03 b-d
LSD $p < 0.05$	1.527	1.392	10.93	7.432

Table 3. Means values of maize genotypes evaluated over four locations of KPK for grain moisture% at harvest and grain yield ha^{-1} during year 2008.

Maize Hybrid	Anthesis Silking Interval		Grain yield (kg ha^{-1})
974 (W)	2.50 b	27.55 c-e	7733.5 ab
P-3025(W)	2.33 b	28.38 b-e	7519.1 bc
Opener (W)	2.42 b	29.03 bc	6454.2 d
CS King	2.83 ab	26.88 de	5060.0 f
Hi Corn	2.42 b	28.58 b-d	7972.2 a
CS-201	2.75 ab	28.21 b-e	6484.6 cd
WD-2X8	2.50 b	26.74 e	8261.5 a
WD-3X6	2.50 b	27.26 c-e	6232.2 e
P-30K08	2.58 ab	30.88 a	7466.5 bc
R-4210	3.00 a	28.15 b-e	6183.5 e
SW-C4	2.58 ab	28.48 b-e	5805.5 e
AZ-C4	2.67 ab	27.41 c-e	5770.9 e
JALAL	2.42 b	29.78 ab	5934.4 e
LSD $p < 0.05$	0.5601	1.816	1256

Ear height (cm)

Analysis of variance for ear height indicated highly significant differences among the four locations. The genotypes also showed highly significant variations across the four locations, while the interaction between genotype and locations (G X L) was also highly significant. The mean values for ear height are given in Table 8. Highest mean value of 107.6 cm was observed for hybrid P-30K08, followed by hybrid Hi Corn with mean value of 94.4 cm, while minimum mean value for ear height was observed for genotype SW-C4 i.e. 76.24 cm. Significant differences were observed among 13 genotypes across four locations for anthesis silking interval (ASI). Therefore, the means for hybrids were not subjected to LSD test.

Table 4. Days to 50% silking comparison of 13 maize genotypes across four different locations of KPK.

Maize Genotypes	KPK AU Peshawar	ARS Baffa	ARS Jamra	CCRI Pirsabak	Means
974 (W)	60	51	55	57	55.83 d-g
P-3025(W)	62	55	54	57	56.83 b-d
Opener (W)	58	51	52	58	54.83 fg
CS King	62	52	55	60	57.42 a-c
Hi Corn	61	55	57	59	57.83 ab
CS-201	63	54	56	58	57.75 ab
WD-2X8	59	52	52	58	55.00 e-g
WD-3X6	59	48	54	56	54.33 g
P-30K08	65	55	54	59	58.50 a
R-4210	63	54	52	60	57.50 a-c
SW-C4	62	50	54	59	56.17 c-f
AZ-C4	61	49	55	60	56.42 c-f
JALAL	65	54	55	60	58.42 a
Means	61.46 a	52.46 d	54.26 c	58.54 b	56.67

Table 5. Days to 50% pollen shedding comparison of 13 maize genotypes across four different locations of KPK.

Maize Genotypes	KPK AU Peshawar	ARS Baffa	ARS Jamra	CCRI Pirsabak	Means
974 (W)	60	49	60	55	55.92 bc
P-3025(W)	61	53	55	55	56.08 bc
Opener (W)	57	49	54	57	54.42 de
CS King	61	50	59	59	57.17 ab
Hi Corn	60	53	56	58	56.75 a-c
CS-201	61	52	57	57	56.75 a-c
WD-2X8	58	49	53	56	54.00 e
WD-3X6	58	46	56	54	53.50 e
P-30K08	64	53	56	58	57.75 a
R-4210	61	51	55	59	56.58 a-c
SW-C4	60	48	56	58	55.42 dc
AZ-C4	59	47	57	58	55.42 dc
JALAL	63	51	56	59	57.50 a
Means	60.26 a	50.23 d	56.00 c	57.28 b	55.94

Grain moisture at harvest (%)

Highly significant differences were observed among the four locations for grain moisture percentage at harvest. Genotypes also showed significant differences for grain moisture at harvest. Genotype x location interaction was also significant for grain moisture at harvest. Means values of 13 maize genotypes evaluated over four locations for

the parameter of grain moisture at harvest is given in Table 9. The mean values for grain moisture percentage at harvest indicated that all the maize genotypes were not having similar grain moisture percentage and had significant differences. The maximum grain moisture percentage was observed in hybrid P-30K08 with value of 30.9 %.The minimum grain moisture percentage was observed for hybrid WD-2X8, with value of 26.7 %.

Table 6. Anthesis silking interval comparison of 13 maize genotypes across four different locations of KPK.

Maize Genotypes	KPK AU Peshawar	ARS Baffa	ARS Jamra	CCRI Pirsabak	Means
974 (W)	1	3	3	2	2.50 b
P-3025(W)	2	3	2	2	2.33 b
Opener (W)	2	3	3	2	2.42 b
CS King	3	3	3	2	2.83 ab
Hi Corn	1	3	3	2	2.42 b
CS-201	3	3	3	2	2.75 ab
WD-2X8	2	3	2	3	2.50 b
WD-3X6	2	3	2	3	2.50 b
P-30K08	2	3	3	2	2.58 ab
R-4210	3	4	3	2	3.00 a
SW-C4	3	3	3	2	2.58 ab
AZ-C4	3	3	2	3	2.67 ab
JALAL	2	3	2	2	2.42 b
Means	2.21 d	3.23 a	2.67 b	2.23 c	2.58

Table 7. Plant height (cm) comparison of 13 maize genotypes across four different locations of KPK.

Maize Genotypes	KPK AU Peshawar	ARS Baffa	ARS Jamra	CCRI Pirsabak	Means
974 (W)	188	229	159	146	180.36 b
P-3025(W)	186	202	148	158	173.44 b-e
Opener (W)	188	221	138	161	176.97 bc
CS King	174	198	136	147	163.55 ef
Hi Corn	195	212	149	160	178.90 bc
CS-201	173	203	144	156	168.79 c-e
WD-2X8	170	222	157	160	177.16 bc
WD-3X6	149	178	143	131	150.34 g
P-30K08	225	268	177	186	213.91 a
R-4210	182	206	148	157	173.38 b-e
SW-C4	168	217	118	156	164.52 d-f
AZ-C4	168	199	116	148	157.81 fg
JALAL	190	220	143	148	175.39 b-d
Means	181.16 b	213.51 a	144.28 d	154.74 c	173.422

Grain yield kg ha^{-1}

Mean square values for grain yield kg ha^{-1} are given in Table 10. Highly significant differences were observed among the four locations for grain yield. Like (Charles *et al.*, 2013). genotypes also showed significant differences for grain yield. Similarly the genotype x location interaction was also significant for this parameter. Mean values for grain yield kg ha^{-1}, indicated that hybrid WD-2X8 had the maximum grain yield of 8261.5 kg ha^{-1}, followed by hybrid Hi-corn hybrid with grain yield of 7972.2 kg ha^{-1}. The minimum grain yield kg ha^{-1} was observed for hybrid CS King with average value of 5060 kg ha^{-1}. Comparison of average grain yield ha^{-1}.of hybrids for the four

locations is given in Table 10. The data in Table 10 reveals that hybrid Hi-Corn ranked first with average grain yield of 12531 kg ha^{-1} at Baffa (location 2), and hybrid P-30k08 ranked second with average grain yield 12141 kg ha^{-1} at Pirsabak (location 4) followed by hybrid WD-2x8 which was third in rank with average yield of 11580 kg ha^{-1}. Maximum number of genotypes produced high yield in ARS Baffa as compared to the other three locations.

The overall means for grain yield ha^{-1} given in table. 10 showed that maximum grain yield of 10210.15 kg ha^{-1} was produced at ARS Baffa (Mansehra) followed by 9333 kg ha^{-1} and 5451 kg ha^{-1} CCRI Pirsabak and KPK AU, Peshawar, respectively with grain yield. The minimum grain yield was of 2697 kg ha^{-1} was produced at Jamra. LSD results revealede significant differences among these values. Mean square values for grain yield ha^{-1} also showed that all genotypes were significantly different from each other at all locations. The interaction between genotypes and locations were also highly significant for grain yield ha^{-1}.

Table 8. Ear height (cm) comparison of 13 maize genotypes across four different locations of KPK.

Maize Genotypes	KPK AU Peshawar	ARS Baffa	ARS Jamra	CCRI Pirsabak	Means
974 (W)	82	112	78	68	85.03 de
P-3025(W)	69	101	68	72	77.39 f
Opener (W)	81	106	68	73	82.31 ef
CS King	85	94	73	72	81.09 ef
Hi Corn	97	118	79	84	94.41 b
CS-201	82	108	73	81	85.80 c-e
WD-2X8	79	119	85	87	92.62 bc
WD-3X6	68	96	86	69	79.64 ef
P-30K08	112	142	81	95	107.60 a
R-4210	87	102	68	82	84.90 de
SW-C4	71	102	61	72	76.24 f
AZ-C4	72	104	56	76	77.17 f
JALAL	95	121	73	75	91.03 b-d
Means	83.17 b	109.68 a	73.05 d	77.25 c	85.78

Table 9. Percent grain moisture comparison of 13 maize genotypes across four different locations of KPK.

Maize Genotypes	KPK AU Peshawar	ARS Baffa	ARS Jamra	CCRI Pirsabak	Means
974 (W)	26	32	31	21	27.55 c-e
P-3025(W)	30	37	28	18	28.38 b-e
Opener (W)	28	34	31	23	29.03 bc
CS King	29	32	29	18	26.88 de
Hi Corn	29	34	31	21	28.58 b-d
CS-201	30	33	30	20	28.21 b-e
WD-2X8	28	32	26	21	26.74 e
WD-3X6	29	30	30	21	27.26 c-e
P-30K08	29	40	32	23	30.88 a
R-4210	29	33	29	22	28.15 b-e
SW-C4	30	36	27	21	28.48 b-e
AZ-C4	28	32	28	21	27.41 c-e
JALAL	29	38	32	21	29.78 ab
Means	28.84 C	33.96 A	29.42 B	20.80 D	28.25

Table 10. Grain yield (kg ha^{-1}) comparison of 13 maize genotypes across four different locations of KPK.

Maize Genotypes	KPK AU Peshawar	ARS Baffa	ARS Jamra	CCRI Pirsabak	Means
974 (W)	6966	11244	3352	9371	7733.5 ab
P-3025(W)	4924	10736	2837	11579	7519.1 bc
Opener (W)	5028	10396	866	9526	6454.2 d
CS King	3134	9179	2143	5784	5060.0 f
Hi Corn	7372	12531	2589	9397	7972.2 a
CS-201	5597	9699	2430	8212	6484.6 cd
WD-2X8	5597	11580	4859	11009	8261.5 a
WD-3X6	5454	8236	3387	7852	6232.2 e
P-30K08	8440	6456	2829	12141	7466.5 bc
R-4210	5499	8397	2649	8188	6183.5 e
SW-C4	4126	9280	1763	8053	5805.5 e
AZ-C4	4200	10040	1549	7294	5770.9 e
JALAL	4526	8291	2807	8114	5934.4 e
Means	5451.1 c	10210.1 a	2620.1 d	8963.08 b	6811.09

DISCUSSION

New introduced maize crop strains are tested across the different locations in order to assess the pattern and the magnitudes of genotype x environments interactions. These genotypes x environments interactions if present for a certain trait of breeder's interest can reduce the correlation between phenotypic and genotypic values and will ultimately reduce progress from selection. Moreover, if the genotype x environment interactions is not prevailing, a single genotype can be recommended for the wider geographical area. This approach will not only lead to increase productivity, but can also considerably reduce the input cost by developing a single variety for a wider agro-ecological zone. To investigate the behavior of genotype at different locations, replicated data were recorded on yield and other agronomic traits. The data were analyzed by standard analysis of variance combined over locations and finally stability analysis was made by SAS (statistical analysis system) program (SAS, 1999). Mean square data for different parameters i.e. days to 50% silking, days to 50% pollen shedding, ASI, height of plant, height of ear, grain moisture at harvest and grain yield kg ha^{-1} of 13 maize genotypes were used. Analysis of variance showed significant differences among the four locations for all parameters. All genotypes were significantly different from each other at four locations for days to 50% silking, days to 50% pollen shedding, anthesis silking interval, plant height, ear height, grain moisture at harvest and grain yield kg ha^{-1}. The genotype x location interactions was also highly significant for all parameters except anthesis silking interval which was not significantly different from each other at all locations. Maximum days to 50% silking and 50% pollen shedding was observed in Peshawar (location1) while the lowest number of days to 50% silking and 50% pollen shedding were observed at Baffa (location 2). Based on yield performance of all genotypes across four locations, Baffa ranked first as compared to the other two locations. This may be due to the favorable environment at Baffa which makes it highly conducive for increased maize production. Hybrid WD-2x8 was high yielding across all four locations, followed by hybrid Hi-corn, while the lowest grain yield was observed for hybrid CS-King at all four locations. Non significant differences among the four locations were observed for anthesis silking interval by all hybrids. The maximum value for ASI was observed in Baffa (location 2) while the minimum value for ASI was observed at Peshawar (location 1). The maize hybrids used in this study indicated highly significant differences for plant height. Maximum plant height value was observed for hybrid P-30K08 while the minimum value for this parameter was shown by hybrid WD-3X6. The hybrids also showed highly significant differences for ear height. Maximum ear height was shown by hybrid P-30K08 and the lowest value was observed for the genotype SW-C4. Similar to Munawar *et al*., (2013). highly significant differences were found among 13 genotypes for grain moisture percentage at harvest across four locations of KPK. Maximum grain moisture percentage was shown by hybrid P-30K08 and minimum grain moisture

was observed for hybrid WD-2X8.

CONCLUSION

Hence it is concluded from this study that Genotypes SW-C4, WD-2X8, 974 (W) and CS-210 had positive response to improved environmental conditions and therefore, it is recommended that these genotypes could give better performance under suitable environment.

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