Electronic Journal of Plant Breeding,
ISSN 0975-928X

DOI: 10.5958/0975-928X.2016.00014.4

AMMI approach for grain yield and stability of maize (*Zea mays* L.)

P. Suthamathi[1] and G. Nallathambi [2]
[1]Regional Research Station,TNAU, Paiyur-635 112,Tamil Nadu
[2]Department of Millets,Tamil Nadu Agricultural University, Coimbatore-641 003,T.N.

(Received: June 2015; Accepted: June 2016)

Abstract
Ninety one hybrids developed by diallel mating involving 14 inbreds were used to estimate stability for four yield related traits under moisture in rainfed, induced and across the environments.The AMMI model which had both additive and multiplicative effects had been applied for the data.The analysis of variance for stability revealed that for all the characters,the mean squares were significant for genotypes, environments,G x E interactions,PCA I, PCA II and PCA III. Among the genotypes, twenty nine genotypes recorded significantly superior mean performance for grain yield per plant in over all environments. Among the high mean performing genotypes, four genotypes viz., P1 x P7, P1 x P10, P2 x P6 and P8 x P11 recorded low interaction, twenty four genotypes with positive type of interaction and one genotype P7 x P13 with negative type of interaction with environment were noticed. Among the environments, L4 recorded low interaction. The environments L2 and L4 recorded positive type of interaction, while L1 and L3 recorded negative type of interaction. Stability analysis for grain yield indicated that hybrids viz., P1x P7, P1 x P10,P2 x P6 and P8 x P11 were showed stable in performance over the environments. The hybrid P1 x P7 was also found to be stable for hundred grain weight apart from grain yield per plant. The hybrids though exhibited high mean performance, depicting differential performance in rainfed, induced and overall environments under moisture conditions and thus were unstable.

Key words: Maize, moisture stress, stability, AMMI approach, grain yield.

Introduction

Agricultural yield is strongly influenced by environmental conditions that generally lead to wide variations in yield, both among years in a location and among locations in a single year or, even further, between locations and the years. Improving yield stability of an agricultural crop throughout production region is an important objective of breeding programmes.

Stability is the ability of a genotype to have always the uniform yield regardless of environmental effects [1]. Genotype x environment interaction (G x E) is a critical factor in crop improvement. Encountering the G x E interaction in study of genotype is a challenge to the plant breeders. A change in environment may have great effect in one genotype than the other. The occurrence of G x E interaction has long posed a major challenge to a complete understanding of a genotype or hybrid. The location effect, seasonal fluctuation and their interaction highly had its influence in the performance of genotypes with its yield potential.

Though maize hybrids are high yielders, the influence of G x E interaction is more on their performance. So the developments of well buffered hybrids or genotypes are the major objective of maize breeders. In maize, G x E interaction was also reported. [4 ,8,9]

Maize hybrids are generally cultivated under rainfed conditions. Since awareness towards industrial utility of maize products have been increasing, the demand of maize grains is also increased. Ultimately there is a need to increase the area of cultivation under maize from existing normal condition to further in stress condition under rainfed areas. Therefore, the stability of cultivar performance over a set of diverse environments is of considerable importance and is given special consideration in breeding programmes. There is always a need to test newly developed cultivars across different environments in order to elucidate the pattern and magnitude of genotype x environment interactions. So, development of a maize hybrid with stable yield under water stress will be of immense use to farming community. With this view, hybrids were evaluated under rainfed and induced moisture stress environments both at research station and at farmers holding.

Among different biometrical techniques are used to assess the G x E interactions, the model like Principle Component Analysis (PCA) and linear regression are not adequate in treating the complex data of yield trials effectively [10].

The AMMI model developed by Zobel *et al*. [10] had both additive and multiplicative effects had been applied for the data. In an AMMI bi plot presentation, when a genotype and environment has the score sign on the PCAI axis interaction is positive and if differ the interaction is negative. If a genotype or an environment has a PCAI score around zero it has small interaction effect and are considered as stable variety over a wide range of

DOI: 10.5958/0975-928X.2016.00014.4

environments. However, genotypes with high mean and high PCAI score are considered as having specific adaptability to the environments

Materials and methods.

The present investigation on genetic studies for drought tolerance in maize was carried out under moisture stress in rainfed and induced environments during the year 2008-2010 at the Regional Research Station, Paiyur, Krishnagiri district and in farmers holding at Dharmapuri district. Ninety one F1 single cross hybrids generated from diallel fashion, their parents (Table 1) and single cross hybrid check CoH(M)5 were tested at four locations both under rainfed and induced moisture stress conditions. The first set of experiments were conducted at Regional Research Station, Paiyur under rainfed and moisture stress induced conditions during August 2009. The second set of experiments were also organized in maize growing areas of Dharmapuri district in farmers holding both under rainfed and moisture stress induced conditions during August 2010 i.e. moisture stress rainfed (E1) at RRS, Paiyur (L1-2009) and farmers holding (L3-2010); moisture stress induced (E2) at RRS, Paiyur (L2-2009) and farmers holding (L4-2010) and overall environments (E3) (L1-L4).

The experiments were conducted in a randomized block design (RBD) with two replications. The plots were 4m length each in two rows with a spacing of 60cm between rows and 25cm between plants.Recommended agronomic practices were followed for all the trials.

The rainfed sowing was dependent on the monsoon, which starts by the middle of August, but rainfall distribution was erratic and can result in drought conditions at critical crop stages particularly during flowering for both years (2009, 2010). Drought was often experienced during the last week of September often coinciding with flowering.

The moisture stress induced experiment (E2) was planted for the year 2009 and 2010. Irrigation water was applied at planting to establish a good plant stand. Two weeks before silking, irrigation was withheld so that the crop was exposed to drought stress during flowering. The observations were recorded in each entry, in each replication and in each season on five randomly selected competitive plants excluding border plants and their mean values were computed for statistical analysis using TNAUSTAT and GENERES packages. The AMMI model developed had both additive and multiplicative effects had been applied for the data. In an AMMI bi plot presentation, when a genotype and environment has the score sign on the PCAI axis interaction is positive and if differ the interaction is negative. If a genotype or an environment has a PCAI score around zero it has small interaction effect and are considered as stable variety over a wide range of environments. However, genotypes with high mean and high PCAI score are considered as having specific adaptability to the environments

Results and discussion

The analysis of variance for stability revealed that for all the characters,the mean squares were significant for genotypes,environments,G x E interactions,PCA I, PCA II and PCA III.(Table 2). Estimates of stability for the characters are furnished in Table3.

Stability analysis for grain yield and its components

Genotypes interact with environment, and breeders usually apply some type of stability analysis to determine the nature of interaction. A number of different approaches to stability analysis have been developed to determine the response of hybrids under different environmental conditions. The 91 hybrids developed by diallel mating involving 14 inbreds were used to estimate stability for 4 yield related traits under moisture stress in rainfed, induced and across the environments.

Number of kernel rows

A total of 106 genotypes studied, 18 genotypes showed significantly high mean of kernel rows than the check in over all environments (E3). Among the high mean performing genotype, two hybrids (P2 x P8 and P2 x P11) with low interaction, two hybrids (P1 x P6 and P7 x P10) with positive interaction and 14 hybrids with negative interaction with environment were observed. Among the four environments, L1 showed low interaction followed by L3 and L4 with positive interaction and L2 with negative interaction. Based on mean and IPCA values, the genotypes P2 x P8 and P2 x P11 were considered as stable with high mean performance.

Number of kernels per row

Thirty one genotypes recorded superior mean performance than the check for number of kernels per row. Among these genotypes P1 x P8, P1 x P11, P2 x P3, P2 x P7, P4 x P5, P6 x P8 and P8 x P10 recorded low interaction with environment. Eighteen genotypes recorded positive type of interaction and six genotypes recorded negative type of interaction with environment. Among the environments, L1 recorded low interaction. The environments L2 and L4 with positive type of interactions and L3 with negative type of interaction were observed.

DOI: 10.5958/0975-928X.2016.00014.4

Based on mean and IPCA values, the genotypes P1 x P8, P1 x P11, P2 x P3, P2 x P7, P4 x P5, P6 x P8 and P8 x P10 were considered as stable with high mean performance for kernels per row.

Hundred grain weight

Among the genotypes, thirty two genotypes recorded significantly superior mean for hundred grain weight than the check. Among these genotypes, ten genotypes recorded low interaction with environment. Eleven genotypes recorded positive and negative type of interaction with environment. Among the environments L2 recorded low interactions. Two environments *viz*. L1 and L3 recorded positive type of interaction and L2 and L4 recorded negative type of interaction.

Based on mean and IPCA values, the genotypes *viz*. P1 x P3, P1 x P7, P2 x P5, P3 x P4, P5 x P10, P8 x P13, P10 x P11, P11 x P14 and P12 x P14 were considered as stable genotypes for hundred grain weight.

Grain yield per plant

Among the genotypes, twenty nine genotypes recorded significantly superior mean performance for grain yield per plant in over all environments. Among the high mean performing genotypes, four genotypes viz., P1 x P7, P1 x P10, P2 x P6 and P8 x P11 recorded low interaction, twenty four genotypes with positive type of interaction and one genotype P7 x P13 with negative type of interaction with environment were noticed. Among the environments, L4 recorded low interaction. The environments L2 and L4 recorded positive type of interaction, while L1 and L3 recorded negative type of interaction.(Table 2 and Fig 1).

Stability analysis for grain yield indicated that hybrids viz., P1x P7, P1 x P10, P2 x P6 and P8 x P11 were showed stable in performance over the environments. The hybrid P1 x P7 was also found to be stable for hundred grain weight apart from grain yield per plant. The hybrids though exhibited high mean performance, depicting differential performance in rainfed, induced and overall environments under moisture conditions and thus were unstable

Large number of locations are necessary to obtain reliable estimates of stability of a hybrids[7].Breeder’s first select high yielding hybrids, and as more data becomes available, select the most stable hybrids from among those with high yield[3]. Developing maize hybrids with yield stability is difficult, but necessary to meet the demand under moisture stress conditions. Unfortunately, it is not uncommon to have situations where selections based on yield stability causes lower mean yield [2,6] and, conversely, were selection for higher means results in less stability [9]. However, it was reported that a selection for wide adaptation to various environments in oat resulted in a significant increase in mean grain yield in the populations[5]. It is concluded that yield and its related traits may be taken in to account while selecting or evaluating maize hybrids for stability performance across the target environments.

DOI: 10.5958/0975-928X.2016.00014.4

References

Becker H.C. 1981. Correlation among some statistical measures of phenotypic stability. Euphytica, **30**: 835-840.

Finlay K.W. and Wilkinson G.N. 1963. The analysis of adaptation in a plant breeding programme. Aust. J. Agric. Res**., 14** : 742-754.

Gama E.E.G.E. and Hallauer A.R.1980.Stability of hybrids reduced from selected and unselected lines of maize**.** Crop Sci., **20** : 623-626.

Gelana Seboksa, Mandefro Nigussie and Gezahegne Bogale. 2001. Stability of drought tolerant maize genotypes in drought stressed areas of Ethiopia. Seventh Eastern and Southern Africa Regional Maize Conference. pp. 301-304.

Helms T.C. 1993. Selection for yield and stability among oat lines. Crop Sci**., 30 :** 423 -426

Holland J.B., Bjonstad A., Frey K.J., Gullord M. and Wesenberg D.M.. 2002. Recurrent selection for broad adaptation affects stability of oat. Euphytica, **126** : 265-274.

Jensen S.D. and Cavalieri A.J. 1983. Drought tolerance in US maize. Agric. Water Mgt**., 7 :** 223-236

Lata S. Guloria., Jai Dev., Katna G., Sood C., Kalia V. and Anand Singh. 2010. Stability analysis of maize (*Zea mays* L.) hybrids across loctors. Electronic J. of plant breeding **1** : 239-243.

Ogunbodede B.A., Ajibade S.R.and Olakojo S.A. 2001. Grain yield stability of new maize varieties in Nigeria. Agrican Crop Sci. J.**, 9:** 685-691.

Zobel R.W., Wright and Gauch H.G. 1988.Statistical analysis of a yield trial Agron. J., **80** : 388-393.

Electronic Journal of Plant Breeding,
ISSN 0975-928X

DOI: 10.5958/0975-928X.2016.00014.4

Table 1. Parents used in crossing

Genotypes	Code
UMI 285	P1
UMI 1085	P2
UMI 1058	P3
UMI 233	P4
UMI 1096	P5
UMI 1069	P6
UMI 1054	P7
UMI 1060	P8
UMI 1029	P9
UMI 1024	P10
UMI 1019	P11
UMI 1009	P12
UMI 917	P13
UMI 61	P14

Table 2. Analysis of Variances for stability (Mean squares) – AMMI model

Sources	df	Number of kernel rows	Kernels per row	Hundred grain weight	Grain yield per plant
Genotypes	107	3.97**	18.65**	12.37**	1618.47**
Environments	3	77.31**	898.73**	678.26**	66257.6**
G x E interaction	321	0.87**	3.51**	3.33**	151.32**
PCA I	109	1.30**	4.61**	4.12**	233.63**
PCA II	107	0.76**	3.14**	3.77**	122.04**
PCA III	105	0.51**	2.74**	2.07**	95.70**
Error	431	934.05	5817.74	4427.97	420521

** - Significant at 1% level

Electronic Journal of Plant Breeding,
ISSN 0975-928X

DOI: 10.5958/0975-928X.2016.00014.4

Table 3. Estimates of stability parameters (AMMI model) for hundred grain weight and grain yield per plant

Sl. No.	Genotypes	Hundred grain weight (g)			Grain yield per plant (g)		
		Mean	IPCA-1	IPCA-2	Mean	IPCA-1	IPCA-2
1.	P1	25.6	-0.5	-0.4	73.2	-2.3	-0.5
2.	P2	25.8	0.1	0.0	73.9	-2.2	-1.5
3.	P3	27.3	0.1	-0.4	76.5	-2.4	-1.8
4.	P4	26.1	0.0	-0.6	77.0	-1.9	-1.7
5.	P5	24.6	-0.3	-0.4	65.3	-1.1	-0.6
6.	P6	26.8	0.0	-0.3	60.5	-1.6	-0.2
7.	P7	25.7	-0.1	-0.2	69.2	-1.9	-0.6
8.	P8	25.3	0.0	-0.1	64.0	-2.8	-0.4
9.	P9	25.7	0.2	-0.5	68.3	-1.3	-1.4
10.	P10	24.1	0.2	-0.2	68.9	-1.2	-1.5
11.	P11	26.4	0.2	0.1	64.5	-1.0	-1.1
12.	P12	24.7	-0.2	1.0	62.2	-2.5	0.3
13.	P13	25.0	-0.3	-0.5	70.3	-1.4	-1.0
14.	P14	24.0	0.3	0.2	67.2	-2.1	-0.2
15.	P1 X P2	28.6	-0.4	-0.1	101.0	0.7	-1.9
16.	P1 X P3	28.8	-0.1	0.0	108.0	0.3	-0.1
17.	P1 X P4	25.9	0.2	-0.1	104.0	0.7	0.9
18.	P1 X P5	28.7	-0.2	0.3	108.0	0.9	-0.6
19.	P1 X P6	27.5	0.2	0.2	111.0	0.6	2.3
20.	P1 X P7	30.1	-0.1	0.7	129.0	-0.1	2.7
21.	P1 X P8	31.5	0.9	-0.2	138.0	1.3	-0.7
22.	P1 X P9	29.9	1.3	0.0	137.0	1.2	0.4
23.	P1 X P10	29.9	0.3	0.0	133.0	-0.1	2.0
24.	P1 X P11	30.8	-0.6	-0.3	138.0	3.5	-2.7
25.	P1 X P12	26.4	-0.8	-0.9	106.0	0.5	-1.3
26.	P1 X P13	29.0	0.3	-0.3	119.0	1.4	-2.2
27.	P1 X P14	27.9	-0.3	-0.3	103.0	-0.4	-0.6
28.	P2 X P3	30.6	-1.1	0.1	136.0	1.2	2.4
29.	P2 X P4	27.8	0.1	0.2	105.0	0.4	-0.8
30.	P2 X P5	30.2	0.1	0.4	138.0	2.5	-1.0
31.	P2 X P6	28.9	-0.1	0.8	126.0	0.1	1.9
32.	P2 X P7	26.8	0.2	0.3	112.0	1.6	-1.2
33.	P2 X P8	31.3	-0.8	1.0	146.0	0.9	-1.1
34.	P2 X P9	27.4	-0.9	-0.4	96.9	-2.2	0.7
35.	P2 X P10	27.6	-0.2	-0.1	100.0	-0.5	0.3
36.	P2 X P11	30.5	-0.8	0.2	139.0	1.9	1.8
37.	P2 X P12	26.0	0.5	-0.1	97.4	0.0	0.4

DOI: 10.5958/0975-928X.2016.00014.4

Table 3. Estimates of stability parameters (AMMI model) for hundred grain weight and grain yield per plant (contd.)

Sl. No.	Genotypes	Hundred grain weight (g)			Grain yield per plant (g)		
		Mean	IPCA-1	IPCA-2	Mean	IPCA-1	IPCA-2
38.	P2 X P13	26.9	1.2	-0.3	103.0	-1.9	0.4
39.	P2 X P14	26.4	0.5	0.4	99.8	1.1	-0.5
40.	P3 X P4	30.9	-0.1	-0.4	141.0	1.3	1.5
41.	P3 X P5	31.3	1.2	0.2	147.0	2.2	1.5
42.	P3 X P6	31.1	-0.6	-0.2	148.0	2.6	0.6
43.	P3 X P7	26.3	-0.3	-0.2	96.8	-0.5	1.2
44.	P3 X P8	27.1	0.7	0.0	97.9	-0.3	-0.4
45.	P3 X P9	25.3	-0.3	-0.6	96.5	0.1	0.0
46.	P3 X P10	26.5	0.0	-0.4	99.8	-0.1	0.3
47.	P3 X P11	24.7	-0.5	0.6	96.4	0.3	0.3
48.	P3 X P12	25.6	-1.2	-0.8	96.8	-0.8	0.4
49.	P3 X P13	28.0	-1.1	0.6	109.0	1.0	-1.7
50.	P3 X P14	26.4	-0.3	-0.2	103.0	1.9	-0.8
51.	P4 X P5	32.2	1.4	0.0	161.0	1.0	-0.3
52.	P4 X P6	31.8	1.3	-0.2	167.0	0.5	0.5
53.	P4 X P7	28.5	0.5	0.2	106.0	-0.6	0.1
54.	P4 X P8	25.9	-0.2	-0.4	94.7	-0.3	0.3
55.	P4 X P9	27.0	0.1	0.0	100.0	-1.6	-0.3
56.	P4 X P10	26.5	0.2	-0.1	105.0	0.5	0.2
57.	P4 X P11	26.0	0.2	0.1	93.9	-0.9	1.9
58.	P4 X P12	27.1	0.3	0.3	99.6	-1.3	0.3
59.	P4 X P13	27.8	0.0	0.0	103.0	-0.8	-0.7
60.	P4 X P14	25.7	0.2	0.4	99.6	0.7	-0.7
61.	P5 X P6	26.7	0.0	-0.6	105.0	-1.0	0.6
62.	P5 X P7	26.0	0.4	0.0	95.7	0.0	1.0
63.	P5 X P8	28.2	-0.2	0.0	104.0	-1.4	0.6
64.	P5 X P9	26.0	0.2	-0.2	98.1	-0.6	0.2
65.	P5 X P10	28.6	0.1	0.0	105.0	0.6	-0.6
66.	P5 X P11	26.1	-1.1	1.0	100.0	-0.3	2.2
67.	P5 X P12	26.4	0.7	0.1	90.0	-0.8	0.8
68.	P5 X P13	25.8	0.1	-0.2	95.3	-0.6	0.2
69.	P5 X P14	26.6	-0.2	1.0	97.2	1.1	0.3
70.	P6 X P7	28.2	0.7	0.7	113.0	0.9	-0.9
71.	P6 X P8	26.3	0.7	0.6	98.4	-1.9	0.7
72.	P6 X P9	26.6	-0.3	0.4	101.0	1.2	0.3
73.	P6 X P10	27.7	-0.4	-0.2	104.0	-0.7	-0.9
74.	P6 X P11	28.2	-1.3	0.3	105.0	-0.5	-0.3

DOI: 10.5958/0975-928X.2016.00014.4

Table 3. Estimates of stability parameters (AMMI model) for hundred grain weight and grain yield per plant (contd.)

Sl. No.	Genotypes	Hundred grain weight (g)			Grain yield per plant (g)		
		Mean	IPCA-1	IPCA-2	Mean	IPCA-1	IPCA-2
75.	P6 X P12	27.5	-0.9	0.0	95.3	-0.3	-0.3
76.	P6 X P13	26.6	0.7	0.0	97.3	-0.8	-0.1
77.	P6 X P14	26.7	-0.2	-0.4	101.0	0.3	0.3
78.	P7 X P8	26.4	-0.7	-0.3	101.0	0.0	0.5
79.	P7 X P9	28.6	0.3	-0.1	100.0	-0.2	0.2
80.	P7 X P10	27.2	0.3	0.1	111.0	0.6	1.2
81.	P7 X P11	29.0	-0.2	-0.4	105.0	-0.8	-0.3
82.	P7 X P12	28.3	-0.3	0.4	103.0	0.8	-0.3
83.	P7 X P13	28.0	0.0	0.1	110.0	-0.4	-0.1
84.	P7 X P14	27.3	0.2	0.1	103.0	-0.5	-0.8
85.	P8 X P9	25.9	-0.5	0.3	99.8	0.9	-0.4
86.	P8 X P10	27.9	-0.1	-0.2	105.0	-0.8	1.0
87.	P8 X P11	27.1	0.3	0.2	108.0	0.0	-0.9
88.	P8 X P12	25.8	0.0	0.1	98.2	0.3	0.5
89.	P8 X P13	28.3	0.0	-0.2	109.0	0.5	1.1
90.	P8 X P14	26.6	0.4	0.1	99.5	0.4	0.3
91.	P9 X P10	26.3	0.3	0.2	97.0	-0.4	0.0
92.	P9 X P11	24.9	-0.2	0.2	99.3	0.8	0.9
93.	P9 X P12	27.7	-0.1	0.0	97.3	-1.6	-0.5
94.	P9 X P13	27.0	0.2	0.1	93.6	-0.5	0.1
95.	P9 X P14	25.7	-0.8	0.4	97.0	-0.1	0.0
96.	P10 X P11	28.3	0.0	0.3	109.0	1.4	-0.5
97.	P10 X P12	26.5	0.7	0.3	95.7	-0.9	0.8
98.	P10 X P13	28.4	0.4	0.0	111.0	0.4	2.3
99.	P10 X P14	27.0	0.0	-0.4	101.0	1.9	-0.3
100.	P11 X P12	27.8	0.2	-0.4	103.0	0.5	-1.1
101.	P11 X P13	27.5	0.2	-0.2	104.0	0.1	1.4
102.	P11 X P14	28.3	0.1	0.0	110.0	0.9	-1.0
103.	P12 X P13	26.6	0.0	-0.6	104.0	0.7	-0.7
104.	P12 X P14	28.1	0.1	0.6	107.0	0.8	-0.5
105.	P13 X P14	27.2	0.3	-0.5	106.0	1.0	0.1
	Check	27.4	0.2	0.1	104.0	1.1	-0.5
	Mean L2	27.9	-1.7	3.1	110.4	9.9	-3.8
	Mean L1	24.4	3.0	0.4	70.6	-4.5	-3.5
	Mean L3	27.0	2.3	-1.4	103.1	-6.4	-1.9
	Mean L4	30.4	-3.6	-2.1	130.2	1.0	9.2
	Grand mean	27.4	0.0	0.0	103.6	0.0	0.0
	CD at 5%	0.61	-	-	3.09	-	-

DOI: 10.5958/0975-928X.2016.00014.4

Fig 1. Biplot graph for mean and PCA I - Grain yield per Plant