Vegetable Science (2015) 42 (2) : 43-46

Generation mean analysis for pod yield and its associated traits in garden pea (*Pisum sativum* L.)

Shubha* and Shri Dhar

Received: July, 2014 / Accepted: June, 2015

Abstract

The present study was conducted to evaluate genetic and epistasis effects governing the inheritance of pod yield and yield components. Parental material comprising of six genetically different pea genotypes were crossed to produce F_1, F_2 and backcross generations. Means of the six generations were recorded for seven characters *viz.* plant height (cm), node bearing first flower, days to 50% flowering, pod length (cm), pod girth (cm), number of seed per pod and, total yield per plant (g). In present study three crosses (VRP-6 × GP-55, Pusa Pragati × GP-17 and Arkel × GP-48) showed significant dominance component [h] for pod yield. Significant estimates of additive component (d) along with significance of additive × additive (i) gene interaction with positive sign pod yield per plant which indicated the presence of increase alleles and associated pair of genes. It can be conclude that relative role of gene action was in general more complex for yield and other associated traits.

Keywords: *Pisum sativum* L., Generation mean analysis, epistasis, yield component.

Introduction

Garden pea (*Pisumsativum* L.) is one of the most important vegetable crops growing during cool season in India. It is an annual herbaceous legume vegetable belonging to the family Fabaceae. It is very nutritious crop grown for both fresh green pods and dried seed throughout the world. Pea seeds are rich in protein (23–25%), slowly digestible starch (50%), soluble sugars (5%), fibre, minerals and vitamins (Bastianelli*etal.*1998). As pea is a self pollinated crop, it offers a good scope to develop high yielding pure line varieties through hybridization followed by selection (Bisht*et al.* 2011). Earlier workers suggested that there would be no separate gene system for yield *per se* and the yield is an end product of the multiplicative interaction between the various components of yield (Sharma and Sain 2003). An understanding of the mode of inheritance of the yield components, the correlations among them, and the association between each component with yield is indispensable for choice of breeding procedures for developing high-yielding varieties. One of the best methods for the estimation of genetic parameters is generation mean analys is (GMA), in which epistatic effects could also be estimated. Generation means analysis approach was followed to estimate the nature and magnitude of gene action for the inheritance of yield components. GMA belongs to the quantitative biometric methods based on measurements of phenotypic performances of certain quantitative traits on as many as possible plant individuals in basic experimental breeding generations (parental, filial, backcross and segregation generations). As it was outlined by Kearsey and Pooni (1996), GMA is a useful technique in plant breeding for estimating main gene effects (additive and dominance) and their digenic (additive x additive, additive x dominance, and dominance x dominance) interactions responsible for inheritance of quantitative traits. It helps us in understanding the performance of the parents used in crosses and potential of crosses to be used either for heterosis exploitation or pedigree selection (Sharma *et al.* 2003). Considering the fact that yield is the most important complex traits and that their improvement is the main objective of pea breeding programmes. We undertook the present study to estimate genetic effects for yield and its component traits to select pea lines with desirable pod characters along with yield.

Materials and Methods

The present investigation was carried out at the Research Farm, Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi during the *rabi* seasons of the year 2012-13 and 2013-14. The experimental material comprise of four early bearing and high yielding

Vegetable Science Division, Indian Agricultural Research Institute, New Delhi
*E-mail: shubha24iari@gmail.com

Table 1. Salient features of garden pea parental lines used in the study

S. No	Parents	Source	Height	Maturity	Salient features
1	Pusa Pragati (PP)	IARI, New Delhi	Dwarf	Early	White flower, Long slightly curved green pod, wrinkled seeds
2	Arkel	IARI, New Delhi	Dwarf	Early	White flower, Long green pod, wrinkled seeds
3	VRP-6	IARI, New Delhi	Dwarf	Early	White flower, Long green pod, wrinkled seeds
4	GP-55	IARI, New Delhi	Tall	Late	White flower, Long green pod, round seeds
5	GP-48	IARI, New Delhi	Dwarf	Medium	Purple flower, green pod z, round seeds
6	GP-17	IARI, New Delhi	Dwarf	Early	White flower, Long green pod, round seeds

(VRP-6, Pusa Pragati, GP-17 and Arkel) variety and two late (GP-48 and GP-55) lines.

The lines were used to develop three F1's, viz. VRP-6 × GP-55, PP× GP-17 and Arkel × GP-48 during winter 2012-13. The F_1 seed of these three crosses along with their parents were sown during winter season of 2013–14 to develop back cross progenies by crossing each F_1 to both of its parents to obtain backcross generations (BC_1 and BC_2). At the same time F_2 seed was obtained by selfing the F_1's. For yield related traits, data were recorded on the plant height (cm), node bearing first flower, days to 50% flowering, pod length (cm), pod girth (cm), number of seed per pod and total yield per plant (g). The details of statistical procedures adopted for analysis of six generation viz.,P_1, P_2, F_1, F_2, B_1, B_2 of selected cross on the nature and magnitude of various types of gene action are presented below. The data were tested for the adequacy of the additive-dominance model using A, B, C and D scaling test as suggested by Mather and Jinks (1982). The scaling tests (A, B, C and D) as suggested by Mather and Jinks (1982) was applied to test the fitness of data to a simple additive-dominance model. The A, B, C and D values were calculated by the following formula,

$A = 2\ B_1 - P_2 - F_1$

$B = 2\ B_2 - P_2 - F_1$

$C = 4\ F_2 - 2F_1 - P_1 - P_2$

$D = 2F_2 - B_1 - B_2$

Where,

P_1, P_2, F_1, F_2, B_1, B_2 are the mean values of the respective generations. Significant deviation of A, B, C, D values from zero indicates presence of epistasis justifying the use of six parameter model. To test the adequacy of additive-dominance model, the individual scaling tests given by Mather as well as joint scaling tests by Cavalli (1952) were applied. First, simple additive-dominance model consisting of mean (m), additive (d) and dominance (h) gene effects were tried and the adequacy of the model was tested by the chi-square test. When this model failed to explain variation among generation means, successively non-allelic interaction parameters *i.e.* additive × additive [i], additive × dominance [d] and dominance × dominance [j] were included in this model.

Results and Discussion

Mean values for the analyzed traits of the crosses are presented in Table 2. Parents used in this research showed difference in almost all the characters studied in crosses. Simple additive-dominance model was adequate as depicted with the non-significance of A, B, C and D simple scaling tests. The significance of A and B scale indicates the presence of all the three types of non allelic gene interaction, C scale suggests the dominance x dominance (l) type of non-allelic gene interaction and significance of D suggested additive x additive (i) type of non-allelic gene interaction for several character implies non-allelic interaction for most of the characters in different cross combinations (Table 3). Plant height is an intrinsic component of plant architecture with effects on yield and its other components. Mean comparison (Table 2) among the six generations showed in cross VRP-6×GP-55, GP-55 is tall variety and effect of tallness is also observed in segregating generation but desirable plant type in garden pea is the one with dwarf growth habit which does not need staking and results in saving resources both in terms of capital and labour.

For the entire three crosses (VRP-6 × GP-55, Pusa Pragati × GP-17 and Arkel × GP-48) simple additive-dominance model failed to explain variation among generation means. All three crosses exhibited significant negative additive gene effect which signifies dwarf plants can be recovered in the early generations. Earliness is a highly desirable quality in garden pea in the sense that the prevailing prices in the market are customarily high early in the season. Days to 50% flowering and node bearing first flower depict the earliness of a particular genotype (Sharma *et al.*2013)**.**Mean value of the first filial generation F_1 was between parental values for the days to 50% flowering and node bearing first flower in crosses. VRP-6 × GP-55 cross exhibited significant positive additive and additive ×additive gene effect which signifies early plants can be recovered in the starting generations.

In garden pea, the overall yield depend pod length, girth and number of seed. It is well known fact that increased progressively with the advancing age of crop up to 12 to 15 days after flowering. In this study pod length

Table2. Mean performance of parents, F_1, F_2, BC_1 and BC_2 for the different characters

Cross	P_1	P_2	F_1	F_2	BC_1	BC_2
Plant height (cm)						
VRP-6 × GP-55	34.94	82.25	76.78	65.54	58.54	78.12
PP × GP-17	32.88	31.53	35.32	33.74	28.40	30.25
Arkel × GP-48	25.94	22.11	25.46	24.37	25.92	28.05
Node bearing first flower						
VRP-6 × GP-55	8.87	14.34	10.92	9.88	8.75	11.72
PP × GP-17	7.94	8.72	7.12	8.22	8.00	8.04
Arkel × GP-48	8.27	8.62	7.65	8.20	8.67	8.27
Days to 50% flowering						
VRP-6 × GP-55	45.23	85.72	72.58	77.22	65.95	83.78
PP × GP-17	40.97	37.98	38.21	40.12	42.36	47.92
Arkel × GP-48	42.23	57.92	54.11	59.54	57.73	54.52
Pod length (cm)						
VRP-6 × GP-55	9.86	8.22	8.08	8.46	8.08	7.76
PP × GP-17	10.12	8.40	8.05	8.67	8.23	7.75
Arkel × GP-48	9.98	7.54	7.95	8.41	8.12	9.88
Pod girth (cm)						
VRP-6 × GP-55	1.19	1.28	1.07	1.14	1.17	1.12
PP × GP-17	1.10	1.19	1.12	1.12	1.02	1.19
Arkel × GP-48	1.09	1.16	1.13	1.07	1.13	1.12
Number of seed per pod						
VRP-6 × GP-55	8.45	7.29	6.29	8.20	8.43	7.28
PP × GP-17	9.98	7.92	7.32	7.79	7.04	7.83
Arkel × GP-48	9.45	7.80	6.16	7.43	7.07	6.81
Total yield per plant (g)						
VRP-6 × GP-55	122.00	98.12	88.98	115.00	105.67	109.02
PP × GP-17	128.23	117.60	108.23	116.43	98.73	67.22
Arkel × GP-48	132.76	64.23	88.22	92.56	97.65	82.33

Table 3. Scaling, Chi square test and epistasis effects in six generation crosses of garden pea

Crosses	A	B	C	D	m	d	h	i	j	l	χ^2
Plant height (cm)											
VRP6×GP55	19.85±10.45	14.97**±4.3	-11.3±13.5	-27.3**±2.3	85.39**±0.39	-8.24**±1.92	4.80±8.05	4.57±4.6	4.17±6.77	-75.88**±15.3	11.03*
PP × GP-17	26.83**±8.6	24.12**±3.78	30.1**±9.47	-43.53**±2.3	52.37**±0.64	-7.32**±1.9	3.15±6.46	3.07±4.58	-0.63±4.5	-29.1**± 6.31	9.22*
Arkel × GP48	5.84±12.83	20.38**±4.74	-18.34 ±13.6	-19.3** ±2.2	81.37**±0.64	-4.06**±1.80	4.00±8.34	3.56±4.32	-7.57±6.8	-64.8**±5.43	8.22*
Node bearing Ist flower											
VRP6× GP55	1.64±1.52	-0.34±0.88	3.45± 1.89	1.11±0.71	11.23**±1.58	-0.38±0.76	-3.76± 4.09	-	-	-	2.93
PP × GP-17	0.95±1.43	1.19±0.87	6.13**±1.79	1.92**±0.73	9.08±0.29	0.03± 0.57	-4.75**±1.45	3.17*± 1.39	-0.11±0.8	1.87±2.53	6.55*
Arkel×GP48	0.86±1.52	2.34**±0.88	0.17± 1.87	-1.55*±0.65	8.29±0.27	-0.54± 0.48	2.34±1.68	-3.98**±1.37	-0.73± .85	-6.24*± 2.55	12.34*
Days to 50% flowering											
VRP6× GP55	14.22 ±7.23	7.65**±1.26	13.69±8.04	4.09**±0.86	58.32**± 0.26	-0.92±0.68	11.35**±4.34	8.18±4.34	3.29± .02	30.05**±8.5	9.4*
PP ×GP17	10.99 ± 6.73	2.92±1.1	-11.8±6.67	22.45±1.11	42.66**±4.39	13.25**±1.19	-	-	-	-	2.64
Arkel ×P-48	17.80±8.37	-1.40± 3.63	9.31± 9.52	-3.54±1.30	36.75± 0.26	1.38±0.96	-	-	-	-	3.23
Pod length (cm)											
VRP-6×GP-55	0.73± 1.44	2.41± 1.78	2.28±1.65	-0.43± 0.54	7.79**±1.26	0.29± 0.65	4.65± 3.47	-	-	-	3.14
PP x GP-17	3.99 ±1.27	4.07±0.86	4.51±1.79	-3.75 ±0.55	9.47 ±0.17	-0.43± 0.42	3.29*±1.36	7.50**±1.10	0.96±0.67	-17.56**± .36	2.84
Arkel x GP-48	1.58±1.47	4.93±0.93	2.56±1.60	-1.00±0.54	8.59**±0.17	1.39± 0.43	10.33±1.32	2.00±1.08	-1.68±0.81	-8.52**± .45	7.58
Pod girth (cm)											
VRP6×GP55	0.48±0.31	0.32±0.28	0.21±0.40	-0.29±0.20	0.68±0.41	-0.16± 0.11	2.42*± 1.10	-	-	-	1.54
PP ×GP-17	0.42±0.30	0.08±0.27	-0.68±0.39	0.59**±0.20	1.13**±0.06	1.04±0.15	1.67**±0.42	1.34**±0.39	0.34	-	4.88
Arkel × GP-48	0.79*±0.31	0.11±0.28	-0.44±0.40	-0.67±0.20	1.29±0.06	3.32*±0.15	1.89±0.42	4.19**±0.39	0.17±0.19	-1.69±0.73	9.88*
Number of seed per pod											
VRP6×GP55	-1.19±1.29	-3.32**± .53	-2.61±1.38	0.85**±0.20	8.23**± 0.06	1.04±0.16	2.99± 0.79	-1.7± 0.41	1.06± .66	-6.02**± .53	10.76*
PP ×GP-17	-1.75±1.22	-2.92±.31	-1.93±1.27	1.82±0.20	8.33 ±0.06	0.17±0.56	-2.89±0.81	-	-	-	1.66
Arkel×GP48	-1.51±1.34	0.53±0.49	-0.76±1.42	-0.23±0.20	6.62*± 0.69	1.08±0.16	0.74± 2.00	-3.63±0.41	0.73±0.67	1.03±1.56	5.54
Total yield per plant(g)											
VRP6×GP55	29.14±18.13	38.89**±8.12	69.25**±19.66	-68.64**±4.1	113.92**±1.33	45**±13.77	-4.76± 4.24	17**.21±10.	5.33±.95	-4.8±9.48	8.65*
PP × GP-17	-2.01±18.47	-1.61± 6.88	4.06±11.98	-27.8±4.94	120.59**±1.33	29.9**±14.04	3.77± 4.17	25.62**±9.88	7.21±20.55	-22.89*±9.2	5.88
Arkel×GP48	23.18*±11.29	43.77**±10.96	28.29±21.83	-6.74± 5.02	82.97**±1.31	83.41**±9.25	-8.71*± 4.26	13.47*±10.05	5.24±7.69	17.39*±6.4	6.43

*5% level of significance ;**1 % level of significance.

cross PP×GP-17 showed significance of dominance component [h]. Genic interaction for pod girth showed significance of dominance component [h] in cross Arkel × GP-48. On the other hand, significant dominance × dominance [j] effects were noticed for the same cross indicated for this cross suggesting that both parent possessed heterozygous loci with dominant alleles for pod girth and pod length. Number of seed per pod has a direct bearing on the total productivity of pea crop. In cross VRP-6×GP-55 significant additive ×dominance gene action observe for number of seed per pod. Further, manifestation of duplicate epistasis by the crosses for several character revealed that this kind of epistasis generally hinders the improvement through selection as the presence of duplicate epistasis decrease the variation in F_2 and subsequent generations (Tyagi, 2001). So, the selection should be delayed until a high level of gene fixation (additive component) is attained. Three crosses

(VRP-6 × GP-55, Pusa Pragati × GP-17 and Arkel × GP-48) showed significant dominance component [h] for pod yield. Significant estimates of additive component (d) along with significance of additive × additive (i) gene interaction with positive sign pod yield/plant indicated the presence of increase alleles and associated pair of genes. This suggested the increased manifestation can be achieved through single progeny selection (Narain *et al*. 2007). It can be concluded that relative role of gene action was in general more complex for yield and other associated traits. Eventually, it can be concluded that the nature and magnitude of gene effects vary with different cross/character-wise. Hence, specific breeding strategy has to be adopted for a particular cross to get improvement in pod yield and its associated traits. Further, duplicate type of epistasis was also found in majority of traits in one or the other cross combinations. In such crosses, the selection intensity should be mild in the earlier and intense in the later generations because it marks the progress through selection.

Acknowledgement

The authors are thankful to Department of Science and Technology (DST) for financial assistance and Indian Agriculture Research Institute (IARI), New Delhi for infrastructural support.

सारांश

प्रस्तुत शोध में सब्जी मटर की फली उपज एवं उपज घटकों के वंशागतित्व को नियन्त्रित करने वाले अनुवांशिक मूल्यांकन तथा एपीस्टेटिक प्रभाव का मूल्यांकन करना है। अनुवांशिक रुप से विभिन्न 6 पैत्रक प्रभेदों को समाहित कर एफ1, एफ2 एवं पश्च संकरण किया गया। छः पीढ़ियों के माध्य सात गुणों पानी पौध ऊँचाई (सेमी.), प्रथम गांठ पर बनने वाला पुष्प, 50 प्रतिशत पुष्पन के दिन, फल की लम्बाई (सेमी.), फल व्यास (सेमी.), प्रतिफल बीजों की संख्या तथा कुल उपज/ पौध (ग्राम) के लिए अंकित किये गये। तीन संकरणों (वी आर पी–6×जी पी–55, पूसा प्रगति× जी पी–17 तथा अर्केल × जी पी–48 ने सार्थक प्रभाविकता घटक (एच) उपज के लिए प्रदर्शित किए। सार्थक आकलन योज्य घटक (डी) के साथ–साथ योज्य ×योज्य (आई) जीन प्रतिक्रिया सार्थक लक्षण उपज/पौध हेतु प्रदर्शित किए जिससे संकेत मिलता है कि एलील की बढ़ती उपस्थिति तथा सम्बन्धित जुड़े जीन्स जिम्मेदार हैं। अतः उपज तथा सम्बन्धित घटकों के लिए जीन प्रक्रिया सामान्यत ज्यादा जटिल है।

References

Bastianelli D, Grosjean F, Peyronnet C, Dupar que M, Régnier JM (1998) Feeding value of pea (*Pisum sativum* L.) 1. Chemical composition of different categories of pea. Animal Science 67: 609-619.

Bisht B and Singh Y V (2011) Combining ability for yield and yield contributing characters in pea (*Pisum sativum* L.) Veg Sci 38(1): 17-21.

Cavalli L (1952) An analysis of Linkage in Quantitative inheritance. *In*: E.C.R. Rieve and C.H. Waddington (ed.), 135-144. HMSO, London.

Kearsey J, Pooni S (1996) The Genetical Analysis of Quantitative Traits. Chapman and Hall, 1st edition, London, p 46.

Mather K and Jinks J L (1982) *In*: Biometrical Genetics, 3rd edn. Chapman and Hall Ltd., London.

Narain V, Singh P K, Kumar N and Singh V S (2007) Gene effects for grain yield and related traits in Sorghum (*Sorghum bicolour* (L) Moench). Indian J Genet 67(1): 34–6.

Sharma A, Kapoor P, Katoch V, Singh Y, Sharma J D (2013) Development of powdery mildew resistant genotypes in garden pea (*Pisum sativum*L.) through generation mean analysis approach. Indian J Genet 73(4): 371-377.

Sharma S N, Sain S (2003) Genetic architecture of grain weight in durum wheat under normal and late sown environments. Wheat Information Service 96*:* 28–32.

Tyagi MK, Srivastava CP (2001) Analysis of gene effects in pea. Legume Research 24: 71-76.