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COMBINING ABILITY ANALYSIS FOR FRUIT YIELD, CAPSAICIN AND OTHER QUANTITATIVE TRAITS IN CHILLIES (*CAPSICUM ANNUM* L.) OVER ENVIRONMENTS

H. C. LOHITHASWA*, R. S. KULKARNI AND A. MANJUNATH

Department of Genetics and Plant Breeding,
University of Agricultural Sciences, GKVK, Bangalore 560 065

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ABSTRACT

Ten parents and their 45 F_1's of chillies from a half diallel cross were evaluated for fruit yield and its components over three environments. Highly significant variation was observed due to genotypes and environments for all the ten traits studied. The genotype × environment interactions were significant for all the characters except days to initiation of flowering. The genotypes Pant C-1, Arka lohit, RHRC 16-5 and X-235 were found to be good general combiners and 15 crosses have been identified as specific combiners for fruit yield and other related traits.

Key Words : *Capsicum annum* L., general combining ability, specific combining ability, genotype × environment interaction

Combining ability effects are considerably influenced by environments, and for a more valid estimation, a study under different environments is likely to bring out the impact of genotype × environment interaction on the estimates. The present investigation was carried out under three different environments to estimate the combining ability of ten lines for ten quantitative traits in chillies.

MATERIALS AND METHODS

Ten elite strains of chillies were selected on the basis of their differences (Table 1) in several quantitative characters including fruit yield with a view to incorporate maximum variability in segregating generations through a ten parent diallel mating design. All the parents and their 45 crosses were grown in randomized block design with two replications during *Kharif* 1995 at GKVK, Bangalore under rainfed condition; summer, 1996 at Main Research Station, Hebbal, Bangalore under irrigated condition and *kharif*, 1996 at Agricultural Research Station, Hiriyur under

*Present address: Agricultural Research Station, UAS, Gulbarga 585 101, Karnataka

rainfed condition. All the three environments form three growing conditions of the crop. Each entry was grown in a 6 m long single row with a spacing of 75 × 60 cm. Data were recorded on five random plants in each replication for the characters viz., days to initiation of flowering, plant height (cm), number of secondary branches, fruit index (fruit length × fruit diameter), average fruit weight (g), ratio of seed weight to fruit weight, Bartlett index for earliness, number of fruits per plant, dry fruit yield per plant (g) and capsaicin content (%). The statistical analysis for combining ability based on mean values was done as per Method II and Model I of Griffing[1]. The pooled analysis over environments was carried out by the method of Singh[2].

RESULTS AND DISCUSSION

The pooled analysis of variance revealed significant variation among the parents for all the traits, thus justifying the use of the material in the present study (Table 2). The genotypes interacted significantly with the environments for all the traits.

Combining ability analysis revealed that gca and sca variances were highly significant for all the characters. Both gca and sca showed significant interaction with environments for all the traits except for number of secondary branches for which gca × environment interaction was non significant. The ratio of additive variance to total genotypic variance revealed the predominance of non additive gene action for all the traits except for plant height, fruit index, avarage fruit weight and Bartletls index for earliness. The gca × environment and sca × environment interactions indicated that both additive and non additive effects were influenced by environment.

GCA effects

The estimates of gca effects (Table 3) on the basis of pooled analysis revealed that the genotypes Pant C-1, Arka lohit, RHRC- 16-5 and X-235 were better general combiners for days to initiation of flowering, Arka lohit, RHRC-165 and Chickballapur for number of secondary branches, IHR 1822-1/3-1/5, Pusa jwala, RHRC-16-5 and Ceylon for fruit index, IHR 1822-1/3-1/5, RHRC-16-5 and Ceylon for average fruit weight, IHR 1822-1/3-1/5, Pusa Jwala, RHRC-16-5 and Ceylon for ratio of seed weight to fruit weight, IHR 1822-1/3-1/5, Pusa Jwala and X-235 for Bartlett index for earliness, Pusa Jwala, Pant C-1, Arka lohit and X-235 for number of fruits per plant and Pusa Jwala, Pant C-1, Arka lohit, RHRC-16-5 and Chickballapur for Capsaicin content.

In view of present findings the parents Pant C-1, Arka lohit, RHRC-16-5 and X-235 offered the best possibilities of exploitation for the development of improved lines of chillies.

Table 1. Pedigree of parents and their mean performance

Parents	Pedigree	Days to initiation of flowering	Plant height	Number of secondary branches	Fruit index	Average fruit weight	Ratio of seed weight to fruit weight	Bartlett index for earliness	Number of fruits per plant	Dry fruit yield per plant	Capsaicin content
IHR 1822-1/3-1/5	Selection from local variety Devanur dabba	23.83	42.25	11.53	13.77	1.05	0.399	0.56	27.53	29.11	0.26
Pusa Jwala	Pureline selection from NP46A × Pure Red	19.83	35.55	15.33	7.81	0.66	0.534	0.70	46.33	24.78	0.50
Pant C-1	Pureline selection from NP46A × Kandhari	28.83	37.43	10.57	4.16	0.33	0.568	0.53	66.66	26.39	0.94
Arka lohit	Pureline selection from local selection IHR 324	33.33	44.58	13.95	6.55	0.52	0.535	0.52	34.42	18.61	0.50
RHRC-16-5	Selection from Rahuri	26.17	45.87	12.25	6.09	0.50	0.332	0.63	49.78	31.35	0.67
X-235	Pureline selection from mutant with yellow anthers × G4	24.83	33.10	11.92	5.02	0.41	0.468	0.56	64.64	29.34	0.67
PMR-57	Pureline selection from a series of crosses involving *C. baccatum* var. *pendulum* × *C. annum* L.	29.00	46.60	12.63	7.58	0.54	0.493	0.54	40.93	21.08	0.56
Chickballapur	Local selection	32.83	55.72	17.67	4.21	0.55	0.471	0.53	45.30	22.68	0.90
G4	Selection from Thohian chillies	26.83	42.85	12.00	7.10	0.65	0.493	0.57	52.24	30.19	0.56
Ceylon	Introduction from ceylon	26.83	39.05	14.58	10.01	0.78	0.535	0.56	41.78	34.79	0.39
S.Em. ±		1.29	3.54	1.88	0.995	0.069	0.059	0.07	12.64	5.92	0.11

Table 2. Analysis of variance over three environments (pooled analysis) for 10 characters in a 10 × 10 diallel set of chillies

Source of variation	Degree of freedom	Days to initiation of flowering	Plant height	Number of secondary branches	Fruit index	Average fruit weight	Ratio of seed weight to fruit weight	Bartlett index for earliness	Number. of fruits per plant	Dry fruit yield per plant	Caps-aicin content
Genotype(G)	54	56.81**	191.19**	20.51**	19.15**	0.10**	0.024**	0.02**	1148.05**	409.69**	0.26**
Environment(E)	2	1697.91**	5162.56**	496.78**	74.02**	2.17**	0.13**	0.10**	29487.13**	25903.56**	2.45**
G × E	108	12.22	75.93**	10.62**	3.91**	0.02**	0.015**	0.02**	614.89**	386.63**	0.06**
gca	9	39.42**	455.98**	26.93**	42.51**	0.23**	0.03**	0.02**	1812.51**	226.91**	0.40**
sca	45	26.20**	23.52	6.92**	2.99**	0.01**	0.01**	0.01**	326.33**	200.43**	0.08**
gca × E	18	6.71**	39.46**	4.71	4.16**	0.02**	0.01**	0.01**	527.46**	282.29**	0.04**
sca × E	90	5.99**	37.67**	5.43**	1.51**	0.01**	0.01**	0.01**	263.39**	175.52**	0.03**
Pooled error	162	2.44	18.82	3.09	0.49	0.001	0.001	0.002	29.32	13.00	0.01
$2\sigma^2gca/2\sigma^2gca+\sigma^2sca$		0.35	0.63	0.25	0.62	0.77	0.27	0.57	0.41	0.02	0.21

*Significant at p = 0.05 and **Significant at p = 0.01

Table 3. General combining ability effects of parents over three environments (pooled analysis) for ten characters in chillies

Parents	Days to initiation of flowering	Plant height	Number of secondary branches	Fruit index	Average fruit weight	Ratio of seed weight to fruit weight	Bartlett index for earliness	Number of fruits per plant	Dry fruit yield per plant	Capsaicin content
IHR 1822-1/3-1/5	–0.911**	0.551	–1.015**	2.250**	0.202**	–0.054**	0.032**	–15.114**	–3.263**	–0.178**
Pusa Jwala	–1.564**	–4.436**	0.823**	0.823**	0.336**	–0.007*	–0.014**	0.030**	3.949**	0.631
Pant C-1	–0.119	–1.726*	–0.465	–0.986**	–0.076**	0.023**	–0.0001	9.496**	3.080**	0.195**
Arka lohit	1.714**	3.514**	0.077	–0.299**	–0.080**	0.013**	–0.016	2.428**	1.378**	0.067**
RHRC-16-5	0.381	2.736**	–0.302	0.272*	0.011**	–0.040**	0.007	1.312	3.227**	0.029**
X-235	–0.244	–3.035**	–0.254	–0.643**	–0.079**	0.011**	0.030**	2.736**	1.487*	0.018
PHR-57	–0.119	0.021	–0.819**	–0.362**	–0.041**	0.026**	–0.007	0.441	–1.861**	0.005
Chickballapur	1.728**	6.205**	1.973**	–1.429**	–0.039**	0.042	–0.035**	–0.169	–2.119**	0.032*
G4	–0.272	1.075	–0.215	–0.069	–0.003	0.004	–0.036**	–5.529**	–3.565**	–0.092**
Ceylon	–0.592	–3.905**	0.197	0.661**	0.040**	–0.010**	–0.003	–4.548**	1.006	–0.114**
S.E. (gi)	0.349	0.686	0.277	0.112	0.003	0.003	0.010	0.856	0.57	0.014

*Significant at P = 0.05 and P = 0.01

SCA effects

The 15 crosses which showed significant positive sca effects for fruit yield are presented in Table 4. The combination Pant C-1 × Pusa Jwala exhibited significant sca effects in respect of fruit index, average fruit weight and number of fruits per plant. The cross Arka lohit × Pusa Jwala showed significant sca effect for the traits plant height, ratio of seed weight to fruit weight, number of fruits per plant and capsaicin content in the desired direction. For the characters viz., number of secondary branches, average fruit weight and capsaicin content, the cross RHRC-16-5 × Arka lohit recorded positive significant sca effects. The cross PMR-57 × Arka lohit exhibited sca effects in the desired direction in respect of ratio of seed weight to fruit weight, Bartlett index for earliness, number of fruits per plant and capsaicin content. The combination PMR-57 × RHRC-16-5 showed significant sca effects in the desired direction for days to initiation of flowering, number of fruits per plant and capsaicin content. The cross Chickballapur × RHRC-16-5 exhibited positive significant sca effects for fruit index, average fruit weight, number of fruits per plant and capsaicin content.

It is interesting to note that all the hybrids were early in flowering as indicated by negative sca effects with high fruit yield per plant. The parental lines in this study were having diverse genetic background of their source populations and hence their crosses exhibited high sca effects. The hybrids which involved PMR-57 (powdery mildew resistant) as one of the parent were found to be powdery mildew resistant indicating the dominance of resistance. The cross combinations PMR-57 × RHRC-16-5 and PMR-57 × Arka lohit exhibited resistance to powdery mildew and significant sca effects and heterosis for fruit yield. The crosses with significant positive sca effects for fruit yield involved parents with low × low or low × high gca effects indicating the presence of non allelic interactions and also manifested heterosis of higher magnitude. Both parents with high gca effects when crossed had probably low magnitude of non additive gene effects resulting in the small degree of sca effects and heterosis. The present findings are in agreement with the earlier results [3-8]. Therefore, recurrent selection for specific combining ability could be followed in the segregating generations of the crosses Pant C-1 × Pusa Jwala, Chickballapur × RHRC-16-5, Arka lohit × Pusa Jwala, X-235 × Pusa Jwala, PMR-57 × Arka lohit and PMR-57 × RHRC-16-5, as this type of selection was proposed on the assumption that an important part of heterosis results from the non linear interaction of genes at different loci, from interaction between alleles at the same locus, or from both causes in combination. It is possible to obtain substantial improvement with regard to fruit yield in addition to other desirable traits like earliness, more number of fruits per plant and capsaicin content. Heterosis breeding could be suggested as male

Table 4. Estimates of specific combining ability (sca) effects for the best specific crosses over three environments (pooled analysis)

Cross	Dry fruit yield per plant	Days to initiation of flowering	Plant height	Number of secondary branches	Fruit index	Average fruit weight	Ratio of seed weight to fruit weight	Bartlett index for earliness	Number of fruits per plant	Capsaicin content	GCA status
Chickballapur × IHR 1822-1/3-1/5	11.531**	-1.492	-2.431	-0.391	-1.564**	-0.041*	-0.011	0.060*	11.681**	-0.155**	LxL
Pant C-1 × Pusa Jwala	9.482**	-0.159	5.769*	-1.455	-0.350	-0.081**	-0.041**	-0.004	25.858**	0.331**	HxL
X-235 × Pusa Jwala	17.756**	-0.034	-1.349	-0.624	-0.606	0.021	-0.006	0.044	17.509**	0.291**	LxL
Arka Lohit × Pant C-1	16.768**	-2.270	-0.857	0.366	0.317	0.033	-0.001	0.011	18.836**	0.036	HxL
Ceylon × Pant C-1	7.454**	-1.798	1.679	1.013	-0.572	-0.010	-0.004	0.017	5.298	0.068	LxL
RHRC-16-5 × Arka lohit	7.766**	0.563	1.031	2.086*	0.324	0.128**	0.019	0.12	0.762	0.118**	HxH
PMR-57 × Arka lohit	4.841*	0.397	0.712	-0.513	-0.899*	-0.002	-0.037**	0.056*	9.399**	0.123**	LxL
G4 × Arka lohit	12.589**	-4.451**	4.125	-2.051*	0.367	0.002	0.008	0.047*	9.216*	-0.126**	LxH
OMR-57 × RHRC-16-5	7.197**	-3.604**	-0.676	-2.418**	-0.361	-0.016	0.024	-0.002	10.087*	0.107*	LxH
Chickballapur × RHRC-16-5	4.675*	-0.451	2.239	-1.322	1.781**	0.049*	0.001	-0.045	9.325*	0.116**	LxH
Ceylon × RHRC-16-5	8.743**	-2.465*	1.583	-0.200	-0.381	-0.002	0.037**	0.043	7.184	-0.016	LxH
PMR-57 × X-235	3.771*	-3.645**	-3.105	0.518	-0.491	-0.020	0.141**	0.026	11.133**	-0.008	LxL
Chickballapur × X-235	4.450*	-1.492	3.410	0.943	1.207**	0.086**	0.059**	-0.001	0.156	-0.209	LxL
Ceylon × PMR-57	8.595**	-1.298	-3.635	-0.349	-0.337	-0.018	-0.017	0.017	9.853*	-0.162**	LxL
S.E. (sij)	1.918	1.176	2.307	0.935	0.372	0.020	0.014	0.024	2.88	0.042	

*Significant at P = 0.0 and **Significant at P = 0.01; L = Low and H = High

sterility source is available in chillies, which can be transferred into the lines showing good combining ability by repeated back crossing and could be directly used in hybrid development for heterosis exploitation.

REFERENCES

1. B. Griffing. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci., **9**: 463-493.
2. D. Singh. 1973. Diallel analysis for combining ability over several environments- II. Indian J. Genet. **33**: 469.
3. A. Singh and H. N. Singh. 1978a. Combining ability in chilli. Indian J. Agric. Sci., **48**: 27-34.
4. A. Singh and H. N. Singh. 1978b. Line × Tester analysis of yield in chilli. Indian J. Genet., **38**: 52-60.
5. M. B. Sontakke. 1981. Genetical studies in chillies (*Capsicum annum* L.). Unpubl. Ph.D. Thesis submitted to UAS, Bangalore.
6. N. B. Gaddagimath, K. G. Hiremath, J. V. Goud and S. S. Patil. 1988. Combining ability studies in chillies. J. Maharashtra Agric. Univ., **13**: 307-309.
7. T. R. S. Pandian and K. G. Shanmugavelu. 1992. Combining ability for yield and yield components in chillies (*Capsicum annum* L.). South Indian Hort., **40**: 202-206.
8. H. M. Krishnamurthy and A. A. Deshpande. 1997. Genetics of yield attributes in chilli (*Capsicum annum* L.). Veg. Sci., **24**: 118-122.