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COMBINING ABILITY ANALYSIS OVER ENVIRONMENTS IN DIALLEL CROSSES OF PEA

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ABSTRACT

Combining ability studies were made over environments for yield and nine yield contributing characters utilizing 12-parent diallel F_1 progenies in pea (*Pisum sativum* L.). Both gca and sca were influenced by environments. This suggested that to have an unbiased estimates of gca and sca, the studies may be conducted over a wide range of environments. Seed weight is observed to be a highly potent character among yield components over environments. Both additive and nonadditive genetic variances were important for all the characters studied. The per se performance of the parents may give a good indication of their gca effects. The additive and nonadditive genetic variances may be exploited following intermating among the progenies within and between promising crosses in early segregating generations.

Key words: *Pisum sativum* L., combining ability, yield contributing characters.

A number of studies on combining ability and its genetic control for yield and yield traits are reported in pea [1–7]. The scope of such studies was limited as they were mostly based on one year/location of testing. The present paper is an attempt to analyse a twelve-parent diallel cross over two years for combining ability x environment interactions, combining ability estimates on the data pooled over environments, and the genetic systems governing the expression of yield and yield contributing characters.

MATERIALS AND METHODS

Twelve diverse and ecogeographically distinct cultivars of pea (*Pisum sativum* L.), including T 163, PG 3, GC 322, GC 141, Sel-2, Early December and L 116 (India), Bonneville and A 474-288 (USA), B 5064 (Sweden), PI 280064 (Canada), and EC 33866 (Portugal), were chosen so as to reflect a wide spectrum of variation for different characters. All possible crosses (nonreciprocal) were made among twelve cultivars. The 66 F_1 progenies along with 12 parents were grown and evaluated in randomized block design with three replications in two consecutive years, i.e., 1978-79 and 1979-80. Each treatment had single row of 2 m length with spacing of 45 and 15 cm between and within rows, respectively. Ten random plants from each row were scored for ten characters (Table 1).

The progeny means were used for statistical analysis. The combining ability analysis was done according to Singh [8] using method 2, model I of Griffing [9].

RESULTS AND DISCUSSION

The analysis of variance for combining ability for the data pooled over environments (Table 1) revealed that mean squares due to general combining ability (gca) and specific combining ability (sca) were highly significant for all the characters. It indicated the importance of both additive and nonadditive genetic components of variation for controlling these characters. The importance of additive and nonadditive gene effects for most of these characters has been reported by a number of workers [1–7].

Table 1. Analysis of variance for combining ability over environments in pea

Source	d.f.	Mean squares									
		days to first flowering	days to maturity	plant height	No. of primary branches	No. of secondary branches	pods per plant	pod length	seeds per pod	seed weight	yield per plant
Gca	11	296.6**	325.1**	25655.6**	1.1**	3.3**	293.3**	3.7**	3.04**	3.8**	31.2**
Sca	66	231.8**	16.4**	1423.3**	0.2**	0.5**	60.9**	0.05**	0.1**	0.1**	17.1**
Environment	1	48.1**	4393.5**	8185.6**	36.4**	22.3**	8055.5**	0.3**	11.6**	0.09	2622.3**
Gca x environment	11	7.6**	17.9**	131.4**	0.3**	0.34**	78.5**	0.05	0.1**	0.03**	13.9**
Sca x environment	66	7.8**	6.0**	122.0**	0.1**	0.3**	20.6**	0.06**	0.1**	0.07**	6.7**
Error	308	1.43	1.9	71.4	0.06	0.15	9.5	0.03	0.04	0.03	3.4

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

Regarding the importance of genotype and environment interactions, the environment had a significant role in the expression of almost all the characters. The mean squares due to gca x environment and sca x environment interactions were highly significant for all the characters except pod length (gca x environment), the magnitude of the former suggesting its equal or higher contribution amongst the different attributes studied. This obviously indicates that the additive genetic variance was equally or even more variable over environments as compared to the nonadditive genetic variance. Sandhu [10] also observed similar results for primary branches and pods per plant in this crop.

The perusal of the mean performance of the parents and their gca effects (Table 2) revealed that per se performance of the parents might give a good indication for their gca effects. Further, gca effects revealed that the parents T 163, PG 3, Sel-2 and Bonneville were superior general combiners for seed yield per plant and seed weight; GC 141, PI 280064, GC 322, EC 33866 and Early December for seeds per pod; GC 141, GC 322, Early December, Bonneville and PG 3 for pod length; and T 163, L 116 and B 5064 (all tall) for plant height and pods per plant. The desirable general combiners for early flowering and maturity were

Table 2. Estimates of general combining ability effects and mean performance (in parentheses) in twelve parents in pea

Parent	Days to first flowering	Days to maturity	Plant height	No. of primary branches	No. of secondary branches	Pods per plant	Pod length (cm)	Seeds per pod	Seed weight (g)	Yield per plant (g)
GC 141	2.4**	1.1**	–14.4**	–0.04	–0.14*	–4.3**	0.5**	0.5**	–0.06	–0.6
	(62.7)	(119.5)	(74.2)	(2.1)	(0.74)	(10.5)	(6.9)	(4.7)	(3.6)	(6.2)
PI 280064	3.6**	1.4**	–11.2**	0.2**	0.01	1.02	–0.3**	0.5**	–0.7**	–1.3**
	(61.4)	(119.2)	(77.4)	(2.4)	(1.3)	(13.7)	(5.5)	(5.0)	(2.7)	(6.5)
GC 322	–2.9**	–3.3**	–27.7**	–0.1**	–0.3**	–3.4**	0.2**	0.3**	–0.01	–0.6
	(48.3)	(109.1)	(43.7)	(1.8)	(0.8)	(12.7)	(6.04)	(4.4)	(3.9)	(7.4)
A 474–288	–3.0**	–1.6**	–22.1**	–0.1**	–0.2**	1.2*	–0.2**	–0.3**	–0.3**	–0.9**
	(48.1)	(117.4)	(62.9)	(1.7)	(1.2)	(18.7)	(5.5)	(3.6)	(3.3)	(7.7)
B 5064	0.6*	1.8**	41.1**	0.03	0.04	5.1**	–0.4**	–0.5**	–0.2**	0.7
	(60.7)	(125.5)	(109.9)	(2.4)	(1.8)	(19.2)	(5.2)	(2.6)	(3.5)	(6.6)
L 116	0.02	2.01**	42.1**	–0.01	0.1	3.4**	–0.6**	–0.3**	–0.3**	–0.5
	(55.7)	(119.6)	(136.5)	(2.0)	(1.8)	(20.4)	(5.0)	(3.6)	(3.4)	(7.7)
EC 33866	–3.5**	–5.7**	–17.3**	–0.08	–0.15	–0.6	–0.1*	0.3**	–0.1**	0.3
	(39.9)	(94.3)	(40.7)	(1.4)	(1.1)	(7.2)	(5.4)	(4.0)	(4.0)	(4.2)
Early	–4.3**	–4.1**	–22.9**	–0.3**	–0.3**	–4.1**	0.3**	0.13**	0.06	–1.5**
December	(43.0)	(105.2)	(46.6)	(1.4)	(1.0)	(9.2)	(6.3)	(4.2)	(3.8)	(5.6)
Sel–2	–1.4**	0.2	–13.1**	0.2**	–0.1	0.4	0.05	–0.2**	0.6**	1.02**
	(51.3)	(118.4)	(72.3)	(2.1)	(0.8)	(12.3)	(6.0)	(3.5)	(5.1)	(7.9)
Bonneville	1.1**	–0.4	–7.3**	–0.3**	–0.2**	–2.0**	0.5**	0.05	0.3**	0.2
	(59.0)	(116.2)	(80.8)	(1.5)	(0.7)	(12.2)	(6.9)	(4.2)	(4.3)	(7.8)
PG 3	0.7**	1.2**	–9.6**	0.08	0.5**	–0.3	0.4**	–0.08	0.4**	1.1**
	(58.0)	(121.3)	(82.0)	(2.4)	(2.0)	(14.3)	(6.5)	(3.4)	(4.7)	(9.2)
T 163	6.8**	7.3**	62.4**	0.4**	0.8**	5.0**	–0.4**	–0.4**	0.4**	1.9**
	(68.5)	(129.9)	(170.4)	(2.9)	(2.0)	(23.2)	(5.0)	(3.2)	(5.0)	(11.6)
SE (gi) ±	0.22	0.25	1.53	0.04	0.07	0.56	0.03	0.04	0.03	0.34

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

Early December, EC 33866, A 474-228 and GC 322, while Sel-2 was a good combiner only for the former character. Similarly, T 163, PI 280064 and Sel-2 were good general combiners for primary branches, and T 163 and PG 3 for secondary branches. It has been observed that the superior general combiners for seed yield per plant were also good general combiners for some of the yield contributing characters, more regularly with seed weight. Thus, it follows that seed weight is a highly potent character among the component characters in pea.

The sca effects of the crosses revealed that all possible combinations between high x low performers/combiners, i.e., high x high, high x low, and low x low, could give promising segregates. The crosses involving high x high parents, e.g. Sel-2 x PG 3 and Bonneville x T 163 could be of immense value for exercising single plant selection in advanced generation since in such hybrids high sca effects were due to additive and additive x additive type of gene effects which are fixable. The other crosses, namely, GC 322 x T 163, EC 33866 x PG 3, Early December x T 163 and Early December x PG 3, which involved at least one good general combiner, may be exploited for isolating desirable transgressive segregates in F_2 if the additive genetic system present in the good combiner and the complementary epistatic effects in the F_1 acted in the same direction to maximise the desirable plant attributes. However, in two hybrids, L 116 x Early December and GC 141 x L 116, significant sca effects associated with low x low performers reflected nonadditive type of gene effects, hence, these hybrids could be exploited for heterosis breeding.

This study identified parents, T 163, PG 3, Sel-2 and Bonneville as superior general combiners for yield and few important yield contributing characters over the environments. It is, therefore, suggested that intermating of randomly selected progenies in early segregating generations (especially in F_2 and F_3) obtained by crossing these parents will release the hidden genetic variability through breakage of undesirable linkages involved in different characters. It may produce an elite population for selection of high yielding lines in advanced generations.

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