www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(4): 2039-2042

www.thepharmajournal.com
Received: 28-02-2022
Accepted: 30-03-2022

Suchitra
Department of Genetics and Plant Breeding, Navsari Agricultural University, Navsari, Gujarat, India

DA Chauhan
Pulses and Castor Research Centre, Navsari Agricultural University, Navsari, Gujarat, India

Anita
Department of Genetics and Plant Breeding, College of Agriculture, Jodhpur, Rajasthan, India

Corresponding Author
Suchitra
Department of Genetics and Plant Breeding, Navsari Agricultural University, Navsari, Gujarat, India

Study of combining ability and gene action in pea (*Pisum sativum* L.)

Suchitra, DA Chauhan and Anita

Abstract
The present experiment was carried out at Pulses and Castor Research Station, Navsari agricultural university, Navsari in *Rabi* 2019. Six diverse elite genotypes (NIFPGr-17-64, GDF-1, NF-18-52 (Local), NIFPVg-17-10, NIFPVg-17-12, and NIFPGr-17-64) were crossed in half diallel fashion for combining ability analysis for yield and yield attributing traits in fieldpea. NIFPVg-17-12 was found as a good general combiner for the duration of the reproductive phase, branches per plant, pods per plant, seeds per pod, and yield per plant. Whereas, for hybrids, GDF-1 × NIFPVg-17-10, GDF-1 × NIFPVg-17-12, and NIFPVg-17-12 × NIFPGr-17-63 were observed as good specific combiners. The magnitude of GCA variance is lesser than sca variance for most of the traits indicating the predominance of non-additive type of gene action.

Keywords: Combining ability, general combining ability (GCA), specific combining ability (SCA), additive gene action, and non-additive gene action

Introduction
Pea (*Pisum sativum* L.) is an important *rabi* legume grown as a garden and field crop throughout the temperate region of the world. It ranks third in production among the grain legumes after soybeans and beans in the world (Suman, *et al*. 2017). The concept of combining ability analysis has distinguished practical importance in plant breeding. Combining ability allows the prediction of the relative efficiency of parents based on early generation performance besides enabling to study of the comparative performance of lines in hybrid combinations. Without knowing genetic variances, plant breeders lack the rational basis to guide them in the choice of parents, the manipulation of progenies, and the selection of superior parents. Combining ability analysis provides clues to the usefulness of individuals to be employed as the parents in the hybridization programme also simultaneously screens the hybrids.
Understanding the nature of gene action is very important for an efficient breeding programme. General combining ability attributes towards additive gene action is theoretically fixable. On the other hand, specific combining ability attributes towards non-additive (dominance and epistatic) gene action is not fixable. The presence of non-additive genetic variance is the primary justification for initiating the hybrid programme (Cockerham, 1961) [1]. The success of any hybridization programme based on the results of combining abilities depends on the extent of genetic parameters remaining stable over environments.

Materials and Methods
The present trial was carried through *Rabi*-2018 for crossing, and *Rabi*-2019 for evaluation at Castor and Pulses Research Station, Navsari agricultural university, Navsari. Six diverse elite genotypes (GDF-1, NIFPGr-17-64, NF-18-52 (Local), NIFPVg-17-10, NIFPVg-17-12, and NIFPGr-17-64) were utilized to carry out combining ability analysis for yield and yield-related traits in fieldpea. All the six genotypes were crossed in half diallel fashion to generate 15 hybrids. The experiment design used was a randomized block design with three replications. Here GDF-1 was used as parent-cum-check. A total of 21 genotypes (15 F_1's+6 parents) were evaluated for ten different characters. Can be closed using conservative treatments such as belly bandages/ abdominal.

Result and Discussion
It was documented that gca and sca variances were significant for most of the traits. The notable results for both gca and sca variances indicate the presence of both additive, and non-

additive types of gene action were involved in the inheritance of the characters (Table 1).

The gca variance is lesser than sca variance in magnitude for most of the traits showing the predominance of non-additive type of gene action. This was also certified by the low magnitude of σ^2gca/σ^2sca ratios. The findings are in confirmation as per reports of Punia *et al.* (2011a) [21], Nassef *et al.* (2013) [19], Kumar *et al.* (2017) [15], Dar *et al.* (2017) [2], Tampha *et al.* (2018) [25], Katoch *et al.* (2019) [12], Yadav *et al.* (2019) [26], Parveen *et al.* (2019) [20] and Nageshwar *et al.* (2020) [18]. For choosing the correct breeding method, a breeder should rely on the nature and magnitude of gene action involved. Because of this, it became evident that breeding for high-yielding varieties may become more effective by appropriate exploitation of additive gene action accompanying non-additive gene action. The present trial was conducted only for one season, and at a single location, this leads to biasness for estimates of genetic variance due to genotype × environment interaction and this would mislead the breeder in concluding gene effects. Hence, it is suggested to test the material over environments and/ or locations so that clear-cut information can be drawn.

The general combining ability effects were estimated for parents and specific combining ability effects were estimated for hybrids. The character-wise summarization of general combining ability effects and specific combining ability of parents and hybrids respectively has been presented in Table 2 and Table 3, respectively.

In the present study, it was recorded that none of the parents was a good general combiner for all the traits. These results are following the findings of Singh *et al.* (2010) [22], Punia *et al.* (2011a) [21], Nassef *et al.* (2013) [19], Kumar *et al.* (2017) [15], Dar *et al.* (2017) [2], Tampha *et al.* (2018) [25], Katoch *et al.* (2019) [16], Yadav *et al.* (2019) [26], Parveen *et al.* (2019) [20] and Nageshwar *et al.* (2020) [18]. The general combining ability effects of different parents for various characters are presented in Table 4.

Table 1: Analysis of variance for combining ability for different traits of fieldpea

Source of variation	Df	Days to 50 per cent flowering	Duration to reproductive phase	Days to maturity	Plant height (cm)	Branches per plant	Pods per plant	Seeds per pod	Pod length (cm)	100- seed weight (gm)	Yield per plant (gm)
GCA	5	9.744**	12.111*	6.031*	277**	2.72**	27.97***	1.46**	1.6**	24.4**	0.99**
SCA	15	7.228**	11.967**	7.158**	69.7**	1.03**	10.14**	0.42**	0.10**	2.02**	0.277
Error	40	2.035	3.821	2.172	14.516	0.264	3.814	0.08	0.04	0.006	0.236
σ^2 GCA		0.96	1.04	0.48	32.82	0.31	3.02	0.17	0.20	3.05	0.09
σ^2 SCA		5.19	8.15	4.98	55.13	0.76	6.33	0.34	0.06	2.01	0.04
σ^2 gca /σ^2 sca		0.18	0.12	0.096	0.59	0.41	0.48	0.50	3.33	1.52	2.25

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

Table 2: Estimation of general combining ability for different traits in field pea

Characters / Parents	Days to 50 percent flowering	Duration of reproductive phase	Days to maturity	Plant height	Branches per plant	Pods per plant	Seeds per pod	Pod length	100-seed weight	Yield per plant
NIFPGr-17-64	-0.13	0.00	-0.10	-3.25*	-0.47**	-1.01	0.37**	-0.04	-1.91**	-0.33*
GDF-1	-0.88	-0.71	-0.26	-6.97**	-0.86**	0.49	-0.19*	0.39**	0.86**	0.12
NF-18-52 (Local)	0.67	0.63	0.32	6.53**	0.57**	-2.43**	-0.10	0.38**	1.74**	-0.41*
NIFPVg-17-10	-1.67**	-2.04**	-1.51**	2.89*	0.16	0.82	0.23*	0.34**	2.02**	0.19
NIFPVg-17-12	1.21*	1.42*	0.57	6.00**	0.63**	2.99**	0.40**	-0.43**	-1.16**	0.53**
NIFPGr-17-63	0.79	0.71	0.99*	-5.21**	-0.02	-0.85	-0.72**	-0.64**	-1.56**	-0.09
SE(gi)	0.46	0.63	0.48	1.23	0.17	0.63	0.09	0.06	0.03	0.16
CD	1.18	1.62	1.22	3.16	0.43	1.62	0.23	0.17	0.07	0.40
SE(gi –gj)	0.71	0.98	0.74	1.91	0.26	0.98	0.14	0.10	0.04	0.24
CD	1.83	2.51	1.89	4.90	0.66	2.51	0.36	0.26	0.10	0.62

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

Table 3: Estimation of specific combining ability for different traits in field pea

Sr. No.	Characters / Hybrids	Days to 50 per cent flowering	Duration of reproductive phase	Days to maturity	Plant height	Branches per plant
1	NIFPGr-17-64 × GDF-1	0.24	1.42	0.58	4.86	0.30
2	NIFPGr-17-64 × NF-18-52 (Local)	2.03	2.76	3.33*	-6.67	0.57
3	NIFPGr-17-64 × NIFPVg-17-10	-1.64	-2.24	-2.50	-2.00	0.19
4	NIFPGr-17-64 × NIFPVg-17-12	-4.18**	-5.70**	-4.25**	9.40*	-0.55
5	NIFPGr-17-64 × NIFPGr-17-63	3.90**	4.34*	3.33*	-4.96	-0.53
6	GDF-1 × NF-18-52 (Local)	-1.89	-2.87	-0.83	-0.12	-0.56
7	GDF-1 × NIFPVg-17-10	-0.89	-0.87	1.33	8.46*	-0.28
8	GDF-1 × NIFPVg-17-12	4.57**	5.67**	5.25**	11.52**	-0.32
9	GDF-1 × NIFPGr-17-63	-2.01	-2.29	-1.83	8.99*	0.60
10	NF-18-52 (Local) × NIFPVg-17-10	4.24**	6.13**	2.75	-5.71	-1.73**
11	NF-18-52 (Local) × NIFPVg-17-12	-1.64	-1.33	-1.33	-4.91	2.15***
12	NF-18-52 (Local) × NIFPGr-17-63	-1.22	-1.62	-2.42	10.49**	0.76
13	NIFPVg-17-10 × NIFPVg-17-12	-2.30	-2.33	-1.50	-1.27	1.61**
14	NIFPVg-17-10 × NIFPGr-17-63	0.78	1.71	1.42	3.73	0.68
15	NIFPVg-17-12 × NIFPGr-17-63	2.57	2.59	-0.33	-6.51	-0.68

	SE(si)	1.04	1.43	1.08	2.79	0.38
	CD	2.24	3.07	2.31	5.98	0.81
	SE(sj)	1.26	1.73	1.31	3.38	0.46
	CD	2.71	3.72	2.80	7.24	0.98
	SE(sii-sjj)	1.43	1.95	1.47	3.81	0.51
	CD	3.06	4.19	3.16	8.17	1.10
	SE(sij-sik)	1.89	2.59	1.95	5.04	0.68
	CD	4.05	5.55	4.18	10.81	1.46
	SE(sij-skl)	1.75	2.39	1.80	4.67	0.63
	CD	3.75	5.14	3.87	10.01	1.35

Sr. No.	Characters / Hybrids	Pods per plant	Seeds per pod	Pod length	100-seed weight	Yield per plant
1	NIFPGr-17-64 × GDF-1	-0.54	-0.72*	-0.81**	-2.26**	-0.21
2	NIFPGr-17-64×NF-18-52(Local)	6.381**	0.26	0.27	-1.19**	0.93*
3	NIFPGr-17-64 × NIFPVg-17-10	-2.20	0.13	-0.18	-1.55**	-0.41
4	NIFPGr-17-64 × NIFPVg-17-12	0.30	0.82**	0.35	0.43**	0.09
5	NIFPGr-17-64 × NIFPGr-17-63	3.46	-0.59*	-0.07	1.40**	0.51
6	GDF-1 × NF-18-52 (Local)	-1.79	0.29	0.11	1.14**	-0.36
7	GDF-1 × NIFPVg-17-10	-0.04	0.62*	0.42	1.55**	0.36
8	GDF-1 × NIFPVg-17-12	5.13	-0.01	0.22	-0.07	0.32
9	GDF-1 × NIFPGr-17-63	-3.37	0.00	-0.13	-1.64**	-0.23
10	NF-18-52 (Local) × NIFPVg-17-10	-1.79	-1.07**	-0.07	0.91**	-0.63
11	NF-18-52 (Local) × NIFPVg-17-12	0.71	0.93**	0.26	-1.01**	0.35
12	NF-18-52 (Local) × NIFPGr-17-63	0.21	0.41	0.05	0.22**	0.61
13	NIFPVg-17-10 × NIFPVg-17-12	-3.20	0.57*	-0.02	-2.20**	-0.44
14	NIFPVg-17-10 × NIFPGr-17-63	0.63	0.02	0.16	-0.10	-0.08
15	NIFPVg-17-12 × NIFPGr-17-63	1.80	-0.82**	-0.21	1.35**	0.35
	SE (si)	1.43	0.21	0.15	0.06	0.36
	CD	3.07	0.44	0.31	0.12	0.76
	SE (sj)	1.73	0.25	0.18	0.07	0.43
	CD	3.71	0.53	0.38	0.15	0.92
	SE (sii-sjj)	1.95	0.28	0.20	0.08	0.49
	CD	4.19	0.60	0.43	0.17	1.04
	SE (sij-sik)	2.58	0.37	0.26	0.10	0.64
	CD	5.54	0.80	0.57	0.22	1.38
	SE (sij-skl)	2.39	0.34	0.25	0.10	0.60
	CD	5.13	0.74	0.53	0.21	1.28

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

Table 4: Classification of parents with respect to general combining ability (GCA) effects for various traits

Characters / Parents	Days to 50% flowering	Duration of reproductive phase	Days to maturity	Plant height	Branches per plant	Pods per plant	Seeds per pod	Pod length	100-seed weight	Yield per plant
NIFPGr-17-64	A	A	A	G	P	A	G	A	P	P
GDF-1	A	A	A	G	P	A	P	G	G	A
NF-18-52 (Local)	A	A	A	P	G	P	A	G	G	P
NIFPVg-17-10	G	P	G	P	A	A	G	G	G	A
NIFPVg-17-12	P	G	A	P	G	G	G	P	P	G
NIFPGr-17-63	A	A	P	G	A	A	P	P	P	A

G = good general combiner having significant gca effects in desired direction
A = average general combiner having either positive or negative but non-significant gca effects
P = poor general combiner having significant gca in undesired direction

Nature and magnitude of general combining ability effects provide a guideline in identifying the better parent and their utilization. The summary of the general combining ability effects of different parents revealed that the parent NIFPVg-17-12 was recognized as a good general combiner for yield per plant and also for the duration to reproductive phase, branches per plant, pods per plant, and seeds per pod. Parent GDF-1 was found good general combiner for plant height, pod length, and 100-seed weight. NIFPVg-17-10 parent was recorded good general combiner for days to 50 per cent flowering, days to maturity, seeds per pod, pod length, and 100-seed weight. Parent NIFPGr-17-64 found a good general combiner for plant height and seeds per pod. NF-18-52 (Local) parent was rated good general combiner for traits like branches per plant, pod length, and 100-seed weight. Parent NIFPGr-17-63 was observed good general combiner for plant height.

In the case of specific combining ability effects, none of the hybrids exhibited favorable sca effects for all the traits. In the present study, the positive specific combining ability is desirable for all the characters except for days to 50 per cent flowering, days to maturity, and plant height as for these characters negative value was considered desirable. Significant specific combining ability was observed in several crosses viz., for days to 50 per cent flowering (cross 4), duration to reproductive phase (cross 8 and 10), days to maturity (cross 4), plant height (cross 8,12, and 4), branches per plant (cross 11 and 13), pods per plant (cross 2), seeds per pod (cross 11,4,6 and 13),100-seed weight (cross 7,5,15,6,10,4 and 12), and yield per plant (cross 2), respectively. The results are in agreement with the findings of Singh *et al*. (2010) [23], Punia *et al*. (2011a) [21], Nassef *et al*. (2013) [19], Kumar *et al*. (2017) [15], Dar *et al*. (2017) [2], Tampha *et al*. (2018) [25], Katoch *et al*. (2019) [12], Yadav *et al*. (2019) [26], Parveen *et al*. (2019) [20] and Nageshwar *et al*. (2020) [18]. High sca effects denote undoubtedly a high heterotic response, but this may be due to the poor performance of the parents in comparison with their hybrids. With the same amount of heterotic effect, the sca effect may be less, where the mean performance of the parents was higher but this estimate may also be biased. This suggested that the selection of cross

The crosses having the best specific combination for yield per plant would have been obtained either through average × good, good × poor, and average × average parental combinations. The best specific combination for NIFPGr-17-64 × NF-18-52 (Local) recorded the significant sca effect for pods per plant and pod length. The second best specific combination for yield per plant NF-18-52 (Local) × NIFPGr-17-63 also recorded significant sca for days to maturity, plant height, and branches per plant. Cross NIFPGr-17-64 × NIFPGr-17-63 third-best specific combiner for yield per plant along with duration to reproductive phase, pods per plant, and 100-seed weight.

Conclusion

The parent NIFPVg-17-12 was observed as a good general combiner for the duration of the reproductive phase, pods per plant, branches per plant, seeds per pod, and yield per plant. Parent NIFPVg-17-10 was found good general combiner for days to 50 per cent flowering, days to maturity, and 100-seed weight. These can be used in hybridization programmes to improve candidate traits. The cross NIFPGr-17-64 × NIFPVg-17-12 found a good specific combiner for days to 50 per cent flowering, days to maturity, and seeds per pod, cross NIFPGr-17-64 × NF-18-52 for pods per plant, and yield per plant and GDF-1 × NIFPVg-17-10 for 100-seed weight. For most of the traits, non-additive gene action was observed, so heterosis breeding can be advised for improving candidate traits.

References

1. Cockerham CC. Implication of genetic variances in a hybrid breeding programme. Crop Sci. 1961;1:47-52.
2. Dar SA, Khan MH, Makhdoomi MI, Sultan SM. Combining ability of yield and yield attributing traits in fieldpea. Electronic J of Plant Breeding. 2017;8(3):927-932.
3. Fisher RA. The correlation relatives on supposititon of Mendelian Inheritance. Trans. Royal Soc. 1918;52:399-433.
4. Grafius JE. Components of yield in oats, a geometrical interpretation. Agron. J. 1959;48:419-423.
5. Griffing BC. A general treatment of the use of diallel cross in quantitative inheritance. Heridity. 1956b;10:31-50.
6. Griffings B. Concept of general and specific combining ability in relation to diallel crossing system. Anst. J. Biol. Sci. 1956a;9:463-93.
7. Gritton ET. Heterosis and combining ability in a diallel cross peas. Crop Sci. 1975;15(4):453-457.
8. Hanson WD, Robinson HF, Comstock RE. Biometrical studies of yield in segregating population of Korean Gespedea. Agron. J. 1956;48:268-272.
9. Hariom S, Nageshwar BK, Rathi M, Tamatam D. Heterosis and combining ability for grain yield and yield associated traits in 10 × 10 diallel analysis in Pea (*Pisum sativum* L.). Int. J Curr. Microbiol. App. Sci. 2017;6(12):1574-1585
10. Jinks JL, Hayman BI. The analysis of diallel cross. Maize genet. Crop News Lett. 1953;27:48-54.
11. Joshi DJ. Combining ability for yield related characters in fieldpea [*Pisum sativum* (L.) var *arvense*.]. Trends in Bio Sci. 2014;7(21):3434-3436.
12. Katoch V, Bharti A, Sharma A, Rathore N, Kumari V. Heterosis and combining ability studies for economic traits in garden pea (*Pisum sativum* L.). Legume Research. 2019;42(2):153-161.
13. Kempthrone O. An introduction to genetic statistics. John Wiley and Sons, Inc., New York, 1957.
14. Koelreuter JG. In 'Methods of plant breeding' (H. K. Hays, F. R. Immer and D.C. Smith Ed.) McGerw Hill book co., Inc., New York, 1766.
15. Kumar M, Jeberson MS, Singh NB, Sharma R. Genetic analysis of seed yield and its contributing traits and pattern of their inheritance in fieldpea (*Pisum sativum* L). Int. J Curr. Microbiol. App. Sci. 2017;6(6):172-181.
16. Kumar S, Katoch V, Bharti A, Sharma S, Sharma A, Kumari V. Heterosis, inbreeding depression and combining ability studies in garden pea (*Pisum sativum* L.). Legume Research. 2019;42(2):1-7.
17. Murty BR, Arunachalam V. The nature of genetic divergence in relation to breeding system in some crop plants, India. J Genet. 1966;26(A):188-198.
18. Nageshwar, Kumar B, Suman H, Madakemohekar AH, Tamatam D. Combining ability and Heterosis analysis for grain yield and yield associated traits in Pea (*Pisum sativum* L.). Legume Research. 2020;43(1):25-31.
19. Nassef DMT, El-Rawy MA. Analysis of gene effects controlling some traits in garden pea (*Pisum sativum* L.) Aus. J Basic Appld. Sci. 2013;7(1):537542.
20. Parveen N, Shakeel A, Malik TA, Awan FS. Genetic studies for improving seed yield and quality traits including carotenoids, chlorophyll and protein contents in pea (*Pisum sativum* L.). Pak. J Bot. 2019;51(6):2105-2110.
21. Punia SS, Ram B, Koli NR, Ranwah BR, Rokaria P, Maloo SR. Genetic architecture of quantitative traits in field pea. J Food Legumes. 2011[a];24(4):299-303.
22. Singh I, Sandhu JS, Singh J. Combining ability for yield and its components in fieldpea. J Food Legume. 2010;23(2):143-145.
23. Singh KP, Singh HC, Verma MC. Genetic analysis for yield and yield traits in pea. J Food Legume. 2010;23(2):113-116.
24. Sparague GF, Tatum LA. General versus specific combining ability in single crosses of corn. J Am. Soc. Agron. 1942;34:923-932.
25. Tampha S, Jeberson MS, Sastry EVD, Shashidhar KS, Sharma PR. Line x tester analysis for yield and its contributing characters in fieldpea (*Pisum sativum* L.). The Pharma Innovation Journal. 2018;7(9):104-109.
26. Yadav B, Sao A, Gauraha G. Combining Ability Analysis for Yield and Attributing Traits in Fieldpea (*Pisum sativum* L.). Int. J Curr. Microbiol. App. Sci. 2019;8(6):1976-1981.