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Original Research Paper

Assessment of gene action and combining ability for advancement of yield and its attributing traits in pansy (*Viola* × *wittrockiana* Gams.) through diallel mating design

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ABSTRACT

Pansy is one of the most important bedding winter annual for sub-tropical climatic conditions. Twenty-eight F_1 hybrids of pansy were evaluated in randomized block design with three replications, to study the combining ability for vegetative and floral characters. The analysis of variance indicated significant variability among all the genotypes for all the characters. The ratio of genetic component of variance indicated the equal importance of additive and non-additive gene action in governing the flower yield and its component traits of pansy. Estimates of general combining ability effects showed that parents Pa-64-1-5-14, Pa-62-4-12-18, Pa-63-1-7-25 and Pa-32-8-7-6 were good general combiners for most of the traits except stalk length and flower size. The specific combining ability effects showed that for yield traits the best cross combinations were Pa-64-1-5-14 × Pa-62-4-12-18, Pa-13-1-2-3 × Pa-47-1-3, Pa-11-1-3-7 × Pa- 62-4-12-18, Pa-64-1-5-14 × Pa-63-1-7-25 and Pa-11-1-3-7 × Pa-64-1-5-14. The study on gene effect of different characters indicated the predominance of non-additive gene effects for most of the characters. The *gca* variances was higher for branches number, flower size, days from bud initiation to flowering and flowers number than *sca* variances, indicating additive gene action, and progeny selection will be effective for the genetic improvement of these traits.

Keywords: Combining ability, diallel analysis, gene action, genetic variance, pansy

INTRODUCTION

Pansy (*Viola* × *wittrockiana* Gams) is a popular winter annual ornamental bedding plant belonging to the family Violaceae. The flowers are various colours with attractive patterns, beautiful forms and variable colour combination ns. The flower size in pansy varies from 2.5 to 8.0 cm and the cultivars are grouped as small and large flowered depending upon the size of the flowers. The large flowered types produce fewer flowers and hence are suitable for pot culture and exhibition purposes. The small flowered types produce flowers profusely and hence are suitable for bedding purposes (Ravikumar & Dhatt 2024a). Pansy is commercially propagated by seeds. The flowers possess sporophytic self- incompatibility and set seed through hand cross pollination (Baweja, 2001). However, information on breeding aspects are meager, therefore, for improving yield with better flowering quality, exploitation of hybrid vigour and combining ability analysis is needed. Nowadays, the selection of parents on the basis of combining ability is becoming important tool for crop improvement among plant breeders. It also provides necessary information on the nature and magnitude of gene effects for growth traits. The half diallel analysis is useful for preliminary evaluation of genetic stocks with large numbers for use in hybridization programmes and to facilitate a sound breeding program. According to Ravikumar & Dhatt (2023), it is appropriate to use the square components of the effects to indicate the corresponding type of gene activity. Therefore, the objective of this study was to select good combiners, which might produce the promising F_1s.

MATERIALS AND METHODS

The present investigation was conducted at the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, Punjab. The experimental material consisted of thirty-six genotypes (eight parents and its twenty-eight crosses) of pansy; parents being developed after 4-5 generations of selfing and F_1s developed by crossing the prominent

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parents of pansy namely Pa-11-1-3-7, Pa-24-4, Pa-64-1-5-14, Pa-62-4-12-18, Pa-32-8-7-6, Pa- 63-1-7-25, Pa-13-1-2-3 and Pa-47-1-3 in all possible combination excluding reciprocals. Seeds of all 28 crosses along with eight parents were sown in open field conditions during October. One month old, healthy, vigorous and uniform plants were transplanted in November. The plot size was 2.4 m x 2.4 m and seedlings were transplanted at a spacing of 30 cm x 30 cm in the main field. The experiment was laid out in a randomized block design with three replications. The data were collected for ten randomly selected plants from each parent and F_1s. Data were recorded on twelve vegetative and floral characters. The combining ability analysis was carried out by employing the procedures given in method-2 (Parents and one set of F_1 without reciprocals) and model-1 (fixed effect) of Griffing (1956).

RESULTS AND DISCUSSION

Analysis of variance for general (*gca*) and specific combining ability (*sca*) showed highly significant differences for all traits under study (Table 1), suggesting the importance of both additive and non-additive components of gene action. The significant mean squares due to *sca* were also reported by Namita et al. (2011) in marigold.

Among the eight parents used, Pa-64-1-5-14, Pa-13-1-2-3and Pa-62-4-12-18 were good general combiners for plant height at first flowering (Table 2). Significant positive GCA effects were desirable for the final plant height, final plant spread and pod setting (%) and parents Pa-64-1-5-14, Pa-62-4-12-18, Pa- 63-1-7-25 and Pa-32-8-7-6 that showed maximum GCA value in the desirable direction, were found to be as a good

Table 1 : Analysis of variance for combining ability for different characters in pansy

Source of variation	df	Plant height at first flowering	Final plant height	Plant spread	Final plant spread	Branches per plant	Stalk length	Flower Size	Days from bud initiation to flowering	Days to flowering	Duration of flowering	Number of flowers/ plant	Pod setting (%)
		Mean sum of squares											
GCA	7	11.55**	328.90**	108.29**	187.76**	215.04**	14.09**	5.786**	36.381**	211.955**	805.952**	112974.2**	551.80**
SCA	28	5.81**	39.15**	12.99**	29.90**	22.43**	3.89**	0.23**	3.006**	53.296**	153.072**	6190.44**	123.03**
Error	70	0.23	0.79	0.38	1.14	0.27	0.17	0.04	0.106	0.934	2.051	54.24	12.85

*and **Significant at P d" 0.05 and P d" 0.01, respectively

Table 2 : Estimation of general combining ability effects in pansy

Genotype	Plant height at first flowering	Final plant height	Plant spread	Final plant spread	Branches per plant	Stalk length	Flower Size	Days from bud initiation to flowering	Days to flowering	Duration of flowering	Number of flowers/ plant	Pod setting (%)
Pa-11-1-3-7	0.22	-4.69*	-0.93*	-3.41*	-3.27*	-0.61*	0.51*	0.15	3.08*	-1.34*	-31.59*	0.012
Pa-24-4	-2.20*	-11.23*	-4.14*	-5.19*	-6.28*	-1.70*	0.58*	1.50*	4.74*	-7.08*	-133.10*	-11.55*
Pa-64-1-5-14	1.28*	7.36*	5.28*	6.58*	7.13*	0.06	-0.90*	-2.28*	-5.96*	13.89*	142.63*	10.85*
Pa-62-4-12-18	0.52*	4.27*	4.38*	5.01*	4.20*	0.07	-1.01*	-2.92*	-7.23*	13.33*	128.84*	3.81*
Pa-32-8-7-6	0.10	2.61*	-1.45*	2.25*	-1.83*	0.80*	0.32*	0.93*	0.31	-3.28*	-33.28*	2.35*
Pa-63-1-7-25	-0.36*	1.48*	0.62*	3.23*	4.02*	0.08	-0.69*	-1.25*	-1.39*	0.41	86.42*	4.25*
Pa-13-1-2-3	0.95*	0.53	-2.60*	-3.14*	-3.48*	1.58*	1.00*	2.38*	4.94*	-10.44*	-112.05*	-9.85*
Pa-47-1-3	-0.50*	-0.54*	0.18	-0.83*	-0.48*	1.27*	0.19*	0.90*	1.51*	-4.68*	-47.84*	1.37
SE(gi)	0.141	0.263	0.183	0.318	0.153	0.121	0.059	0.096	0.284	0.424	2.17	1.05

*Significant at 5% level of significance general combiner for these traits. The parents Pa-64-1-5-14, Pa-62-4-12-18 and Pa-63-1-7-25 exhibited highly significant and positive GCA effects and were thus adjudged as good general combiners with respect to these parameters. For stalk length, Pa-13-1-2-3, Pa-47-1-3 and Pa-32-8-7-6 exhibited the significant positive general combining ability effects, hence designated as good general combiners. On the basis of earliness, parents, Pa-64-1-5-14, Pa-62-4-12-18 and Pa-63-1-7-25 for traits *viz.*, days from bud initiation to flowering and days to flowering revealed the best combiner due to their significant negative GCA effects. Similarly, Vi-13-2 and Vi-15–2 expressed superior general combining effects for flower yield and considered as good general combiners in periwinkle (Ravikumar & Dhatt 2024). Significant and positive *sca* value for plant height at first flowering and plant spread ranges from -3.15 to 5.12 and -7.39 to 5.32, respectively (Table 3). Out of the twenty-eight crosses, twelve crosses showed significant positive *sca* for these traits. The estimated range of *sca* value for final plant height ranged between -11.13 to 15.10 and final plant spread ranged from -4.46 to 11.43. Eleven crosses showed significant positive *sca* effects for these two traits being maximum in Pa- 64-1-5-14 × Pa-63-1-7-25. The range for number of branches per plant scaled from -7.19 to 9.79. For this trait, ten crosses exhibited the highest positive *sca* values being high in Pa-64-1-5-14 × Pa-32-8-7-6 and it was on par to Pa-64-1-5-14× Pa-63-1-7-25. Estimation of SCA effects indicated that out of twenty-eight F_1 hybrids, eighteen hybrids exhibited significant *sca* value for stalk length and ranged from -2.53 to 3.79. The best five combinations exhibited positive and significant *sca* effects were Pa-62-4-12-18 × Pa-13-1-2-3 followed by Pa-11-1-3-7 × Pa-13-1-2-3, Pa-64-1-5-14 × Pa-13-1-2-3, Pa-64-1-5-14 × Pa-47-1-3 and Pa-63-1-7-25 × Pa-47-1-3.

The estimated *sca* range for days from bud initiation to flowering is from -2.86 to 3.85 and eleven cross combination showed significantly higher negative *sca* effects. For days to flowering (planting to flowering), out of the total twenty-eight cross combinations, eighteen crosses exhibited significant negative *sca* effects and the best five cross combinations were Pa-62-4-12-18 × Pa-47-1-3, Pa-24-4 × Pa-32-8-7-6, Pa-24-4 × Pa-64-1-5-14, Pa-32-8-7-6× Pa-47-1-3 and Pa-32-8-7-6× Pa-13-1-2-3. The estimated *sca* range for the duration of flowering is from -8.93 to 16.07. Fourteen crosses showed significant positive *sca* values and the promising top five combiners with the highest positive *sca* values were Pa-24-4× Pa-62-4-12-18, Pa-11-1-3-7×Pa-62-4-12-18, Pa-24-4× Pa-63- 1-7-25, Pa-11-1-3-7× Pa-64-1-5-14 and Pa-24-4× Pa-64-1-5-14. For yield traits *viz.*, number of flowers per plant and pod setting (%) the estimates of *sca* value ranged from between -129.95 to 125.51 and -22.90 to 18.54, respectively. Amongst all cross combinations, ten crosses and eight crosses showed significant positive *sca* effects in these respective traits respectively. For both the traits, the best five cross, combinations were Pa-64-1-5-14× Pa-63-1-7-25, Pa-64-1-5-14× Pa-62- 4-12-18, Pa-13-1-2-3× Pa-47-1-3, Pa-11-1-3-7× Pa-62-4-12-18 and Pa-64-1-5-14× Pa-32-8-7-6. The cross combination involving H × L or L × H followed by H × H and L × L *gca* parents with the highest significant *sca* effects may be obtained for different vegetative and floral traits. Crosses having both the parents as low general combining ability may involve dominance × dominance or epistatic interactions. Such crosses may not give good transgressive segregates in further generations. The crosses involving high x high and high × low or low × high general combiners and showing high SCA effects could be utilized for developing high yielding genotypes and obtaining transgressive segregates in F_2, generation. The above results are in conformity with the findings of Kumar et al. (2004) in China aster and Song & Bang (2001) in petunia.

The estimate of genetic components of GCA and SCA variances and their ratios for vegetative and floral components are given in Table 4. Since the concepts of GCA and SCA were presented by Sprague & Tatum (1942). The ratio of genetic component of variance (σ^2GCA/σ^2SCA) proposed by Backer (1978) and it indicated the equal importance of additive and non-additive gene action in governing the flower yield and its component traits of pansy. High magnitude of GCA variances were observed for traits *viz.*, higher for number of branches per plant (22.47), flower size (0.57), days from bud initiation to flowering (3.62) and number of flowers per plant (11292) which indicated that additive gene action governed these traits.

Table 3 : Estimation of specific combining ability effects in pansy

Cross Combition	Plant height at first flowering	Final plant height	Plant spread	Final plant spread	Branches / plant	Stalk length	Flower Size	Days from bud initiation to flowering	Days to flowering	Duration of flowering	Number of flowers/ plant	Pod setting (%)
Pa-11-1-3-7× Pa-24-4	-1.14*	2.74*	2.98*	-1.00	2.82*	-0.10	0.69*	1.80*	4.08*	-2.99*	2.45	-4.39
Pa-11-1-3-7× Pa-64-1-5-14	4.82*	3.95*	5.08*	5.19*	4.96*	1.09*	-0.72*	-1.30*	-6.22*	13.77*	56.06*	8.53*
Pa-11-1-3-7× Pa-62-4-12-18	2.07*	2.52*	1.16*	7.61*	3.79*	0.81*	-0.38*	-1.63*	-2.62*	15.01*	92.65*	17.17*
Pa-11-1-3-7× Pa-32-8-7-6	0.70	-0.68	3.58*	-0.28	-2.80*	-0.04	0.44*	1.19*	-4.45*	7.94*	-9.16	1.43
Pa-11-1-3-7× Pa-63-1-7-25	2.93*	-1.94*	2.28*	0.38	-0.54	0.37	-0.06	0.92*	-2.52*	13.07*	42.93*	6.92*
Pa-11-1-3-7× Pa-13-1-2-3	2.49*	1.42	2.87*	5.54*	-1.92*	3.31*	-0.12	-1.06*	2.91*	8.11*	-30.77*	-16.56*
Pa-11-1-3-7× Pa-47-1-3	0.91*	-1.18	-0.93	1.68	0.02	0.57	0.51*	1.27*	3.98*	-7.74*	35.98*	-4.39
Pa-24-4× Pa-64-1-5-14	-1.95*	-9.92*	-7.39*	-4.46*	-7.19*	-0.83*	0.15	1.06*	-8.55*	13.51*	-129.95*	3.76
Pa-24-4× Pa-62-4-12-18	-0.97*	-5.80*	-5.73*	-0.91	-3.63*	-1.28*	0.07	1.25*	-5.62*	16.07*	-108.73*	5.80
Pa-24-4× Pa-32-8-7-6	-1.57*	-3.65*	-1.57*	-5.74*	1.40*	0.44	-1.36*	-2.65*	-8.79*	1.34	11.14	-1.33
Pa-24-4× Pa-63-1-7-25	1.34*	-4.52*	1.10	-1.62	-5.21*	1.02*	0.10	0.31	-2.51*	13.81*	-87.85*	0.36
Pa-24-4× Pa-13-1-2-3	1.69*	0.43	5.32*	4.56*	1.39*	-2.53*	-0.09	-0.76*	-4.41*	5.51*	-70.99*	0.66
Pa-24-4× Pa-47-1-3	-1.04	-3.55*	1.43	-1.77	2.70*	1.47*	0.01	-0.07	-0.35	-2.93*	40.95*	2.82
Pa-64-1-5-14× Pa-62-4-12-18	1.10*	8.33*	1.76*	-0.28	0.60	-2.00*	-0.39*	-0.24	-2.92*	-0.23	89.25*	18.54*
Pa-64-1-5-14× Pa-32-8-7-6	1.28*	10.33*	3.34*	9.54*	9.79*	-0.03	0.17	1.74*	-1.75*	4.04*	71.08*	6.96*
Pa-64-1-5-14× Pa-63-1-7-25	5.12*	15.10*	4.11*	11.43*	9.52*	0.92*	0.08	-1.11*	-4.15*	7.84*	125.51*	8.96*
Pa-64-1-5-14× Pa-13-1-2-3	1.33*	-5.41*	0.50	2.60*	-6.69*	2.72*	0.24	2.31*	-1.05	-3.79*	-94.60*	-1.73
Pa-64-1-5-14× Pa-47-1-3	-3.02*	-4.74*	-2.14*	3.04*	-2.34*	2.29*	-0.15	-2.86*	1.01	-2.23	-98.78*	-22.90*
Pa-62-4-12-18× Pa-32-8-7-6	-1.22*	-6.48*	-2.14*	-1.95	-6.96*	-1.84*	-0.28	-2.54*	-4.49*	4.27*	-10.09	-5.03
Pa-62-4-12-18× Pa-63-1-7-25	-3.15*	6.59*	2.27*	4.25*	-0.14	0.51	-0.26	-0.94*	3.14*	-8.93*	-77.83*	-19.99*
Pa-62-4-12-18× Pa-13-1-2-3	-0.29	-11.13*	-2.07*	-2.08*	-4.94*	3.79*	0.42*	3.85*	6.18*	-3.56*	-86.08*	-21.36*
Pa-62-4-12-18× Pa-47-1-3	-1.27*	2.74*	0.02	2.24*	-4.47*	1.93*	-0.04	-1.88*	-9.05*	-1.33	-23.69*	-7.53*
Pa-32-8-7-6× Pa-63-1-7-25	1.48*	6.36*	-0.91	-1.78	-1.90*	-1.18*	-0.03	0.72*	3.65*	-3.33*	-17.03*	6.97*
Pa-32-8-7-6× Pa-13-1-2-3	-2.36*	2.48*	-0.23	0.03	-1.22*	0.06	0.29	-1.07*	-6.32*	-2.29	-8.89	-10.17*
Pa-32-8-7-6× Pa-47-1-3	-1.61*	-0.91	3.16*	4.11*	1.26*	-1.84*	-0.07	0.29	-8.55*	12.27*	41.94*	0.32
Pa-63-1-7-25× Pa-13-1-2-3	-0.98*	4.23*	2.40*	1.51	-2.12*	-0.36	0.38*	1.65*	-3.35*	-7.16*	-83.99*	-8.47*
Pa-63-1-7-25× Pa-47-1-3	-2.20*	-3.13*	-3.51*	-3.32*	-2.95*	2.09*	-0.08	1.26*	5.75*	-4.93*	-37.57*	5.36
Pa-13-1-2-3× Pa-47-1-3	-2.05*	0.71	1.04	3.85*	4.21*	-0.72	-0.34	-0.57	-3.51*	8.11*	98.44*	17.32*

*Significant at 5% level of significance

Table 4 : Estimates of genetic components of variance for different vegetative and flowering characters in pansy

Character	σ^2g	σ^2s	Variance ratio (σ^2g/σ^2s)	Predictability ratio $2\sigma^2g/(2\sigma^2g + \sigma^2s)$
Plant height at first flowering	1.13	5.58	0.20	0.28
Final plant height	32.82	38.35	0.65	0.53
Plant spread	10.79	12.60	0.85	0.63
Final plant spread	18.66	28.76	0.64	0.56
Number of branches per plant	22.47	22.16	0.96	0.75
Stalk length	1.39	3.72	0.37	0.42
Flower size	0.57	0.18	3.02	0.85
Days from bud initiation to flowering	3.62	2.90	1.25	0.71
Days to flowering	21.10	52.36	0.40	0.44
Duration of flowering	80.39	151.02	0.53	0.52
Number of flowers per plant	11292	6136.2	1.84	0.78
Pod setting (%)	53.89	110.18	0.48	0.49

The variance ratio for number of branches per plant (0.96), flower size (3.02), days from bud initiation to flowering (1.25), number of flowers per plant (1.84) and $2\sigma^2g/(2\sigma^2g + \sigma^2s)$ ratio was 0.75, 0.85, 0.71 and 0.78 respectively confirmed the importance of additive gene action. The predominance of additive gene action was also reported by Gupta et al. (2001) in marigold. These traits with high magnitude of additive gene action can be easily improved through line selection which would favor the increased expression of the traits. The traits, *viz.*, plant height at first flowering, final plant height, plant spread, final plant spread, stalk length, days to flowering, duration of flowering and pod setting showed the higher magnitude of SCA component variance which indicated that non-additive gene action govern these traits. Similarly, predictability ratio was also found less than one for traits *viz.*, plant height at first flowering (0.28), final plant height (0.53), plant spread (0.63), final plant spread (0.56), stalk length (0.42), days to flowering (0.44), duration of flowering (0.52), and pod setting (0.49). It confirmed the predominant role of non-additive gene action in the expression of these traits. Hence, heterosis breeding would be the best option for improvement of these traits (Ravikumar & Dhatt 2023a).

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