Indian J. Genet., **54** (2): 197–203 (1994)

COMBINING ABILITY AND HETEROSIS FOR PROTEIN AND METHIONINE CONTENT IN LENTIL (*LENS CULINARIS*)

AJAY KUMAR,* D. P. SINGH AND B. B. SINGH

Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad 224229

(Received: March 25, 1994; accepted: June 3, 1994)

ABSTRACT

Combining ability and heterosis were studied in line x tester crosses between 10 female and 3 male parents for protein and methionine content in lentil. The gca and sca variances showed that gene action was predominantly nonadditive for both characters. The varieties Ranjan, Precoz and Pusa 4 were good general combiners for protein and methionine content (both in protein and flour). Only one cross, E 153 x K 75, showed significant sca effect for protein content. Two crosses, NDL 1 x Pant L 234 and IC 78415 x Pant L 406 were good specific combinations for methionine content alone (in protein as well as flour). BP heterosis ranged from – 13.0 to 12.2% for protein content. The BP heterosis ranged from – 18.6 to 27.2% and from – 24.0 to 47.6% for methionine content in protein and flour, respectively.

Key words: Combining ability, line x tester, heterosis, quality, *Lens culinaris*, lentil.

Information about the combining ability of parents and nature of gene effects helps in selection of suitable parents for hybridization, proper understanding of inheritance of characters, and in isolating the promising hybrids for further exploitation in breeding programmes. Several workers have studied combining ability for quality traits in various pulse crops like mungbean [1, 2] and chickpea [3]. However, in lentil, such studies are limited to yield and yield components only [4–6] and no attempt seems to have been made for quality characters, so far. The present study aims to obtain information on combining ability and heterosis for protein and methionine content, the limiting essential amino acid in lentil.

MATERIALS AND METHODS

Ten diverse genotypes of diverse ecogeographic origin (NDL 1, Ranjan, Precoz, Pusa 4, IC 784013, EC 151015, IC 78415, E 153, E 258 and 1363) were crossed with three well adapted

*Present address: Division of Plant Breeding, Indian Institute of Pulses Research, Kanpur 208024.

varieties (Pant L 234, Pant L 406 and K 75) as testers to produce 30 F1s in line x tester mating design. All 30 hybrids and their 13 parents were grown together in randomized block design with two replications. Each plot had a single row of 3 m length. The spacing was 30 cm between and 5 cm within rows. All the recommended cultural practices were followed. Combining ability analysis was done according to Kempthorne [7] and Arunachalam [8]. The magnitude of heterosis was calculated over the better parent (BP).

The seeds harvested from F_1 plants and their parents were used for the estimation of protein and methionine content in flour. Total nitrogen content in flour was determined by the procedure of Varley [9] with the help of Technicon Autoanalyser. Crude protein content as percentage in flour was obtained by multiplying nitrogen content with 6.25. Methionine content (mg/100 g of flour) was estimated by the colorimetric method described by McCarthy and Paille [10] and was also calculated as per cent of protein to evaluate the correlated response, if any, to change in protein content.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) revealed highly significant differences for protein as well as methionine content. The differences were significant among the lines, but nonsignificant

Table 1. Analysis of variance (mean squares), combining ability, and variance components for protein and methionine content in lentil

Source	d.f.	Protein content	Methionine content in protein	Methionine content in flour
Replication	1	2.0	0.002	6.7
Treatments	42	5.7*	0.008**	1049.5**
(i) Parents	12	6.5**	0.003**	516.7**
(a) Among lines	9	8.6**	0.002**	599.1**
(b) Among testers	2	1.4	0.000	72.0
(c) Lines vs. testers	1	0.1	0.014**	664.6**
(ii) Hybrids	29	4.8**	0.009**	1043.2**
(a) Due to lines	9	11.2**	0.002**	2877.8**
(b) Due to testers	2	0.6	0.001	33.1
(c) Due to lines x testers	18	2.1*	0.003**	228.1**
Parents vs. hybrids	1	20.6**	0.060**	7625.0**
Error	42	0.7	0.001	31.1
σ^2gca		0.1	0.0002	22.7
σ^2sca		0.7	0.0010	98.5
$(\sigma^2\text{sca}/\sigma^2\text{gca})^{1/2}$		2.9	2.3500	4.3

*,**Significant at P = 0.05 and 0.001, respectively.

among the testers, for both characters. The line vs. testers component was significant only for methionine content (in protein and flour). The hybrids differed significantly for both the traits. The differences among hybrids due to lines and line x tester interaction were significant but nonsignificant due to testers for both the characters. A comparison of parents vs. hybrids revealed highly significant differences between parents and hybrids for both characters studied indicating a substantial amount of hybrid vigour in the crosses.

The magnitude of gca and sca variances (Table 1) revealed greater importance of the latter for both characters, indicating predominance of nonadditive gene action in the inheritance of these traits. Predominance of nonadditive gene action for protein [3] and methionine content [1] was also reported earlier. Degree of dominance indicated over dominance for both traits.

The estimates of gca effects of the parents (Table 2) revealed that the parents Ranjan, Precoz, and Pusa 4 were good general combiner for protein and methionine content (in

Table 2. General combining ability (gca) effects and mean performance of parents for protein and methionine content in lentil

Parent	Protein content		Methionine content			
			in protein		in flour	
	gca	mean (%)	gca	mean (%)	gca	mean (mg/100 g)
Lines:						
NDL 1	-2.1^{**}	24.8	-0.09^{**}	0.61	-32.4^{**}	150
Ranjan	1.2^{**}	26.3	0.04^{**}	0.62	18.3^{**}	164
Precoz	1.4^{**}	21.0	0.09^{**}	0.62	28.9^{**}	162
Pusa 4	2.6^{**}	26.4	0.05^{**}	0.62	26.9^{**}	130
IC 784013	-0.8^{*}	23.0	-0.01	0.57	12.3^{**}	126
EC 151015	-0.3	24.1	-0.01	0.57	-19.3^{**}	114
IC 78415	-0.7	22.3	-0.10^{**}	0.54	-27.1^{**}	120
E 153	-0.3	21.8	0.06^{**}	0.58	-7.7^{*}	132
E 258	-1.0^{**}	20.6	-0.05^{**}	0.55	-5.7^{*}	138
1363	0.1	22.6	0.02^{*}	0.55	5.6^{*}	124
SE (gi) lines ±	0.4		0.01		2.3	
Testers:						
Pant L 234	0.0	23.5	-0.01	0.53	-0.9	124
Pant L 406	0.2	24.2	0.00	0.54	-0.5	130
K 75	-0.2	22.6	0.01	0.52	1.5	118
SE (gi) testers ±	0.2		0.01		1.3	
Rank correlation	0.88^{**}		0.94^{**}		0.90^{**}	

*,**Significant at P = 0.05 and 0.01, respectively.

protein and flour). The association between gca effects and per se performance was significant for both characters (Table 2). The understanding of combining ability effects together with per se performance of parents and crosses provide guidelines for their further use in generating useful breeding material [11]. The parents that appeared to be good on the basis of their gca effects and per se performance were Ranjan and Pusa 4 for protein content; Ranjan, Precoz and Pusa 4 for methionine content in protein and Ranjan and Precoz in flour. In order to synthesize a dynamic population with most of the favourable genes, it will be partinent to make use of the aforesaid parents in a multiple crossing programme.

Of the 30 crosses, only E 153 x K 75 showed significantly high sca effects for protein content (Table 3). Four F_1 hybrids exhibited significant positive sca effects for methionine content in protein alone and eight crosses only in flour. Two crosses, NDL 1 x Pant L 406

Table 3. Heterosis (%) over better parent (BP) and specific combining ability (sca) effects for protein and methionine content in lentil

Cross	Protein content		Methionine content			
			in protein		in flour	
	BP	Sca	BP	sca	BP	sca
NDL 1 x Pant L 234	-10.6**	-0.1	-3.1	0.05*	-13.3**	9.6*
NDL 1 x Pant L 406	-13.0**	0.9	-7.8	0.02	-20.0**	0.8
NDL 1 x K 75	-6.8	1.0	-18.6**	-0.06**	-24.0**	-8.8*
Ranjan x Pant L 234	-1.7	0.3	-0.9	-0.05*	-2.4	-11.1**
Ranjan x Pant L 406	-1.2	0.2	9.9*	0.02	8.5*	6.5
Ranjan x K 75	-5.4	-0.5	15.4**	0.04*	8.5*	4.5
Precoz x Pant L 234	12.1**	0.6	12.4**	-0.01	19.8**	12.3**
Precoz x Pant L 406	8.2*	0.2	17.2**	0.02	5.4	-6.1
Precoz x K 75	9.9*	-0.8	15.1**	-0.01	10.2**	-6.1
Pusa 4 x Pant L 234	6.1	1.1	13.0**	0.02	36.9**	4.3
Pusa 4 x Pant L 406	-1.3	-1.1	10.3*	0.00	38.5**	-0.1
Pusa 4 x K 75	1.8	0.1	7.9	-0.02	36.9**	-4.1
IC 784013 x Pant L 234	3.7	0.9	10.2*	0.01	32.3**	-4.1
IC 784013 x Pant L 406	2.4	1.0	5.8	-0.01	13.9**	17.5**
IC 784013 x K 75	-6.6	-1.9*	9.9*	0.00	47.6**	18.5**
EC 151015 x Pant L 234	-5.5	-1.3*	7.2	0.01	6.5	-1.7
EC 151015 x Pant L 406	2.1	0.4	2.9	-0.02	-1.5	-6.1

(Contd.)

Table 3. (contd.)

Cross	Protein content		Methionine content			
	BP	sca	in protein		in flour	
			BP	sca	BP	sca
EC 151015 x K 75	3.2	0.9	11.0*	0.02	22.0**	7.9
IC 78415 x Pant L 234	0.7	0.0	– 6.1	– 0.02	– 3.2	– 5.7
IC 78415 x Pant L 406	– 0.1	0.3	5.9	0.04*	6.2	– 11.9**
IC 78415 x K 75	3.2	– 0.3	– 2.9	– 0.02	1.7	– 6.1
E 153 x Pant L 234	0.3	– 0.4	20.5**	0.01	16.7**	8.9*
E 153 x Pant L 406	– 3.9	– 1.0	10.3*	– 0.05*	13.6**	4.5
E 153 x K 75	12.2**	1.4*	27.2**	0.04*	1.5	– 13.5**
E 258 x Pant L 234	– 4.6	– 0.9	6.4	0.02	1.5	– 7.1
E 258 x Pant L 406	0.3	0.7	– 4.8	– 0.05*	5.8	– 1.5
E 258 x K 75	3.4	0.1	11.4*	0.03	14.5*	8,5*
1363 x Pant L 234	3.2	–0.1	12.4**	– 0.03	21.0**	– 8.4*
1363 x Pant L 406	2.0	0.1	24.0**	0.03	29.2**	9.2*
1363 x K 75	8.1*	0.1	19.4**	0.00	29.0**	– 0.8
SE (sca efects) ±		0.6		0.02		3.9
SE (S_{ij}–S_{kl}) ±		0.9		0.03		5.6

*,**Significant at P = 0.05 and P= 0.01, respectively.

and IC 78415 x Pant L 406 distinguished by giving significant sca effects for methionine simultaneously in protein and flour. The sca effects of different crosses indicated that high gca of the parents was no guarantee of high sca effects in different crosses. The BP heterosis ranged from – 13.0% (NDL 1 x Pant L 406) to 12.2% (E 153 x K 75) for protein content, from – 18.6% (NDL 1 x K 75) to 27.2% (E 153 x K 75) for methionine content in protein, and from – 24.0% (NDL 1 x K 75) to 47.6% (IC 784013 x K 75) in flour (Table 3). Five and 17 hybrids displayed significantly positive BP heterosis for protein and methionine content (both in protein and flour), respectively. Three hybrids, viz., Precoz x Pant L 234, Precoz x K 75 and 1363 x K 75 exhibited significant positive heterosis over BP for protein as well as methionine content (in protein and flour).

The estimates of genetic variation influences breeding methodologies. A considerable influence of nonadditive genetic variance as recorded for both traits would favour heterosis breeding programme. But in crop like lentil, where it is not possible due to various limitations including biological feasibility, heterosis breeding is ruled out. However, breeding methods like biparental mating and diallel selective mating [12], which provide better opportunities for selection, recombination and accumulation of desired genes, can usefully employed for exploiting nonadditive genetic variation. Crosses E 153 x K 75, Ranjan x K 75, Precoz x Pant L 234, IC 784013 x Pant L 406, IC 784013 x K 75, E 153 x Pant L 234, E 258 x K 75, and 1363 x Pant L 406, which exhibited significant and positive BP heterosis along with desirable sca effects for one or both characters would well be utilized in the breeding programme for increasing the protein and methionine content in lentil.

ACKNOWLEDGEMENT

The authors are thankful to Dr. P. N. Tiwari, Project Director, Nuclear Research Laboratory, I.A.R.I., New Delhi for providing facilities for estimation of protein and methionine content.

REFERENCES

1. A. S. Tiwari and S. Ramanujam. 1976. Combining ability and heterosis for protein and methionine contents in mugbean. Indian J. Genet., **36**(3): 353–357.

2. A. R. Pathak, P. P. Zaveri, J. A. Patel and H. R. Kher. 1990. Inheritance of protein content in mungbean under different environments. Indian J. Genet., **50**(3): 276–278.

3. P. M. Salimath, P. N. Bahl and J. Kumar. 1988. Genetic analysis for seed protein content in chickpea (*Cicer arietinum* L.). Legume Res., **11**(2): 71–74.

4. T. S. Sandhu, J. S. Brar and R. S. Malhotra. 1981. Combining ability for harvest index and grain yield in lentil. Crop Improv., **8**(2): 120–123.

5. J. P. Singh and I. S. Singh. 1991. Genetic analysis of some quantitative characters in lentil. Indian J. Pulses Res., **4**(2): 147–150.

6. J. P. Singh and I. S. Singh. 1993. Combining ability in lentil. Indian J. Pulses Res., **6**(1): 25–30.

7. O. Kempthorne. 1957. An Introduction to Genetic Statistics. John Wiley and Sons, New York.

8. V. Arunachalam. 1974. The fallacy behind the use of a modified line x tester design. Indian J. Genet., **34**(2): 280–287.

9. J. A. Varley. 1966. Automatic method for determination of nitrogen, phosphorus and potassium in plant material. Analyst., **91**: 119–126.

10. T. F. McCarthy and M. M. Paille. 1959. A rapid determination of methionine in crude proteins. Biochem. Biophys. Res. Commun., **1**(1): 29–33.

11. G. N. Hazarika, V. P. Singh and R. P. S. Kharb. 1988. Combining ability for yield components in pigeonpea. Indian J. Pulses Res., **1**(2): 11–17.

12. N. F. Jensen. 1970. A diallel selective mating system for cereal breeding. Crop Sci., **10**: 629–635.