International Journal of Plant & Soil Science

34(19): 62-69, 2022; Article no.IJPSS.87359
ISSN: 2320-7035

Genotype X Environment Interaction Studies in Single Cross Maize Hybrids for Quality Traits under Different Environments

Khushbu Chittora [a*¥], R. B. Dubey [b#] and Narayan Ram Gurjar [c‡]

[a] Department of Agriculture, Rajasthan Government, Rajasthan, India.
[b] Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan 313001, India.
[c] Agriculture University, Jodhpur, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i1931089

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/87359

Original Research Article

Received 08 March 2022
Accepted 17 May 2022
Published 19 May 2022

ABSTRACT

Sixty eight genotypes of maize (48 hybrids, 16 parents and 4 checks were evaluated under three different environments to test their stability. Variance due to genotypes, environments and genotype x environment interactions were found significant for oil content, starch content and protein content. Regression approach by Eberhart and Russel 1966 used to investigate the nature of G x E interaction and for identifying genotypes possessing general and specific adaption. None of the hybrids had stability for all quality traits. For Grain Starch content hybrid EI-1155-1 x EI-2416, for oil content hybrid EI-670-2 x EI-2403 and for Protein content hybrids EI-2187 x EI-2403, EI-536-3 x EI-2403, EI-2176 x EI-561-2,EI-2173 x EI561-7 had higher mean values, non significant deviation from regression and regression coefficient around unity (bi=1) indicating the stable performance in different environment and wider adaptability.

Keywords: Grain quality; protein; oil; starch content; stress; linear regression; regression coefficient.

[¥]Assistant Agriculture Officer;
[#]Professor;
[‡]Research Scholar;
**Corresponding author: E-mail: khushboo23290@gmail.com;*

1. INTRODUCTION

Maize (*Zea mays* L.; 2n=20) is an important annual cereal, short day, C_4 crop of the family Poaceae. Maize along with wheat and rice provides at least 30 percent of the food calories to more than 4.5 billion people in 94 developing countries where one-third of children are malnourished. By 2050, the demand for maize in the developing world will be almost double to the current demand. However, an estimated 15 to 20 per cent of yield losses each year reported due to drought and climate changes. Maize is affected by drought at different growth stages in different regions. Germination potential, seedling growth, seedling stand establishment, overall growth and development, pollen development, silk development, anthesis–silking interval, pollination, embryo development, endosperm development and kernel development are the events in the life of maize crop which are seriously hampered by drought stress [1].

The use of genetics to improve drought tolerance and provide yield stability is an important part of the solution to stabilizing global production. That is why the development of maize varieties with enhanced tolerance to drought stress and higher water use efficiency (WUE) has become a high priority goal for major breeding programs, both in the private and public sectors [2]. Regression approach is being increasingly used to investigate the nature of G x E interaction and for identifying genotypes possessing general and specific adaption in almost all the crop plants. In present study, we use Eberhart and Russell [3] model to identify hybrids suitable for different environment for the protein, oil, and starch compounds of grains.

2. MATERIALS AND METHODS

The experimental material comprised of 12 inbred lines *viz.,* EI-2176*,* EI-2145, EI-670-2, EI-1155-1, EI-2173, EI-1280-1, EI-2187, EI-2174, EI-586-03, EI-2172, EI-536-3 and EI-2173-56 and 4 testers EI-2403, EI-2127, EI-561-2, EI-2416 their 48 F_1s and 4 checks *viz.,* HM-5, CHM-08-287, Vivek maize hybrid-21 and PMH-3. These 48 F_1s were obtained by crossing 12 inbred with 4 testers in line x tester mating design during late *kharif* 2016.

Total 68 genotypes (12 inbred lines, 4 testers, 48 crosses and 4 checks) were sown in a randomized block design with three replications in three different environments during spring 2018 at Plant Breeding and Genetics farm, Rajasthan College of Agriculture, Udaipur (Rajasthan). Each treatment was sown in single row plot of 4 meter length maintaining crop geometry of 60 x 25 cm row to row and plant to plant spacing, respectively. Each environment was separated by 2 m channel for proper water management. Non-experimental rows were planted around the layout to eliminate border effects. The other recommended agronomical practices were used to raise a healthy crop. Starch content of the seeds was estimated by using Anthrone reagent method. Oil content of the seeds was estimated by using Soxhlet's ether extraction method [4] and Protein content of the seeds was estimated by using Lowry's method [5]. The details of the three environments are presented in Table 1.

Table 1. Details of the environments

Environment 1	Normal irrigation
Environment 2	Irrigation withheld at anthesis for 20 days
Environment 3	Irrigation withheld at grain filling stage for 20 days

2.1 Estimation of Stability Parameters

Two parameters of stability *viz.* regression coefficient (b_i) and mean square deviation from linear regression (S^2d_i) were calculated.

1. The regression coefficient (b_i) is the regression of the performance of each genotype under different environments on the environmental means over all the genotypes. It was estimated as:

$$b_i = \frac{\sum_{j=1}^{l} Y_{ij} \times I_j}{\sum_{j=1}^{l} I_j^2}$$

2. The mean squares deviation from regression (S^2d_i) was estimated as:

$$S_{di}^2 = \left(\frac{\sum_{j=1}^{l} \hat{\delta}_{ij}^2}{l-2} \right) - \frac{S_e^2}{r}$$

Where,

S^2_e = Estimate of pooled error mean square and

$$\sum_{j}^{l}\hat{\delta}_{ij}^{2}=\left(\sum_{j=1}^{i}Y_{ij}^{2}-\frac{Y_{i}^{2}}{l}\right)-\frac{\left(\sum_{j=1}^{i}Y_{ij}^{2}.I_{j}\right)^{2}}{\sum_{j=1}^{i}I_{j}^{2}}$$

3. RESULTS AND DISCUSSION

The pooled analysis of variance (Table 2) revealed significant differences among the hybrids for all the traits thus indicated the existence of genetic variability. Mean square due to environment, genotype and genotype x environment, were significant for all characters, indicating that all the hybrids interacted considerably well with the environmental conditions. Mean square due to genotypes was significant for all traits under study. Analysis of variance by Eberhart and Russel, [3] (Table 3) revealed that Mean square due to environment (E) plus genotypes x environment (G x E) interaction also found significant for all characters. Mean square due to environment (linear) was significant for grain protein content. The mean square due to G x E linear interaction was significant for all characters. The significant mean square due to pooled deviation for all characters was significant indicated that the genotype differed considerably with respect to their stability.

The stability parameters, such as regression coefficient (bi) and deviation from regression (S^2di) along with mean performance of genotypes for character under study were computed to assess the stability and suitability of performance over the environment (Table 4) and results are narrated as following.

3.1 For Grain Starch Content

Out of 68, 47 genotype exhibited non-significant deviation from regression (S^2di), indicating their predictable behavior for grain starch content. Among parental lines, tester EI-2127 inbred lines EI-1280-1, EI-2187 and EI-EI-2174 showed regression coefficient around unity (bi= 1), whereas tester EI-2416 and inbred lines EI-2172 and EI-2173-56 had above unity (b>1)regression coefficient stable performance in different environments as normal as well as water stressed conditions for higher grain starch content, especially.

Non-significant with higher mean value from regression (S^2di) was observed in 36 hybrids. Out of which, hybrids EI-2176 x EI-2403, EI-2145 x EI-2127, EI-2173 x EI-2403, EI-EI-2174 x EI-2403, EI-586-03 x EI-2403, EI than population mean which indicates that inbred line have deviation -2176 x EI-2127, EI-670-2 x EI-2127, EI-1280-1 x EI-2127, EI-2187 x EI-2127, EI-1280-1 x EI-561-2 , EI-2187x EI-561-2 , EI-EI-2174 x EI-561-2 , EI-2173-56 x EI-561-2 , EI-2176 x EI-2416 , EI-670-2 x EI-2416 , EI-1155-1 x EI-2416 , EI-2173 x EI-2416 , EI-2187 x EI-2416 and EI-2172 x EI-2416 showed regression coefficient around unity (bi= 1) with higher mean values than population mean indicating the stable performance in different environment for higher grain starch content. Four hybrids *viz*. EI-2172 x EI-2403, EI-2145 x EI-2127, EI-1155-1 x EI-2127 and EI-536-3 x EI-2127 depicted regression coefficient less than unity (bi<1) along with higher mean value than population mean showed hybrids superiority and stability water stressed environments for higher grain starch content. The two hybrids *viz.,* EI-2176 x EI-561-2 and EI-2145 x EI-561-2 exhibited regression coefficient above unity (bi> 1) along with higher mean value than population mean showed hybrids superiority and stability under favorable environments for higher starch content.

3.2 Grain Oil Content

Out of 68, twelve genotype showed non-significant deviation from regression (S^2di) indicating their predictable behavior for grain oil content.

Tester EI-2416 and inbred line EI-2173, showed regression coefficient around unity (bi=1) with higher mean value than population mean indicating stable performance under different environment. Inbred line EI-2176 showed regression coefficient above unity (bi> 1) with higher mean value than population mean indicating stable performance of inbred line under favorable environment.

Non-significant deviation from regression (S^2di) was observed in five hybrids. Out of which, hybrid *viz.,* EI-670-2 x EI-2403, showed regression coefficient around than unity (bi= 1) with higher mean values than population mean showed hybrids superiority and stability under different environments for higher oil content. while hybrid EI-586-03 x EI-561-2 showed regression coefficient less than unity (bi<1) and one hybrid EI-2145 x EI-2416 exhibited regression coefficient above unity (bi> 1) along with higher mean value than population mean showed hybrids stability under unfavorable and favorable environments for higher oil content.

3.3 Grain Protein Content

Non-significant deviation from regression (S^2di) was observed in 3 parents but only one parent EI-586-03 exhibited higher mean value than population mean with regression coefficient around unity (bi=1) indicating stable performance under different environment.

Non-significant deviation from regression (S^2di) was observed in fifteen hybrids. Out of them, four hybrids *viz.,* EI-2187 x EI-2403, EI-536-3 x EI-2403, EI-2176 x EI-561-2 and EI-2173 x EI-561-2, showed higher mean value than population mean regression coefficient around unity (bi=1) indicating stable performance under different environment. One hybrid EI-2145 x EI-2403 showed regression coefficient above unity (bi> 1) with higher mean values than population mean, While, hybrid EI-586-03 x EI-2416 exhibited regression coefficient less than unity (bi<1) with higher mean value than population mean, indicating hybrids performance were stable under favorable and unfavorable as moisture deficit environments for protein content, respectively. similar findings for starch content, oil content and protein content were reported by Dadeech and Joshi [6], Shanthi et al. [7], Baudh Bharti et al. [8] and Patel and Kathiria [9]. Further classification of genotype as per their suitability in different environment is shown in Table 4.

Table 2. Pooled analysis of variance grain starch content, grain oil content and grain protein content

SN	Source	df	Grain starch content	Grain Oil content	Grain Protein content
1.	Environment	2	1975.10**	37.85**	188.95**
2.	Rep./Env	6	1.03	0.01	0.01
3.	Genotype	67	50.60**	1.68**	3.61**
4.	G x E	134	7.27**	0.24**	0.52**
5.	Pooled Error	402	0.81	0.01	0.02
5.	Bartlet	2	2.33	1.94	0.47

**, ** Significant at 5% and 1% respectively*

Table 3. Analysis of variance Eberhart and Russel [3]

SN	Characters	Genotype [67]	E+(G x E) [136]	E (L) [1]	G x E (L) [67]	Pool dev. [68]	Pool Err [402]
1.	Grain starch content (%)	16.87**	12.07**	0.28	23.45**	1.03**	0.27
2.	Grain oil content (%)	0.56**	0.27**	0.01	0.46**	0.08**	0.00
3.	Grain protein content (%)	1.20**	1.10**	0.03*	1.97**	0.26**	0.01

[ ] Degrees of freedom
**, ** Significant at 5% and 1% respectively*

Table 4. Stability parameters for grain starch content (%), grain oil content (%) and grain protein content (%)

SN	Genotype	Grain starch content (%)			Grain oil content (%)			Grain protein content (%)		
		μ_i	b_i	S^2d_i	μ_i	b_i	S^2d_i	μ_i	b_i	S^2d_i
1	EI-2403	60.91	1.89	3.580**	3.96	0.09	0.078**	7.54	1.05	0.021*
2	EI-2127	61.70	1.18*	-0.173	3.18	1.64	0.203**	8.12	1.02	0.284**
3	EI-561-2	56.85	1.13*	-0.236	4.08	0.38	0.007*	9.27	1.03	0.031*
4	EI-2416	63.19	1.35	0.659	3.74	0.41	0.002	7.83	1.01	0.578**
5	EI-2176	58.65	1.13*	-0.236	3.73	1.32	0.021**	8.40	1.03	0.394**
6	EI-2145	56.12	1.13*	-0.236	3.92	0.63	0.069**	8.55	0.76	1.230**
7	EI-670-2	54.24	0.53	1.201*	3.70	0.89	0.001	9.52	0.95	0.224**
8	EI-1155-1	64.57	0.67	0.352	3.17	1.38	0.033**	7.67	0.90*	-0.000
9	EI-2173	59.14	1.13*	-0.236	3.97	0.77*	-0.001	8.08	1.06	0.112**
10	EI-1280-01	60.00	1.13*	-0.236	3.73	0.97*	-0.000	7.63	1.16	0.082**
11	EI-2187	59.73	1.11	-0.006	4.28	0.42	0.044**	8.64	1.03	0.074**
12	EI-2174	61.47	0.87	0.556	3.17	0.40	0.002	7.27	1.04	0.138**
13	EI-586-03	57.13	2.00	4.642**	3.85	1.05	0.041**	8.54	1.03	0.014

SN	Genotype	Grain starch content (%)			Grain oil content (%)			Grain protein content (%)		
		μ_i	b_i	S^2d_i	μ_i	b_i	S^2d_i	μ_i	b_i	S^2d_i
14	EI-2172	60.84	1.95	4.095**	3.26	0.84	0.034**	7.48	1.05**	-0.006
15	EI-536-3	58.45	1.13*	-0.236	4.08	1.18	0.040**	8.86	1.01	0.305**
16	EI-2173-56	59.91	2.06	5.221**	4.06	0.32*+	-0.002	7.75	1.04*	0.000
17	EI-2176 x EI-2403	63.85	1.13*	-0.236	4.11	1.30	0.044**	8.39	0.94	0.662**
18	EI-2145 x EI-2403	61.31	1.13*	-0.236	4.02	1.37	0.012**	8.41	0.45	0.746**
19	EI-670-2 x EI-2403	57.66	0.09	2.570**	4.80	1.26	0.004	9.27	0.68	0.376**
20	EI-1155-1 x EI-2403	61.95	0.47	1.525**	3.95	0.61	0.007*	7.80	1.05	0.049**
21	EI-2173 x EI-2403	62.02	1.13*	-0.236	4.21	1.02	0.010**	7.90	1.23*	-0.005
22	EI-1280-01 x EI-2403	62.92	0.36	2.271**	3.74	1.08	0.023**	7.95	1.01*	-0.003
23	EI-2187 x EI-2403	60.99	0.09	4.699**	4.11	1.04	0.122**	8.55	1.05*	-0.000
24	EI-2174 x EI-2403	62.14	1.13*	-0.236	4.03	1.73	0.064**	8.03	1.01	0.339**
25	EI-586-03 x EI-2403	62.45	1.13*	-0.236	3.88	1.01	0.065**	7.72	1.04*	0.001
26	EI-2172 x EI-2403	63.74	0.63	0.650	3.34	1.71	0.228**	7.85	1.01	0.434**
27	EI-536-3 x EI-2403	57.99	1.13*	-0.236	3.94	1.84	0.085**	8.53	1.04*	-0.005
28	EI-2173-56 x EI-2403	58.88	1.13*	-0.236	4.82	0.97	0.055**	8.50	1.01	0.478**
29	EI-2176 x EI-2127	59.75	1.13*	-0.236	4.31	1.36	0.054**	8.10	1.05*	0.003
30	EI-2145 x EI-2127	62.07	0.31	2.692**	3.99	1.63	0.034**	8.86	1.98*+	-0.001
31	EI-670-2 x EI-2127	61.73	1.13*	-0.236	3.86	0.91	0.023**	8.12	1.02	0.174**
32	EI-1155-1 x EI-2127	64.35	0.63	0.650	3.66	1.38*	-0.001	7.69	1.02	0.224**
33	EI-2173 x EI-2127	59.57	1.13*	-0.236	4.45	1.02	0.402**	8.94	1.05	0.047**
34	EI-1280-01 x EI-2127	61.05	1.13*	-0.236	3.67	1.48	0.038**	8.52	1.01	0.545**
35	EI-2187 x EI-2127	62.55	1.13*	-0.236	4.44	1.20	0.294**	7.61	1.02	0.250**
36	EI-2174 x EI-2127	62.98	0.25	3.145**	3.78	1.00	0.060**	7.80	1.03	0.062**
37	EI-586-03 x EI-2127	57.23	1.13*	-0.236	3.53	1.09	0.248**	9.34	1.01	0.529**
38	EI-2172 x EI-2127	62.18	0.25	3.145**	4.67	0.56	0.263**	7.77	1.06	0.198**
39	EI-536-3 x EI-2127	62.18	0.69	0.422	4.28	0.62	0.015**	7.74	1.06	0.196**
40	EI-2173-56 x EI-2127	62.69	1.78	2.648**	4.34	1.42	0.034**	6.92	1.04*	-0.005
41	EI-2176 x EI-561-2	59.80	1.24	-0.078	4.27	0.33	0.137**	8.78	1.00	0.008
42	EI-2145 x EI-561-2	61.95	1.40	0.401	4.58	1.02	0.082**	8.44	1.58	0.044**

SN	Genotype	Grain starch content (%)			Grain oil content (%)			Grain protein content (%)		
		μ_i	b_i	S^2d_i	μ_i	b_i	S^2d_i	μ_i	b_i	S^2d_i
43	EI-670-2 x EI-561-2	58.98	1.13*	-0.236	3.61	0.50	0.027**	10.13	1.02	1.316**
44	EI-1155-1 x EI-561-2	61.42	1.13*	-0.236	4.85	0.60	0.020**	7.61	1.04	0.007
45	EI-2173 x EI-561-2	58.19	1.40	0.401	4.34	1.32	0.085**	8.50	1.04*	-0.003
46	EI-1280-01 x EI-561-2	62.77	1.13*	-0.236	4.41	0.63	0.161**	7.64	1.03	0.092**
47	EI-2187 x EI-561-2	60.47	1.13*	-0.236	4.74	1.26	0.083**	7.70	1.09	0.985**
48	EI-2174 x EI-561-2	62.40	1.13*	-0.236	3.77	-0.16	0.055**	7.46	1.05	0.050**
49	EI-586-03 x EI-561-2	58.90	1.13*	-0.236	3.82	0.70	0.004	8.36	1.06	0.206**
50	EI-2172 x EI-561-2	62.90	0.42	1.882**	3.69	0.95	0.005	8.28	1.21	0.027*
51	EI-536-3 x EI-561-2	63.98	0.58	0.909*	4.77	1.58	0.300**	7.73	1.01	0.445**
52	EI-2173-56 x EI-561-2	63.60	1.13*	-0.236	4.44	1.02	0.125**	7.64	1.04**	-0.006
53	EI-2176 x EI-2416	65.81	1.13*	-0.236	3.91	2.09	0.386**	7.28	0.84	0.257**
54	EI-2145 x EI-2416	58.80	1.13*	-0.236	3.90	1.57*	0.000	8.75	0.59	1.297**
55	EI-670-2 x EI-2416	62.05	1.13*	-0.236	4.25	0.24	0.005*	7.84	1.01	0.375**
56	EI-1155-1 x EI-2416	66.33	0.93	0.249	4.01	0.90	0.096**	7.12	1.01	0.456**
57	EI-2173 x EI-2416	60.92	1.13*	-0.236	4.31	1.29	0.141**	7.95	1.00	0.794**
58	EI-1280-01 x EI-2416	61.65	-0.24	8.677**	3.17	1.03	0.587**	8.69	1.03	0.039**
59	EI-2187 x EI-2416	60.71	1.13*	-0.236	3.96	1.61	0.129**	8.28	1.02	0.299**
60	EI-2174 x EI-2416	58.54	1.13*	-0.236	4.02	1.14	0.037**	8.16	0.58	0.010
61	EI-586-03 x EI-2416	65.02	1.13*	-0.236	3.44	0.86	0.028**	8.22	0.53	0.001
62	EI-2172 x EI-2416	61.66	1.13*	-0.236	3.81	0.15	0.016**	8.12	0.69*	-0.001
63	EI-536-3 x EI-2416	57.45	1.13*	-0.236	4.66	1.31	0.013**	9.71	1.03	0.669**
64	EI-2173-56 x EI-2416	62.71	0.36	2.271**	4.81	1.40	0.012**	7.62	1.08	0.733**
65	HM-5	62.09	1.12*	-0.263	3.80	0.80	0.021**	8.26	1.05	0.023*
66	CHM-08-287	61.31	1.08	0.492	4.53	1.35*	-0.000	8.27	1.03	0.038**
67	Vivek Maize Hybrid 21	61.51	0.38	0.459	4.49	0.92	0.034**	7.06	1.04*	-0.001
68	Pratap Hybrid Maize-3	63.07	0.70	-0.204	4.20	0.27	0.037**	7.98	0.27	0.003

**, ** Significantly deviating from zero at 5% and 1% respectively*
+, ++ Significantly deviating from unity at 5% and 1% respectively

Table 5. Classification of genotype suitable for various environments

Sr. No.	Characters	Different environments (bi=1)	Unfavorable environments (bi <1)	Favorable environments (bi >1)
1	Grain Starch content (%)	EI-1155-1 x EI-2416	EI-2172 x EI-2403, EI-1155-1 x EI-2127 and EI-536-3 x EI-2127	EI-2176 x EI-2403, EI-2145 x EI-2403, EI-2173 x EI-2403, EI-2174 x EI-2403 , EI-586-03 x EI-2403, EI-670-2 x EI-2127, EI-1280-01 x EI-2127, EI-2187 x EI-2127, EI-2145 x EI-561-2, EI-1280-01 x EI-561-2, EI-2187 x EI-561-2, EI-2174 x EI-561-2, EI-586-03 x EI-561-2, EI-2173-56 x EI-561-2, EI-2176 x EI-2416, EI-2145 x EI-2416, EI-670-2 x EI-2416, EI-2187 x EI-2416, EI-586-03 x EI-2416, EI-586-03 x EI-2416 and EI-2172 x EI-2416
2	Grain Oil content (%)	EI-670-2 x EI-2403	EI-586-03 x EI-561-2	EI-2145 x EI-2416
3	Grain Protein content (%)	EI-2187 x EI-2403, EI-536-3 x EI-2403, EI-2176 x EI-561-2,EI-2173 x EI561-7	EI-586-03 x EI-2416	EI-2145 x EI-2403

4. CONCLUSIONS

This study revealed that genotypes, environments and genotype x environment interaction were significant for quality traits in maize. The genotypes therefore performed differently within each environment and their relative performance varied from one environment to another. The stability parameters, such as regression coefficient (bi) and deviation from regression (S^2di) along with mean performance of genotypes for quality traits were computed to assess the stability and suitability of performance over the environments. Among all the inbreds and hybrids none of the genotype had stability for all quality traits. The inbreds lines found suitable for wider adaptability can be use into further breeding programs and single cross hybrids, which are stable and superior for quality traits could be tested in large scale trials across environments for their wide adaptation in diverse ecological regions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Aslam M, Maqbool MA, Cengiz R. Effects of drought on maize. Springer Briefs; 2015.
2. Maazou ARS, Tu JL, Qiu J, Liu ZZ. Breeding for drought tolerance in maize (*Zea mays* L.). American J. of Plant Sci. 2016;7:1858-1870.
3. Eberhart SA, Russell WA. Stability parameters for comparing varieties. Crop Sci. 1966;6:36-40.
4. A.O.A.C. Official methods for oil analysis for Association of Official Agricultural Chemists 10th Ed Washington, D.C.; 1965.
5. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Journal of Biological Chemistry. 1951;193:265 (The original method).
6. Dadheech A, Joshi VN. Stability analysis for quality traits in maize (*Zea mays* L.) Agric. Sci. Digest. 2007;27(1):26–29.
7. Shanthi P, Satyanarayana E, Suresh babu G, Sai Kumar R. Studies on exploitation of heterosis for grain yield and quality parameters in quality protein maize (QPM) genotypes (*Zea m*ays L.). Crop Res. 2011; 41(1,2&3):171-175.
8. Baudh Bharti, Dubey RB, Kumar A, Dadheech A, Dhobi RK. Stability analysis for grain yield and quality parameters in QPM (*Zea mays* L.) inbred line crosses. Int. J. Curr. Microbiol. App. Sci. 2017; 6(6):3177-3185.
9. Patel P, Kathiria KB. Stability analysis for quality traits in maize (*Zea mays* L.). Electronic Journal of Plant Breeding. 2017;7(3):634-639.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/87359