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Research Article

G × E interaction and stability of yield in paprika genotypes (*Capsicum annuum* var *longum*) in Tamil Nadu

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Abstract :
Genotype × Environment interaction of five parents and four F_1 hybrids along with check were grown in four diverse environments to study the genotype environment interaction and phenotypic stability for fruit yield and its components. Sufficient G × E interaction was exhibited by the genotypes for all the traits studied. Two genotypes Arka Abir, Arka Abir × Bydagi – kaddi were stable across environments because of their non-significant deviation from linearity. The hybrid Arka Abir × Bydagi – kaddi manifested above average performance accompanied by responsiveness around unity and was recognized for general adaptability. This hybrid could be utilized in alternate breeding programmes to tap high yielding potentiality with wider adaptability.

Key words:
Paprika, *Capsicum annuum* var *longum*, stability, G × E interaction

Introduction

The word paprika originates from the Greek/Latin peperi-piper which means pepper. The Capsicum goes by many common names, including pepper, chilli, chile, aji and paprika. The spice paprika refers to the longum type of Capsicum, which when fully ripe, dried and milled is used as a spice and colouring agent in the food or cosmetic industries respectively. Paprika belongs to *Capsicum annuum var.annuum longum* group (GRIN, species of Capsicum). Any non- pungent, dried red powder is paprika to form any type of *Capsicum annuum* that's non- pungent and brilliant red color .In Hungary, there are cultivars that are paprika and are hot. Pungency varies from 1000-2500 SHU. In the 1980s, the bydagi was the only low pungent variety, used in India grown in North Karnataka between Shimoga and Hubli. About a decade ago in the Warangal Dt. of A.P, a variety of paprika known as Tomato Chilli got a big boost due to the success of oleoresin industry. This necessitated the need to identify the particular variety of sweet paprika suitable for tropical conditions to target the international oleoresin market. When non-pungent paprika is used, the product is called 'paprika oleoresin' and this is mainly used as a natural colouring agent in the food and cosmetic industries (Derera, 2000).The effects of genotype and environment on phenotype may not be always independent.

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The phenotypic response to change in environment is not same for all the genotypes and the consequences of variation exhibited in phenotype depend upon the prevailing environment. Very often plant breeders encounter situations wherein the relative rankings of varieties change from location to location and or from year to year. The interaction in the effect of genetic and non-genetic on the development is termed as "genotype-environment interaction" (Comstock and Moll, 1963). Multilocational testing of genotypes provides an opportunity to plant breeders to identify the adaptability of a genotype to a particular environment and also stability of the genotype over different environments. Johnson *et al*.(1955) stated that the capacity of a given variety high for yielding in a range of environments had an importance equal to that of its yield potential. Borlaugh (1965), Eberhart and Russell (1966) and St.Pierra *et al*.(1967) have also stressed the advantages of selection for wide adaptability. Stability analysis in Hot pepper was studied earlier in Asian Vegetable Research Development Center by Yayeh zewdie and Paulos (1995), while nine elite chilli varieties from different South Asian Countries were evaluated for stability at Indian Institute of Horticultural Research, Bangalore by Madhavi Reddy and Sadashiva (2003) and AMMI analysis for fruit yield stability of Chilli was studied by Anand *et al*.,(2006 a).

Keeping the above in view the present investigation was undertaken to identify stable genotypes under different locations in Tamil Nadu (L1-Hosur, L2-

Yercaud, L3 -Thadiyankudisai, L4 -Alandurai) for yield and yield contributing component characters in Paprika (*Capsicum annuum* var *longum*)

Material and Methods

A set of ten paprika genotypes along with check Kt-Pl-19 were studied for stability parameters under four different environments viz., Horticultural Research Station Yercaud (Shervaroy hills). Farmer's field located at Hosur, Horticultural Research Station, Thadiyankudisai (lower pulney hills) Farmer's field located at Alandurai village (North of Coimbatore). The trials at Hosur (L1), Yercaud (L2), Thadiyankudisai (L3), and Alandurai (L4) were conducted in *Kharif* season 2007. The four paprika hybrids along with their parents were raised in a randomized complete block design with three replications, with taking care of sowing in the month of June in all the locations. The ridges were formed at 60 cm apart. Forty days old vigorous and healthy seedlings were planted at a spacing of 60 x 45 cm. Time of planting was taken care to be first week of June 2007 for all the four locations. Standard horticultural practices recommended for chilli (*Capsicum annuum*) (Anon,2004) were adopted. Observations were recorded on ten randomly selected plants for each genotype in each replication, for all the four characters studied (Table 2). Stability parameters like the regression coefficient (b_i) and mean square deviation from the linear regression ($S^2 d_i$) were estimated using the model proposed by Eberhart and Russel (1966).

The details of parents and check utilized in the present study were furnished below (Table 1).

These five parents were used to synthesize four F_1 hybrids namely Acc.12 × Acc.23, Acc.13× Acc.23, Acc.19 × Acc.26 and Acc.26 × Acc.19 which were used as the base breeding material for the study.

Result and discussion

The analysis of variance for stability is presented in Table 2. The genotype × environment mean squares were further partitioned into variance due to genotype × environment (linear) and pooled deviation (non linear) for all the traits. The analysis of variance indicated that mean squares due to genotype × environment (linear) and mean squares due to pooled deviation (non linear) were significant for all the traits taken for the present study. The mean square values from the pooled analysis of variance indicated highly significant variation due to genotypes for all the traits. This revealed the presence of genetic variability in the breeding material under investigation. Highly significant environmental variance represented adequate heterogeneity between the environments and their suitability for evaluating the genotypes for all the component characters. The additive environmental variance was found to be of considerable magnitude as indicated by the significant variance due to environment (linear) for all the characters. The pooled deviation is significant indicating that the unpredictable portion formed the major part of the G × E interaction that the genotypes tested differed considerably in their stability for those characters.

In the present study the mean performance coupled with the regression coefficient (bi) and deviation from linearity (S^2di) of each genotype represented its adaptability (Table2,3). With these conditions, the genotypes were classified and discussed for their adaptability and stability in respect of various component characters studied. The differential response of genotypes when grown under different seasons (environments) has also been reported by Sooch *et al*. (1981), Kouser *et al*. (2003), Madhavi Reddy and Sadashiva (2003), Malathi (2004), Anand *et al*. (2006b) and Vijayaraghavan (2008).

Eberhart and Russell (1966) described an ideal variety as one which showed high mean value over a wide range of environments, a regression co-efficient (b_i) around unity and deviation from regression co-efficient (S^2_{di}) around zero.

The stability parameters of paprika genotypes on number of fruits per plant and fruit weight are in Table 3, while for fresh fruit yield per plant and dry fruit yield per ha are in Table 4.

Number of fruits per plant

The fruits per plant ranged from 55.32 (P1) to 81.23 (P1×P2) with a mean of 64.49. Seven genotypes (P3, P4, P5, P3×P2, P4×P5, P5×P4) exhibited significant deviation from regression (S^2di). Among the hybrids P1×P2 displayed higher *per se* performance along with regression coefficient (bi) greater than 1 and S^2di (-0.11). Although the parents P1, P2 were below the average mean, they showed non significance for deviation from regression (7.84 and 6.37) respectively.

The number of fruits for six genotypes (P3, P4, P3 × P2, P4 × P5, P5 × P4, check) exhibited significant deviation from regression (S^2di) and were termed as unstable over environment. Among the stable ones, P1× P2 displayed higher mean performance along with regression coefficient (bi) greater than 1 and was proposed for general adaptability. Though the parents P1 and P2 found to be stable they were below the average mean.

Fruit Weight

The fruit weight of the genotypes varied from 12.34g (P1) to 20.88g (P3 x P2) with a population mean of 15.68g. Six genotypes (P3, P1 × P2, P3 × P2, P4 × P5, P5 × P4 and check) showed significant deviation from linearity (S^2di). The parents P1 (-1.42), P2 (-1.51), P4 (-1.60) and P5 (-0.61) responded non-significantly for S^2di.The variety P4 manifested lesser average fruit weight supplemented with regression coefficient (bi) around unity.

Only the non-linear component of genotype × environment was significant for the fruit weight, the deviation from regression (S^2di) alone was considered for interpretation for stability (Choudary and Paroda,1980). Six paprika genotypes (P3, P1 × P2, P3 × P2, P4 × P5, P5 × P4 and check) were found to be unstable on account of their significant deviation from linearity (S^2di). The parent P4 manifested lesser average fruit weight supplemented with regression coefficient (bi) below unity,so poorly adapted to the environments.

Fresh fruit yield per plant

The yield per plant varied from 631.16g (P1) to 1347g (P3×P2) with a mean of 947.15g. Only 3 genotypes P2 (-21.83), P3 (-380.90), P5 × P4 (-893.73) showed their non-significant deviation from regression (S^2di). The hybrid P5 × P4 alone registered above average yield per plant and regression coefficient (bi) was above 1.

The fresh fruit yield per plant for three genotypes P2, P3, P5 × P4 showed stability owing to their non-significant deviation from regression (S^2di). The hybrid P5 × P4 alone registered higher mean yield per plant and regression coefficient (bi) was above 1 and so it was having specific adaptability. However, the parent P2 had non significant deviation from regression and bi below unity and hence it is proposed for specific environments.

Dry fruit yield per hectare

The highest dry fruit yield 4.34t/ha was obtained from the hybrid P1 × P2, whereas the lowest dry fruit yield 2.50t/ha was realized from P4.The linear regression(bi) was significant for 5 genotypes (P1, P5, P1 × P2, P4 × P5, P5 × P4) while the deviation from regression (S^2di) was significant for eight genotypes (P2, P3, P4, P5, P3 × P2, P4 × P5, P5 × P4 and check) (Table 4) .Two genotypes P1 (-0.14), P1 × P2 (0.00) showed non-significant deviation from linearity. The hybrid P1×P2 manifested above average performance accompanied by responsiveness around unity and non significant S^2di.

The highest dry fruit yield was obtained from the hybrid P1× P2, whereas the lowest dry yield was realized from the parent P4. The linear regression (bi) was significant for 5 genotypes (P1, P5, P1× P2, P4 × P5, P5 × P4) while the deviation from regression (S^2di) was significant for eight genotypes (P2, P3, P4, P5, P3 × P2, P4 × P5, P5 × P4 and check) depicting preponderance of unpredictable components of environment x genotype interaction.

Only P1 showed stability with average responsiveness to across environments for number of fruits in this study. Most of the stable genotypes had above or below average responsiveness to the environment for most of the characters. A desirable genotype should exhibit high mean performance and low genotype × environment interaction for economically important traits like yield but more flexible for other characters. Such varieties are said to be "well buffered" as these can adjust their genotype state in response to the changing environmental conditions, which is referred to as "genetic homeostasis" (Mohanty and Prusti, 2001). Earlier, Grafius (1956) and Bradshaw (1965) also reported that plasticity in one or more component characters might allow stability in the final character. It is inferred that, alleles that confer broader adaptation might be required to achieve yield and stability in Paprika across environments.

It is also clear that most of the low yielding, genotypes exhibited stability over all the environments. This might be due to plasticity in their traits. This is in corroboration with results of Ortiz and Izquierdo (1994). They suggested that, the phenotypic stability could be the result of their high plasticity due to its heterogeneous composition.

Among the stability parameters, the potentiality of the genotype to express greater mean over the environment is the most important stability parameter, since S^2di =0 and bi=1 may not have practical utility if the genotype is lesser yielding one. Contradictory and favourable result in this study is hybrids generally possessed stable performance over the different environments with greater mean performance compared to their parents. Such results were noticed earlier by Revanappa and Kajjidoni (2004). Two genotypes Arka Abir**,** Arka Abir × Bydagi – kaddi were found to be stable across environments because of their non-significant deviation from linearity. The parent Arka Abir, therefore might be important germplasm source in a Paprika breeding programme. The hybrid Arka Abir × Bydagi – kaddi showed above average responsiveness with stability. These results are in line with earlier workers Mohanty and Prusti, (2001), Manikannan *et al*. (2002), Revanappa and Kajjidoni, (2004) and Vijayaraghavan (2008).The stable Paprika hybrid Arka Abir × Bydagi – kaddi can be adopted for cultivation in Tamil Nadu and can be utilized in breeding programmes for developing varieties with general adaptability.

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Table 1. The details of parents and check utilized in the study

Code no used	Name of Genotype	Source
Acc.12 (P1)	Arka Abir	IIHR, Bangalore
Acc.23 (P2)	Bydagi – kaddi	TNAU, Coimbatore
Acc.13 (P3)	CO 4	TNAU, Coimbatore
Acc.19 (P4)	Simla Paprika	TNAU, Coimbatore
Acc.26 (P5)	KTPL – 18	TNAU, Coimbatore
Acc.18 (Check)	KTPL -19	TNAU, Coimbatore

Table 2. Analysis of variances for stability (mean sum of squares) - Eberhart and Russell model

Sources of variation	df	Number of fruits	Fruit weight(g)	Yield plant $^{-1}$ (g)	Dry yield ha^{-1} (t)
Varieties	9	408.16**	25.81**	207410.12**	1.88**
Env.+ (Var. × Env.)	30	51.91	9.75	14872.42	1.14
Environments	3	212.93**	60.73**	28240.06**	0.53**
Var × Env.	27	34.02*	4.08*	13387.13**	0.10*
Environments (Lin.)	1	638.79**	182.19**	84720.18**	1.60**
Var. × Env.(Lin.)	9	40.90	4.97	22901.82	0.07
Pooled Deviation	20	27.53	3.28	7766.88	0.10

*, ** Significant at 5 and 1per cent level respectively

Table 3. Stability parameters of paprika genotypes for number of fruits and fruit weight

	Number of fruits			Fruit weight (g)		
Genotypes	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
P1 (Acc. 12)	55.32	0.19	7.84	12.34	0.34**	-1.42
P2 (Acc. 23)	58.78	0.74**	6.37	13.80	0.50**	-1.51
P3 (Acc. 13)	55.90	0.47	69.67**	15.60	1.89**	3.56**
P4 (Acc. 19)	55.52	0.65*	29.61**	13.52	0.87**	-1.60
P5 (Acc. 26)	59.15	0.52*	37.15**	13.50	1.38**	-0.61
P1 × P2	81.23	1.31**	-0.11	17.71	0.70**	4.22**
P3 × P2	79.57	2.27**	18.68**	20.88	1.36**	1.91**
P4 × P5	70.40	2.36**	25.92**	17.13	0.58	9.08**
P5 × P4	70.71	1.32**	6.75**	16.00	1.59**	2.89**
Check	58.33	0.13	57.30**	16.35	0.74**	-0.22**

*, ** Significant at 5 and 1per cent level respectively

Table 4. Stability parameters of paprika genotypes for yield per plant (g) and dry yield per ha (t)

	Yield per plant (g)			Dry yield per ha (t)		
Genotypes	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
P1 (Acc. 12)	631.16	0.20	584.78**	2.63	0.79**	-0.14
P2 (Acc. 23)	806.75	0.82**	-21.83	3.09	0.57	-0.09**
P3 (Acc. 13)	842.75	3.23**	-380.90	2.66	1.55	0.03**
P4 (Acc. 19)	773.00	1.60**	8224.88**	2.50	0.33	0.08**
P5 (Acc. 26)	779.16	3.19**	5246.33**	2.54	2.14**	-0.10**
P1 × P2	1261.00	-0.12	8036.83**	4.34	1.41**	0.00
P3 × P2	1347.00	-1.88	11179.44**	4.28	-0.28	-0.13**
P4 × P5	1062.50	-0.59	7638.45**	3.62	1.22**	-0.09**
P5 × P4	1024.41	2.07**	-893.73	3.30	1.36**	-0.09**
Check	943.75	1.46**	5514.97**	3.14	0.86	0.13**

*, ** Significant at 5 and 1per cent level respectively