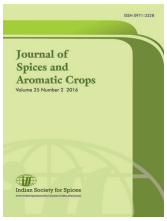
Journal of Spices and Aromatic Crops
Vol. 25 (2) : 175–181 (2016)
www.indianspicesociety.in/josac/index.php/josac

Indian Society for Spices



Genotype x environment interaction and stability analysis for yield and its attributes in garlic (*Allium sativum* L.)

R K Singh*, B K Dubey & R P Gupta

National Horticultural Research and Development Foundation,
Post-Darna Sangavi, Taluka-Niphad, Nashik-422 003, Maharashtra.
**E-mail: singhrknbpgr@gmail.com*

Received 28 April 2015; Revised 05 August 2015; Accepted 16 September 2015

Abstract

Genotype environment interaction is very important to the plant breeder in developing improved varieties. The present investigation was carried out at National Horticultural Research and Development Foundation, Karnal to identify the suitable and stable genotypes for *Rabi* season with higher yield and others horticultural attributes. It is concluded from present investigation that the genotype G-384, G-324, G-378, G-376 and check *Yamuna Safed*-3 (G-282) performed well in favorable environment for gross as well as marketable yield and considered as most stable and responsive genotype as it possesses higher yield along with the bi=one or near one and non-significant S^2di values and hence could be recommended for adoptability. These above genotypes can be further exploited in breeding programme for increasing the production of garlic.

Keywords: *Allium sativum*, garlic, G x E interaction, stability analysis

Introduction

Garlic (*Allium sativum* L.) is an important bulbous crop and widely cultivated throughout country. It is highly valued for its flavor enhancing capacity (Roy & Chakraborti 2002), has higher nutritive values than other bulbous crops and can also used for preparation of pickle (Pandey & Singh 1987). China, India, Korea, Russian Federation, Myanmar, Ethiopia, USA and Egypt are the major garlic growing countries. Presently garlic area is 2.31 lakh ha, with production of 12.52 lakh metric tonnes and productivity of 5.43 t ha^{-1}. The above achievements are certainly because of the adoption of high yielding improved varieties and innovative technology. The average productivity of garlic in India is 5.43 t ha^{-1}, which is very low if compared to other garlic growing countries. Garlic production is highly influenced by agro-techniques and environmental conditions. It posses a wide range of variability on bulb traits and yield attributes as well as the storability in spite of being vegetatively propagated crop.

The relative performance of crop varieties is generally different in different environment. This is due to varieties genetic constitution and environment in which it has been grown. The genotypes grown in multi environmental trials may react differently to a range of climate conditions, soil characteristics or technical practices (Lacaze & Roumet 2004). These

differential responses of genotypes in different environment are collectively known as the genotype environment interaction. The goal of any plant breeding programme is to develop cultivars with high yielding potential with stable performance over a wide range of environments. Several methods have been reported for analyzing the genotype environment interaction and stability of performance in crop plant (Finlay & Wilkinson 1963; Eberhart & Russell 1966; Perkins & Jinks 1968; Lin *et. al*. 1986, Westcott 1986; Becker & Leon 1988). Among the different approaches Eberhart & Russell (1966) and Perkins & Jinks (1968) models have been commonly used to estimate stability parameters in various crop plants. Keeping all above facts in view, the present study was carried out with available garlic genotypes over a wide range of agro-climatic conditions for commercial exploitation or effective utilization in breeding programme.

Materials and methods

The present investigation was carried out at National Horticultural Research & Development Foundation Regional Research Station, Karnal, Haryana during three consecutive years 2008–11 with 11 genotypes and 5 checks i. e. *Yamuna Safed* (G-1), *Agrifound White* (G-41), *Yamuna Safed*-2 (G-50), *Yamuna Safed*-3 (G-282) and *Yamuna Safed*-4 (G-323) in randomized block design with three replications to identify the suitable and stable genotypes for *Rabi* season with higher yield and others horticultural attributes. Soil of the experimental block was clay loam, medium in organic carbon (0.58%), available nitrogen (385.2 kg ha^{-1}), phosphorus (45.13 kg ha^{-1}) and high in available potash (291.2 kg ha^{-1}). Cloves of uniform size (8-10 mm) were selected and planted in first fortnight of October in bed size of 3.0 m × 1.5 m with the spacing of 10 m × 7.5 cm. The climate of Karnal is subtropical with minimum and maximum temperature ranging between 2°C to 42°C and favorable for garlic cultivation. Recommended cultural operations were carried out to ensure a healthy crop growth and development. Harvesting was done as per the maturity of different genotypes. The observations were recorded on ten randomly selected plants in each replication for all the characters *viz.*, plant height (cm), number of leaves $plant^{-1}$, weight of 20 bulbs (kg), weight of 50 cloves (g), number of cloves $bulb^{-1}$, total yield (q ha^{-1}), marketable yield (q ha^{-1}) and stemphylium blight intensity. The data were analyzed statistically for stability parameters based on mean performance over the years as per the model suggested by Eberhart & Russell (1966) for various traits.

Results and discussion

The pooled analysis of variance of eight characters is presented in Table 1. The mean square due to genotypes was significant for all the traits. This showed variability among the genotypes for these characters. The mean square due to environment (years) were significant for all the traits except leaves per plant and number of cloves per bulb indicating that the performance over years was not stable. The mean square due to G X E interaction was significant for weight of 20 bulbs, gross yield, marketable yield and stemphylium blight intensity indicating differential response of genotype to different environment. This result was in agreement with Singh *et al* (1995), Mohanty & Prusti (2001) and Khar *et al.* (2007). Significant mean square due to environment + (genotype x environment) interaction for plant height, weight of 20 bulbs, weight of 50 cloves, gross yield, marketable yield and stemphylium blight intensity revealed that the variety considerably with existing environment condition for these traits. Significant mean square due to environment (linear) indicated considerable difference among environment and their predominant effect on all the traits except leaves $plant^{-1}$, number of cloves $bulbs^{-1}$. The variance due to G X E interaction (L) was significant for weight of 20 bulbs, weight of 50 cloves, gross yield, marketable yield and stemphylium blight intensity. However, highly significant pooled deviations for plant height and leaves $plant^{-1}$ indicated non-linear response of the genotype due to environmental changes and greater role of unpredictable component of G X E interaction towards difference in stability

Table 1. Analysis of variance for horticultural traits over three years in garlic genotypes

Source of variation	DF	Plant height (cm)	Number of leaves plant^{-1}	Weight of 20 bulbs (kg)	Number of cloves bulb^{-1}	Weight of 50 cloves (g)	Gross yield (q ha^{-1})	Marketable yield (q ha^{-1})	Stemphylium blight intensity
Genotypes	15	157.08**	0.40**	0.002**	230.46**	409.12**	3114.17**	2142.58**	27.49**
Environments	2	110.01**	0.06	0.001**	0.81	39.72**	323.52**	174.25**	0.71**
G × E	30	6.14	0.10	0.0005	1.67	8.72	105.93*	61.23*	0.38**
E + (G × E)	32	12.63*	0.10	0.002**	1.61	10.65*	119.53**	68.29*	0.40**
E (L)	1	220.02**	0.11	0.002**	1.61	79.43**	647.04**	348.50**	1.42**
G × E (L)	15	7.18	0.08	0.0008**	1.79	12.43*	167.45**	95.15**	0.68**
Pooled deviation	16	4.78**	0.11*	0.0017	1.45	4.68	41.64	25.60	0.07
Pooled error	90	1.92	0.05	0.0022	1.42	5.71	48.16	22.02	0.52

* Significant at 5% level; ** Significant at 1 % level; DF=Degrees of freedom

of the genotypes. The similar result was reported by Patel *et al.* (2011) and Dhaduk *et al.* (2011) for both traits in garlic. The pooled deviation was non-significant for weight of 20 bulbs, number of cloves bulbs^{-1}, weight of 50 cloves, gross yield & marketable yield and stemphylium blight intensity, indicating the absence of non-linear incidence for these traits.

The stability analysis for individual genotype for plant height revealed that only one genotype G-1 showed stable performance for dwarf plant height having mean value lower over the environment mean (x) of the varieties with the bi values near to one and had non- significant deviation from the regression. This trait was unpredictable for G-41 and was having significant deviation from the regression. Stability for average performance for more number of leaves plant^{-1} was noted in G-189, G-324 and *Yamuna Safed* (G-1). The number of leaves plant^{-1} unpredictable for genotypes G-294, G-368, checks *Yamuna Safed*-3 (G-282) and *Yamuna Safed*-4 (G-323) were having significant deviation from regression. The stability for weight of 20 bulbs was recorded in genotype G-384 with high mean value with bi=one.

It was suggested that an ideal genotype should be having high mean performance, regression coefficient (bi) near unity and deviation from regression on (S^2di) were zero (Eberhart & Russell 1966).

The stability for number of cloves bulbs^{-1} was recorded in G-360 and Yamuna Safed-3 (G-282) with lower mean and bi less than one and non-significant deviation from regression. Two genotypes *viz.* G-294 and *Yamuna Safed*-3 (G-282) have recorded stable performance for weight of 50 cloves (g) and having high mean with bi equal to one and had non-significant deviation from regression. The average performance of stability in all the environment was exhibited by genotype G-384 (240.18 q ha^{-1}) for gross yield and which was highest among all genotype followed by *Yamuna Safed*-4 (G-324) (229.66 q ha^{-1}), G-376 (223.98 q ha^{-1}) against an average total yield of (189.87 q ha^{-1}). Only one genotype G-378 showed stable performance for gross yield having mean value more over

Table 2. Grouping of garlic genotypes on the basis of means, regression coefficient (bi), deviation from regression (S^2di) of yield and yield contributing traits

Characters	>Mean bi>1 S^2di (NS)	>Mean bi = 1 S^2di (NS)	>Mean bi <1 S^2di (NS)	<Mean bi >1 S^2di (NS)	<Mean bi = 1 S^2di (NS)	<Mean bi < 1 S^2di (NS)	< or > Mean, bi< = > S^2di (S^2)
Plant height (cm)	G-189, G-324,G-368	— —	G-384, G-342, G-378	G-360, G-323, G-50	G-1	G-294, G-200, G-351, G-282	G-41
Leaves plant^{-1}	G-189, G-324, G-1	G-41	G-376, G-368, G-378, G-384	G-342, G-360, G-351, G-50, G-378	— —	G-200, G-294, G-282	G-294, 368, 282,323
Weight of 20 bulbs (kg)	G-323, G-376, G-189, G-200, G-41, G-50	G-384	G-324, G-282	G-360, G-50, G-351	— —	G-368, G-342, G-G-200, G-378	— —
No. of cloves bulb^{-1}	G-323	— —	G-324, G-41, G-1, G-189, G-50, G-368	G-351, G-200, G-294, G-378, G-384, G-342	— —	G-360, G-282	G-282
Wt of 50 cloves (g)	G-360, G-41, G-282	G-294, G-282	G-384	G-189, G-323	G-1, G-200	G-50, G-368	— —
Gross yield (q ha^{-1})	G-368, G-376, G-384, G-294, G-342, G-324	G-378	G-360, G-282, G-189	G-50	G-200, G-1, G-41, G-323	G-323	G-189
Marketable yield (q ha^{-1})	G-282	G-376, G-384	G-323, G-189, G-324	G-368, G-50, G-351, G-1, G-342, G-200	— —	G-360, G-294, G-378	G-342
Stemphylium blight (Int.)	G-50, G-323, G-282, G-351, G-1, G-200, G-41	— —	G-360	— —	— —	G-294, G-189, G-342, G-378, G-376, G-364, G-324, G-384	— —

Table 3. Genotypic performance and stability parameters of garlic genotypes

Genotypes	Plant height (cm)			Number of leaves plant^{-1}			Weight of 20 bulbs (kg)			Number of cloves bulb^{-1}		
	μ Mean	β i	S^2di	μ Mean	β i	S^2di	μ Mean	β i	S^2di	μ Mean	β i	S^2di
G-189	97.744	1.504	0.086	8.684	2.030	0.127	0.675	1.524	0.000	40.933	-4.225	-0.712
G-200	91.086	0.468	-1.478	8.239	-0.511	0.015	0.644	3.089	0.000	21.818	2.625	-1.326
G-294	88.004	0.244	-1.977	8.511	-2.342	0.277	0.558	-3.736	0.000	21.790	3.737	-1.015
G-324	105.308	1.593	-1.781	8.723	1.888	-0.046	0.678	0.640	0.000	34.356	0.287	-0.466
G-342	100.972	0.572	-1.377	8.551	1.500	0.042	0.611	0.719	0.000	20.233	6.059	-1.303
G-351	87.088	0.552	-1.373	8.434	4.693	-0.052	0.576	3.299	0.000	14.713	2.226	-1.186
G-360	84.968	1.386	0.032	8.539	3.798	-0.022	0.416	1.808	0.000	16.294	-2.667	-0.253
G-368	105.978	1.323	-0.066	8.939	-2.027	0.408	0.592	0.627	0.000	34.089	-0.430	-0.021
G-376	88.330	0.777	-0.777	8.907	-0.123	-0.039	0.618	1.973	0.000	27.473	4.497	-0.752
G-378	100.55	0.210	-1.945	8.973	-1.650	0.006	0.557	-3.831	0.000	21.758	4.893	-1.085
G-384	98.477	0.448	1.527	9.344	-2.618	-0.028	0.729	1.050	0.000	26.049	5.508	1.704
G-1*	87.977	0.786	-1.421	8.722	4.871	-0.052	0.632	3.894	0.000	38.744	-3.974	-1.428
G-41*	89.403	0.918	3.162	9.512	1.387	-0.039	0.695	3.755	0.000	35.017	-0.486	-1.411
G-50*	88.352	3.095	5.641	8.492	4.854	-0.052	0.611	2.184	0.000	41.644	-5.188	-1.427
G-282*	86.558	0.673	-1.458	8.116	-5.627	0.255	0.647	-2.277	0.000	19.983	-4.411	12.170
G-323*	86.577	1.450	-1.977	8.556	5.877	0.179	0.664	1.281	0.001	28.363	7.548	-1.135
Population Mean	92.961			8.703			0.619			27.704		

* - Five checks

Contd.

Genotypes	Weight of 50 cloves (g)			Gross yield (q ha^{-1})			Marketable yield (q ha^{-1})			Stemphylium bligh (Int.)		
	μ Mean	β i	S^2di	μ Mean	β i	S^2di	μ Mean	β i	S^2di	μ Mean	β i	S^2di
G-189	56.667	1.251	-5.287	224.678	-4.329	380.535	170.018	-1.795	2.566	1.768	0.137	-0.492
G-200	66.667	0.767	-5.551	130.791	0.580	-48.601	122.371	1.662	-17.844	9.752	5.932	-0.445
G-294	70.889	0.852	-6.163	189.540	2.209	-44.043	123.196	-0.579	4.806	4.456	0.612	-0.497
G-324	57.778	-1.993	9.269	229.667	4.311	54.071	174.789	-1.276	-22.460	2.666	-2.316	-0.504
G-342	75.556	3.910	-2.448	191.979	3.262	-27.099	132.301	7.491	154.778	4.447	-0.482	-0.341
G-351	81.667	2.693	-3.298	178.580	1.163	-48.933	115.580	1.662	-24.685	8.416	2.865	-0.488
G-360	73.111	1.595	3.704	189.790	0.238	-47.741	81.117	0.083	-17.079	5.941	-1.877	-0.454
G-368	58.889	-1.385	8.363	205.886	1.594	-42.527	128.606	1.326	-24.844	2.223	-1.861	-0.472
G-376	81.667	2.784	-5.770	223.981	1.836	-29.126	155.459	1.017	6.025	2.763	-1.216	-0.499
G-378	78.222	1.856	1.223	207.497	0.749	-46.529	121.773	-0.217	-2.429	4.951	-0.229	-0.365
G-384	70.667	-1.113	-6.123	240.186	1.994	-47.534	183.248	0.848	-23.042	2.464	-2.460	-0.419
G-1*	56.444	0.946	8.556	135.394	0.565	-47.076	123.849	2.211	-12.411	7.013	4.448	-0.510
G-41*	75.000	1.825	-6.067	169.556	0.834	-46.403	158.426	1.234	-9.952	12.591	5.613	-0.511
G-50*	41.667	-0.383	-6.030	178.520	3.082	21.240	124.919	1.607	-24.067	6.616	1.678	-0.181
G-282*	84.556	1.062	-5.934	189.193	-0.613	-48.304	162.022	1.334	-0.254	7.680	2.699	-0.457
G-323*	65.889	1.336	-2.531	152.706	-1.476	-48.754	144.587	-0.607	22.547	6.142	2.456	-0.453
Population mean	68.458			189.871			138.891			5.618		

* - Five checks

environmental mean (x) of the genotype with the bi value near to one and had non-significant deviation from regression. Gross yield was unpredictable for genotype *Yamuna Safed*-5 (G-189) and recorded significant deviation from regression. Marketable yield is the most important trait and was found maximum in genotype G-384 (183.24 q ha^{-1}) as compared overall mean yield (138.89 q ha^{-1}). The genotype G-189, G-324, G-376, G-41 and G-282 registered mean yield which ranged from 170.01 q ha^{-1} to 155.45 q ha^{-1} over the environmental variable average and the genotypes G-323, G-189 and G-324 performed better in poor environment, where as the deviation from regression was significant in genotype G-342, there by exhibiting unpredictable marketable yield. Most of the genotypes had bi values more than one, indicating that these genotypes responded well in favorable environment.

However, it can be concluded that the genotype G-384, G-324, G-378, G-376 and check *Yamuna Safed*-3 (G-282) performed well in favorable environment for gross as well as marketable yield and considered as most stable and responsive genotype as it possesses higher yield alongwith the bi=one or near one and non-significant S^2di values and hence could be recommended for adoptability.

References

Backer H C & Leon J 1988 Stability analysis in plant breeding review. Plant Br. 101: 1–23.

Dhaduk L K, Patel A G, Mehta D R & Gareja M M 2011 Phenotypic stability analysis for bulb yield and its attributes in onion (*Allium cepa* L.). National symposium on *Alliums*: Current scenario and emerging trends. Organized by Indian Society of *Alliums*, Directorate of onion and Garlic Research, Rajgurunagar, 12-14 March, 147pp.

Eberhart S A & Russell W A 1966 Stability parameters for comparing varieties. Crop Sci. 6: 36–40.

Finlay K W & Wilkinson G N 1963 The analysis of adaptation in plant breeding programme. Australian J. Agric. Res. 14: 742–754.

Khar A K, Devi A, Mahajan V & Lawande K E 2007 Stability analysis of some elite onion lines in late *Kharif* season. Indian J. Hort. 64: 415–419.

Lacaze X & Raumet P 2004 Environment characterization for the interpretation of environmental effect of genotypes x environmental interaction. Thero. Appl. Genet. 109: 1632–1640.

Lin C S, Binus M R & Lefkovitch L B 1986 Stability analysis where do we stand. Crop Sci. 26: 894–900.

Mohanty B K & Prusti A M 2001 Genotype x environment interaction and stability analysis in *Kharif* onion. Veg. Sci. 28: 17–21.

Pandey U C & Singh N 1987 Garlic the less problematic and most profitable crop. Haryana Farm 16: 23–24.

Patel A G, Dhaduk L K, Mehta, D R, Madariya R B & Undhad S V 2011. Genotypes x environment interaction and stability analysis for bulb yield and its attributes in garlic (*Allium sativum* L.). National symposium on *Alliums*: Current scenario and emerging trends. Organized by Indian Society of *Alliums*, Directorate of onion and Garlic Research, Rajgurunagar, 12-14 March, 148.pp.

Perkins J M & Jink J I 1968 Environmental and genotypic x environment components of variability-III: multiple lines and crosses. Heredity 23: 339–56.

Roy S K & Chakraborti A K 2002 Post harvest management and processing of onion and garlic. In: Singh H P, Mann J S, Pandey U B, Lallan Singh & Bhonde S R (Eds.), Souvenir - Onion and garlic: Production-utilization (pp.66–72). A consultative meeting on accelerated production and export of onion and garlic, New Delhi, 19-20 April.

Singh J, Pandey U C & Rana M K 1995 Stability parameters for desirable traits in onion (*Allium cepa* L.) cultivars. Haryana J. Hort. Sci. 24: 60–64.

Westcott B 1986 Some methods of analysing genotype-environment interaction. Heredity 56: 243–253.