Internat. J. agric. Sci. Vol.2 No.2 July 2006 : (486-489)

Genotype X environment interaction for moisture stress reaction in *winter* maize

Suresh Prasad Singh* and P.B.Jha
Department of Plant Breeding, Rajendra Agricultural University, PUSA (SAMASTIPUR) (BIHAR) INDIA

ABSTRACT

Genotype(G) X Environment(E) interaction in winter maize involving ten diverse parents and their 45 F_1s under four variable environments (early and late sowing with moisture stress and non-stress conditions) were studied for twelve characters, including anthesis-silking interval, tassel condensation, tassel vigour index and grain yield. Significant interaction was observed due to genotype x sowing dates x moisture regimes for tassel condensation, ear height, effective ear length, 500-grain weight and grain yield. Based on mean performance of grain yield and response to environments, the crosses namely, P_1x P_{10} ($G_{15}C_{22}$MH 148U-1-1-1-6-3-BB x CML 117), P_5 x P_6 (Pop 27-S_4-4U-1-3 x Pop 147 (EEY DMR) S_1-117-3 and P_9 x P_{10} (EEY DMR S_1-3-1-1-2-3 x CML 117) were identified to be suitable for early as well as late sowings under both moisture regimes. However, P_1 x P_5 ($G_{15}C_{22}$MH 148U-1-1-1-6-3-BB x Pop 27-S_4-4U-1-3) and P_5 x P_{10} (Pop 27-S_4-4U-1-3 x CML 117) responded significantly better under moisture stress as well as late sowing conditions.

Key words : Maize, Genotype x environment interaction, Environmental sensitivity

INTRODUCTION

Maize (*Zea mays* L.) is an important coarse grain cereal crop and is widely grown throughout the year under different climatic situations. About 80% of the maize area is under rainfed and subjected to various levels of moisture stress, frequently, which causes significant reduction in yield. Water deficits for one or two days during tasselling or pollination may cause as much as 22% reduction in yield (Robins & Domingo, 1953). However, depending upon stage, duration of drought and sensitivity of genotypes, reduction in yield may increase or decrease. The knowledge of G x E interaction is of vital importance for breeders in the process of evolution of improved varieties for moisture stress conditions and also for allocation of resources. Therefore, the present investigation was carried out with the objective to screen out suitable parents as well as crosses having small G x E interaction for yield which could be utilized for further breeding programme under moisture stress condition of rabi and spring seasons of Bihar.

MATERIALS AND METHODS

The experimental materials comprised of ten advanced generation moisture stress tolerant diverse inbred lines (Singh and Jha, 2004). They were crossed in diallel fashion (excluding reciprocals). Altogether ten parents, their forty-five hybrids and two checks (Pusa Early Hybrid-1 and 2) were grown in randomized complete block design with three replications during the rabi season in four diverse environments, viz., (i) Early sowing (02.11.2000) moisture stress (ii) Early sowing moisture non-stress (iii) Late sowing (2.12.2000) moisture stress and (iv) Late sowing moisture non-stress. In the crop stand, moisture stress was created by reducing the irrigation number to one which was applied at knee height stage. Along with the character grain yield under different situations the observations were taken on eleven quantitative characters namely, anthesis-silking interval, tassel condensation, tassel vigour index, plant height, ear height, effective ear length, ear girth, grain filling per cent, kernel rows per ear, 500-graing weight and harvest index. The genotype-environment interaction stability parameters were estimated by following the method suggested by Eberhart and Russel (1966).

RESULTS AND DISCUSSION

In the present investigation the pooled analysis of variance was conducted to test the significance of the influence (individual and interaction) of the four environmental factors during the crop growth period (Table 1). The mean squares due to replication within sowing dates and moisture regimes was significant for all the characters except for tassel vigour index, plant height, ear height and grain filling per cent. Individual influence due to genotypes, sowing

Table 1 : Pooled analysis of variance for design of experiment for twelve quantitative characters in maize

Source	d.f.	Mean Squares											
		Anthesis-silking interval	Tassel condens-ation	Tassel vigour index	Plant height	Ear height	Effective ear length	Ear girth	Grain filling per cent	Kernel rows per ear	500-grain weight	Harvest index	Grain yield
1. Replications within sowing dates and moisture regimes	8	3.30**	0.014**	3.63	59.50	25.45	35.54**	1.57**	9.70	4.19**	105.38**	50.80**	175.69**
2. Sowing dates	1	204.50**	8.75**	8615.99**	48276.61**	21001.91**	9308.84**	109.18**	10242.49**	20.36**	64242.77**	6791.40**	8258.69**
3. Moisture regimes	1	1456.15**	28.93**	33455.82**	167673.13**	113959.15**	33840.18**	586.27**	39151.15**	59.66**	290411.40**	26599.63**	32841.69**
4. Sowing dates x Moisture regimes	1	17.05**	0.27**	115.46**	636.40**	1446.65**	23.95**	2.99**	1.53	0.99	1412.70**	39.73**	134.98**
5. Genotypes	56	1.58**	0.54**	356.39**	661.53**	358.74**	353.28**	6.05**	350.42**	15.98**	2068.95**	204.94**	616.82**
6. Genotypes x Sowing dates	56	0.62	0.045**	5.10	34.49	94.41**	20.96**	0.32	19.48**	1.83	72.37**	5.72	16.55**
7. Genotypes x Moisture regimes	56	0.70**	0.122**	29.77**	100.99**	113.75	47.54**	1.36**	31.94**	2.51**	205.64**	20.17**	75.68**
8. Genotypes x Sowing dates x Moisture regimes	56	0.33	0.017**	5.09	22.10	98.53**	15.62**	0.385	15.48	1.37	26.52*	3.07	10.22**
9. Residual error	448	0.495	0.004	8.69	40.79	28.79	8.72	0.39	17.24	1.36	19.21	8.57	5.78

*, ** : Significant at 5% and 1% level of significance, respectively.

***Author for correspondence**

Table 2 : Estimates of mean performance of grain yield for fifty-seven genotypes in maize

Sl. No.	Entry	Grain Yield				
		Early sowing	Late sowing	Moisture non-stress	Moisture stress	Mean over environments
1	P_1	31.00	26.00	31.83	25.17	28.50
2	P_1 x P_2	47.70	41.92	52.40	37.22	44.81
3	P_1 x P_3	40.58	36.58	48.08	29.08	38.58
4	P_1 x P_4	41.27	31.44	44.26	28.45	36.36
5	P_1 x P_5	47.32	43.81	50.17	40.96	45.56
6	P_1 x P_6	48.63	39.15	53.30	34.48	43.89
7	P_1 x P_7	39.23	31.49	42.47	28.24	35.36
8	P_1 x P_8	35.05	27.50	38.32	24.23	31.27
9	P_1 x P_9	36.89	29.09	41.12	24.85	32.99
10	P_1 x P_{10}	48.69	44.80	52.00	41.49	46.75
11	P_2	35.02	30.97	36.70	29.28	32.99
12	P_2 x P_3	34.75	27.15	37.12	24.78	30.95
13	P_2 x P_4	37.33	24.43	38.23	23.54	30.88
14	P_2 x P_5	49.67	42.55	52.50	39.72	46.11
15	P_2 x P_6	32.80	27.46	37.36	22.91	30.13
16	P_2 x P_7	36.21	27.67	39.20	24.68	31.94
17	P_2 x P_8	31.27	24.01	34.51	20.77	27.64
18	P_2 x P_9	32.34	23.81	34.98	21.18	28.08
19	P_2 x P_{10}	49.55	43.83	54.55	38.83	46.69
20	P_3	29.64	25.83	30.25	25.22	27.74
21	P_3 x P_4	43.25	38.30	51.43	30.12	40.77
22	P_3 x P_5	43.03	34.10	48.10	29.03	38.57
23	P_3 x P_6	34.99	26.41	36.88	24.51	30.70
24	P_3 x P_7	30.68	26.64	35.63	21.69	28.66
25	P_3 x P_8	29.75	22.61	30.11	22.25	26.18
26	P_3 x P_9	31.33	26.60	36.19	21.74	28.97
27	P_3 x P_{10}	37.56	29.18	39.88	26.86	33.37
28	P_4	29.42	25.81	30.99	24.24	27.62
29	P_4 x P_5	47.69	38.29	49.55	36.43	42.99
30	P_4 x P_6	36.79	28.15	39.00	25.94	32.47
31	P_4 x P_7	47.15	34.83	51.10	30.87	40.99
32	P_4 x P_8	42.14	35.43	48.43	29.15	38.79
33	P_4 x P_9	27.50	21.00	30.33	18.24	24.28
34	P_4 x P_{10}	45.96	39.03	52.50	32.50	42.50
35	P_5	30.78	27.61	33.22	25.16	29.19
36	P_5 x P_6	51.02	43.60	54.32	40.30	47.31
37	P_5 x P_7	45.83	37.26	53.03	30.06	41.55
38	P_5 x P_8	31.36	25.04	33.55	22.86	28.20
39	P_5 x P_9	43.46	38.76	52.05	30.18	41.11
40	P_5 x P_{10}	46.77	42.71	49.39	40.08	44.74
41	P_6	25.00	20.17	25.33	19.83	22.58
42	P_6 x P_7	35.26	27.61	38.05	24.82	31.43
43	P_6 x P_8	43.70	34.32	49.35	28.62	39.01
44	P_6 x P_9	42.32	32.45	45.72	29.05	37.38
45	P_6 x P_{10}	46.43	40.60	49.15	37.89	43.52
46	P_7	27.06	21.67	28.00	20.72	24.36
47	P_7 x P_8	33.58	24.53	35.29	22.82	29.06
48	P_7 x P_9	32.70	26.43	34.93	24.20	29.56
49	P_7 x P_{10}	46.06	38.33	54.05	30.34	42.20
50	P_8	27.90	22.25	29.01	21.14	25.07
51	P_8 x P_9	38.35	32.70	41.30	29.75	35.53
52	P_8 x P_{10}	44.20	37.70	51.16	30.73	40.95
53	P_9	26.65	20.80	27.00	20.45	23.72
54	P_9 x P_{10}	48.60	43.18	52.26	39.42	45.89
55	P_{10}	34.05	28.93	35.23	27.75	31.49
56	PEH-1	46.30	34.10	51.85	28.55	40.20
57	PEH-2	44.19	32.47	49.39	27.26	38.32
	Mean	38.68	31.73	42.13	28.27	35.20
	S.Em.(±)	1.40	1.39	1.52	1.25	1.39
	CD at 5%	3.87	3.83	4.21	3.45	3.85

dates and moisture regimes was significant for all the characters studied. Interaction effect, due to sowing dates and moisture regimes, was observed to be significant for all the characters except for grain filling per cent and kernel rows per ear. Mean squares due to genotypes x sowing dates was significant for the characters tassel condensation, ear height, effective ear length, grain filling per cent, 500-grain weight and grain yield indicating ranking for these genotypes was highly affected by changing the sowing dates, while the mean squares due to interaction between genotypes and moisture regimes was significant for all the characters except for ear height which indicated that ear height was not affected by different moisture regimes. The cumulative interaction effect of genotypes with sowing dates and moisture regimes was significant only for tassel condensation, ear height, effective ear length, 500-grain weight and grain yield, which revealed that ranking of genotypes for these characters were influenced by changing sowing dates and moisture regimes. Significant effect of environment on genotypes for grain yield in maize was also observed by Jha *et. al.* (1986), Dass *et. al.* (1987), Mahajan and Khehra (1992), Paradkar *et. al.* (1995), Mani and Singh (1999), Luquez *et. al.* (2000) and Menkir and Akintude (2001).

P_5 x P_{10}, P_6 x P_{10} and P_9 x P_{10} were having significantly higher yield in comparison to PEH-1 under moisture stress condition. These twelve crosses were also out yielded PEH-1 in early, late and moisture non-stress conditions indicating that they were less affected by different environmental fluctuations. However, the grain yield of genotypes when averaged over environments, only eight crosses, viz., P_1 x P_2, P_1 x P_5, P_1 x P_{10}, P_2 x P_5, P_2 x P_{10}, P_5 x P_6, P_5 x P_{10} and P_9 x P_{10} significantly out yielded the better check PEH-1.

The mean performances and response to different environmental situations (b & S^2d) for grain yield of sixteen top ranking genotypes have been presented in Table 3. In the experiment, the crosses, P_1 x P_2, P_1 x P_{10}, P_2 x P_{10}, P_4 x P_5, P_5 x P_6 and P_9 x P_{10} were observed to have average stability, i.e., less sensitivity over the environments, as these crosses had shown significantly higher mean grain yield over environments than the grand mean and average response values. The genotypes, P_1 x P_6, P_4 x P_7, P_4 x P_{10}, P_5 x P_7, P_7 x P_{10}, P_8 x P_{10}, PEH-1 and PEH-2 were found to have higher mean grain yield than grand mean, but were sensitive to favourable environments, therefore, they

Table 3 : Mean grain yield and environmental response of 16 top ranking crosses of maize

Sl. No.	Entry	Early sowing	Late sowing	Moisture non-stress	Moisture stress	Mean over environments	Environmental sensitivity(b)	Response to non-linearity(S^2d)
1	P_1xP_2	47.70	41.92	52.40	37.22	44.81	1.05	-1.26
2	P_1xP_5	47.32	43.81	50.17	40.96	45.56	0.64*	-2.36
3	P_1xP_6	48.63	39.15	53.30	34.48	43.89	1.36**	-2.92
4	P_1xP_{10}	48.69	44.80	52.00	41.49	46.75	0.72	-2.04
5	P_2xP_{10}	49.55	43.83	54.55	38.83	46.69	1.07	-0.97
6	P_4xP_5	47.69	38.29	49.55	36.43	42.99	1.02	0.81
7	P_4xP_7	47.15	34.83	51.10	30.87	40.99	1.52	-0.22
8	P_4xP_{10}	45.96	39.03	52.50	32.50	42.50	1.37	3.29
9	P_5xP_6	51.02	43.60	54.32	40.30	47.31	1.02	-1.47
10	P_5xP_7	45.83	37.26	53.03	30.06	41.55	1.57	0.99
11	P_5xP_{10}	46.77	42.71	49.39	40.08	44.74	0.66**	-2.78
12	P_7xP_{10}	46.06	38.33	54.05	30.34	42.20	1.59	4.27
13	P_8xP_{10}	44.20	37.70	51.16	30.73	40.95	1.38	5.42
14	P_9xP_{10}	48.60	43.18	52.26	39.42	45.89	0.89	-2.31
15	PEH-1	46.30	34.10	51.85	28.55	40.20	1.71**	-1.94
16	PEH-2	44.19	32.47	49.39	27.26	38.32	1.62**	-2.69

The estimates of mean performance of grain yield under different environmental situations have been presented in Table 2. In case of early sowing only one cross P_5 x P_6 exhibited significantly higher yield than the better check, Pusa Early Hybrid-1 (PEH-1). Grain yield of nineteen crosses namely, P_1x P_2, P_1 x P_5, P_1 x P_6, P_1 x P_{10}, P_2 x P_5, P_2 x P_{10}, P_3 x P_4, P_3 x P_5, P_4 x P_5, P_4 x P_7, P_4 x P_{10}, P_5 x P_7, P_5 x P_9, P_5 x P_{10}, P_6 x P_8, P_6 x P_{10}, P_7 x P_{10}, P_8 x P_{10}, and P_9 x P_{10} was found to be statistically at par with that of the check PEH-1. Under late sown situation, fifteen crosses, viz., P_1 x P_2, P_1 x P_5, P_1 x P_6, P_1 x P_{10}, P_2 x P_5, P_2 x P_{10}, P_3 x P_4, P_4 x P_5, P_4 x P_{10}, P_5 x P_6, P_5 x P_9, P_5 x P_{10}, P_6 x P_{10}, P_7 x P_{10} and P_9 x P_{10} were observed to be significantly higher yielder as compared to PEH-1. None of the genotypes significantly out yielded PEH-1 under moisture non-stress situation, however, the crosses, P_1 x P_2, P_1 x P_3, P_1 x P_5, P_1 x P_6, P_1 x P_{10}, P_2 x P_5, P_2 x P_{10}, P_3 x P_4, P_3 x P_5, P_4 x P_5, P_4 x P_7, P_4 x P_8, P_4 x P_{10}, P_5 x P_6, P_5 x P_7, P_5 x P_9, P_5 x P_{10}, P_6 x P_8, P_6 x P_{10}, P_7 x P_{10}, P_8 x P_9, and P_9 x P_{10} were found to have statistically similar grain yield. Altogether twelve crosses namely, P_1 x P_2, P_1 x P_5, P_1 x P_6, P_1 x P_{10}, P_2 x P_5, P_2 x P_{10}, P_4 x P_5, P_4 x P_{10}, P_5 x P_6,

were identified to be suitable under early sowing and moisture non-stress situations. Furthermore, the crosses, P_1 x P_5 and P_5 x P_{10}, have shown high response to unfavourable environments with high average yield, therefore, they were identified as suitable for moisture stress as well as late sowing conditions. The cross P_1x P_5 has shown high response to unfavourable environments for tassel condensation, plant height, effective ear length and harvest index. However, P_5 x P_{10} responded significantly towards unfavourable environments for effective ear length, grain filling per cent, kernel rows per ear and harvest index.

REFERENCES

Dass, S., Ahuja, V. P. and Singh, M. (1997). Combining ability for yield in maize. *Indian J. Genet.* **57 (1) :** 98-100.

Eberhart, S.A. and Russell, W.A. (1969). Yield and stability for a 10 line diallel of single cross and double cross maize hybrids. *Crop Sci.* **9 :** 357-361.

Jha, P.B., Khehra, A.S. and Akhtar, S.A. (1986). Stability analysis for grain development and yield in maize. *Crop Improv.* **13 (1) :** 16-19.

Luquez, J., Weilenmann, M. E. and Suarez, W. (2000). Performance of commercial maize hybrids grown in two different environments in Southern part of Buenos Aires province. *Tests of Agrochemicals* and *Cultivars* 21 : 31-32 (c.f. PBA **72 (4) :** 442.)

Mahajan, V. and Khehra, A.S. (1992). Stability analysis of kernel yield and its components in maize (*Zea mays* L.) in winter and monsoon seasons. *Indian J. Genet.* **52 (1) :** 63-67.

Mani, V.P. and Singh, N.K. (1999). Stability analysis of yield in maize (*Zea mays* L.). *Indian J. Agric. Sci.* **69 (1) :** 34-38.

Menkir, A. and Akintude, A.O. (2001). Evaluation of the performance of maize hybrids, improved open pollinated and farmers' local varieties under well-watered and drought stress conditions. *Maydica* **46 (4) :** 227-238 (c.f. PBA **72 (8) :** 9116).

Paradkar, V.K., Upadhyay, P.C. and Sharma, R.K. (1995). Phenotypic stability of grain yield and its components in maize under micro and macro environments. *Mysore J. Agric. Sci.* **29 (3) :** 193-198.

Robins, J. S. and Domingo, L.E. (1953). Some effects on severe soil moisture deficits at specific stages in corn. *Agron. J.* **45 :** 618-621.

Singh, S. P. and Jha, P. B. (2004). Combining Ability Analysis in Maize (*Zea mays* L.) under Moisture Stress Condition. *Crop Improv.* **31 (2) :** 180-188

Received : September, 2005; Accepted : March, 2006