Biological Forum – An International Journal 16(7): 135-140(2024)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Combining Ability Analysis in Pumpkin [*Cucurbita moschata* Duch. Ex Poir.] for Earliness and Yield Related Traits

Akshita Bisht[1], S.K. Maurya[2*], Lalit Bhatt[2], Dhirendra Singh[3] and Birendra Prasad[4]
[1]Ph.D. Scholar, Department of Vegetable Science,
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India.
[2]Senior Research Officer, Department of Vegetable Science,
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India.
[3]Professor, Department of Vegetable Science,
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India.
[4]Professor, Department of Genetics and Plant Breeding,
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India.

(Corresponding author: S.K. Maurya)*
(Received: 02 May 2024; Revised: 20 May 2024; Accepted: 13 June 2024; Published: 15 July 2024)
(Published by Research Trend)

ABSTRACT: Combining ability studies are more reliable because they clarify the nature and extent of different types of gene action involved in the expression of quantitative traits, and they offer valuable information for choosing parents based on how well the inbreds perform. A half diallel mating design was used to hybridize eight parental lines of pumpkin, producing 28 F_1 hybrids (excluding reciprocals). The generated F_1 hybrids, parental lines and commercial check (Narendra Agrim) were evaluated in the summer of 2023 at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, to investigate the combining ability for earliness, yield and yield attributed traits using a randomized complete block design with three replications. The ratio of genetic variance was less than unity, indicating that non-additive gene action predominated in all traits. The analysis revealed that none of the parents was found good general combiners for all the traits consistently, however for majority of the traits studied, PPU-2, PPU-5 and PPU-7 were identified as good general combiners. Also, the F_1 hybrids namely PPU-2 × PPU-5, PPU-5 × PPU-7, PPU-2 × PPU-6 and PPU-3 × PPU-6 were found to be the best cross combinations for the majority of the traits examined. It may be feasible to increase fruit yield and earliness even further through hybridization and selection in transgressive segregants.

Keywords: Combining ability, gene action, half diallel, pumpkin, fruit yield.

INTRODUCTION

An important cucurbitaceous plant that is cultivated commercially all over the world is *Cucurbita moschata* Duch Ex. Poir. It is regarded as one of the marvels of the vegetable world because of its peculiar and extravagant characteristics (Dhiman *et al*., 2009). Both immature and mature fruit stages of pumpkin are eaten as culinary vegetables (Kumar *et al*., 2018). It provides a valuable source of carotenoids & ascorbic acids that have a major role in nutrition in the form of pro-vitamin A and vitamin C as antioxidants (Norshazila *et al*., 2014). Pumpkin seeds are a great source of minerals, fiber and unsaturated fatty acids. The pulp can be used to extract pectin, a polysaccharide that is widely used in the food industry. Furthermore, recent research has revealed the existence of polysaccharides with biological activity, such as the ability to lower blood glucose and raise insulin serum levels, suggesting possible applications in the management of diabetes (Caili *et al*., 2006). As a result, pumpkin is becoming a more important vegetable in diets, but hybrid varieties with high yielding capacities and high beta carotene content have received comparatively less attention. Additionally, the limited number of excellent pumpkin varieties cannot meet the enormous market demand and hinders the advancement of *Cucurbita* breeding initiatives (Yunli *et al*., 2020).

Despite the crop's great variability, very little effort has been made to take advantage of it in breeding programs (Tamilselvi *et al*., 2015). Developing an appropriate breeding strategy for a crop requires a thorough understanding of the genetic behaviour of a character. The crop is suitable for commercial breeding due to its monoecious nature, noticeable and solitary flowers, numerous seeds per fruit, and broad variation in fruit size, shape, and yield (Pooja and Maurya 2022). Over the past years, a number of researchers have improved pumpkin yield by using heterosis breeding (Sirohi and Ghorui 1993). In cross-pollinated crops, heterosis has been shown to present good yield-improving potential (Kumar *et al*., 2018).

Analysis of combing ability is used to determine which better combiners can be hybridized to take advantage of heterosis and to choose superior crosses for immediate application or additional breeding efforts (Murtadha *et al*., 2018). The 'expected' value of any particular cross, according to Allard (1960), is the sum of the GCA's of its two parental lines, while SCA is the measure of the deviation from this expected value. Hence, GCA values characterize the parental form's overall utility with regard to the relevant attribute, while SCA highlights the significance of the combined action of the parental forms' genes (Baker, 1978). It is undesirable to have a significant amount of variability in the SCA effects of a particular trait in the starting material for breeding, as this raises the likelihood of producing hybrid progenies with an average value of that trait. The predicted improvement from SCA and GCA will be correlated with their respective variances (Griffing, 1956). To ascertain whether a quantitative trait's dominant gene actions are additive or non-additive, the mean square ratio for GCA and SCA is utilized. The performance of the progeny chosen using GCA values is higher when the ratio approaches unity (Baker, 1978).

Using the first-generation hybrids (F_1) without reciprocals, diallel cross analysis provides a rapid and thorough summary of the dominance relationships among the studied parent plants as well as the genetic parameters linked to combining ability (Kumar *et al*., 2023). Additional information is provided by diallel analysis when parents are involved, including the distribution of dominant and recessive genes within the parent plants, the average degree of dominance, and the existence or absence of epistasis (Zongo *et al*., 2019). Harshini *et al*. (2024) pointed out that the improved performance seen in F_1 hybrids with significant high SCA effects is mainly due to the predominance of non-additive gene effects. Hosen *et al*. (2022) noted a predominance of non-additive gene action on the inheritance for all the traits examined was indicated by the fruit yield and quality characteristics, indicating that heterosis breeding would be beneficial to achieve improvements in the genotypes of the pumpkin. Thus, estimating the general combining ability of parents and the specific combining ability of cross combinations was therefore crucial for determining the superiorities in parents as well as in hybrids. In order to improve the desired horticultural traits, the current study was conducted to gather data for the identification of good general and specific combiners.

MATERIAL AND METHODS

The experimental material comprised of eight parental lines *viz*., PPU-1, PPU-2, PPU-3, PPU-4, PPU-5, PPU-6, PPU-7 and PPU-8. All these parental lines were crossed in half diallel mating design (excluding reciprocals) during summer season 2022 and evaluated in next succeeding year, 2023. The 28 F_1 hybrids and their parents were evaluated in a randomized complete block design (RCBD) with 10 plants each in three replications at the Vegetable Research Centre, Department of Vegetable Science, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (India). In each row, seeds were sown keeping row-to-row and plant-to-plant spacing 300 cm × 60 cm, respectively. Observations were recorded from five random plants for days to anthesis of first female flower, days to first fruit harvest, average fruit weight, no. of fruits per plant, fruit yield per plant, number of primary branches per plant, vine length at harvest and root length.

Combining ability was calculated in accordance with Method II Model I of Griffing (1956). The data pertaining to combining ability was compiled and subjected using windostat 9.30 and XLstat 2022 for testing the significance of differences for general combing ability (GCA) and specific combining ability (SCA) among parents and F_1 hybrids, respectively.

RESULT AND DISCUSSION

Almost all of the characters in the study showed highly significant variances in their general and specific combining abilities. The results showed that the general and specific combining abilities of parents and crosses were significantly different. For every trait, the GCA/SCA variance ratio was less than unity which showed the predominance of non-additive gene action (Table 1). For the following characters *viz*., days to anthesis of first female flower (0.27), days to first fruit harvest (0.08), average fruit weight (0.12), no. of fruits per plant (0.16), fruit yield per plant (0.20), number of primary branches per plant (0.22), vine length at harvest (0.11) and root length (0.06) the ratio of GCA to SCA variance showed that the SCA variance was larger than the GCA variance suggesting that non-additive gene action predominates (Table 1). This suggested that heterosis breeding should be used and the restricted scope of population improvement for these characters could be used. In regards to these characters, Jha *et al*. (2009) ; Hosen *et al*. (2022) found similar outcomes in pumpkin.

Table 1: Analysis of variance for combining ability in pumpkin.

Source of variation/Parameters	GCA (General Combining Ability)	SCA (Specific Combining Ability	Error	GCA variance	SCA variance	GCA/SCA ratio
D.F.	7	28	70			
Days to anthesis of first female flower	37.98 **	14.81 **	1.59	3.63	13.21	0.27
Days to first fruit harvest	25.32 **	30.16 **	1.80	2.35	28.35	0.08
Average fruit weight (kg)	878.39 **	711.31 **	10.15	0.009	0.07	0.12
No. of fruits per plant	1.09 **	0.65 **	0.01	0.10	0.64	0.16
Fruit yield per plant (kg)	2.73 **	1.34 **	0.01	0.27	1.33	0.20
Number of primary branches per plant	1.00 **	0.45 **	0.00	0.10	0.45	0.22
Vine length (m) at harvest	3.24 **	2.88 **	0.01	0.32	2.86	0.11
Root length (m)	56.52 **	89.48 **	0.22	5.63	89.26	0.06

*, ** : Significant at 0.05 and 0.01 probability level, respectively

A. GCA estimates of parents

In the half diallel mating design system, estimates of the GCA effects that are positive or negative would suggest that a particular parental line is significantly better or worse than the average of the group involved. Table 2 lists the general combining ability (GCA) effects of the eight parental line for various traits.

When it comes to the number of days until the first female flower anthesis and the first fruit harvest, earliness is a key factor in favouring hybrids over pure line varieties. The GCA effect was found to have an impact on the number of days until the first female flower anthesis, ranging from –2.69 (PPU-1) to 2.29 (PPU-6). PPU-2 (-2.57), PPU-3 (-1.28) and PPU-5 (-0.57) were discovered to be highly significant negative general combiners, along with the other parents. Significantly negative GCA impacts were observed for the number of days until the first fruit harvest, ranging from -1.99 (PPU-2) to 2.84 (PPU-4). PPU-2 and PPU-5 displayed the earliest harvest times, with respective values of -1.99 and -1.62 respectively.

The number of fruits on each vine and the average fruit weight directly affect yield. The GCA impact varied from -0.11 (PPU-8) to 0.15 (PPU-2) for the average fruit weight. For this attribute, PPU-5 (0.08), PPU-7 (0.06), and PPU-3 (0.03) also exhibited a highly significant positive GCA effect, indicating their suitability as general combiners. The GCA value of the number of fruits per plant ranged from -0.43 (PPU-6) to 0.55 (PPU-5). PPU-2 (0.25) and PPU-8 (0.23), the other parental lines, have significant positive values for this trait.

Since high yield per vine is a major factor in farmers' decisions to accept or reject a variety or hybrid, also it is the ultimate goal of any breeding program. For yield per vine, the GCA impact ranged from -1.17 (PPU-3) to 2.08 (PPU-5). PPU-5 (2.08), PPU-2 (1.02), and PPU-7 (0.61) were the best general combiners for yield per vine because they had a large positive GCA effect.

The GCA value for the number of primary branches varied from -0.40 (PPU-3) to 0.45 (PPU-5). For this parameter, PPU-2 (0.27), PPU-4 (0.19), and PPU-8 (0.16) are the other best combiners. Vine length had highly significant GCA values ranging from -0.98 (PPU-6) to 0.70 (PPU-5). In a similar manner, the GCA for root length ranges from 2.77 (PPU-7) to -4.22 (PPU-8). With GCA values of 2.77 and 2.51, respectively, PPU-7 and PPU-6 were the best combiners (Table 2).

The combining ability effects were inconsistent for all the yield components, possibly due to negative associations among the characters, and the estimates of GCA effects showed that none of the parents exhibited good GCA for all the characters. As a result, it was challenging to choose good combiners for all the characters together (Solanki and Shah 1990). This demonstrates that genes from various sources would need to be combined in order to produce distinct desirable characters (Nehe *et al*., 2007). PPU-2, PPU-5, and PPU-7 were the three parental lines that performed best overall in terms of earliness and fruit yield out of the eight. An intermating population involving all possible crosses among themselves subjected to biparental mating in the early generation will be expected to offer the maximum promise in breeding for yield and earliness because these parents were superior for the majority of the traits (Mule *et al*., 2012). Similar results were observed by Pandey *et al*. (2010).

Table 2: Estimation of general combing ability effects (GCA).

Parents	Days to anthesis of first female flower	Days to first fruit harvest	Average fruit weight (kg)	No. of fruits per plant	Fruit yield per plant (kg)	Number of primary branches per plant	Vine length (m) at harvest	Root length (cm)
PPU-1	-2.69 **	-0.73	-0.09 **	-0.15 **	-0.61 **	-0.37 **	0.18 **	-2.59 **
PPU-2	-2.57 **	-1.99 **	0.15 **	0.25 **	1.02 **	0.27 **	0.02	0.007
PPU-3	-1.28 **	0.37	0.03 **	-0.31 **	-1.17 **	-0.40 **	0.23 **	0.11
PPU-4	0.92 **	2.84 **	-0.03 **	-0.01	-0.27 **	0.19 **	-0.71 **	0.69 **
PPU-5	-0.57	-1.62 **	0.08 **	0.55 **	2.08 **	0.45 **	0.70 **	0.71 **
PPU-6	2.29 **	1.10 **	-0.09 **	-0.43 **	-1.07 **	-0.21 **	-0.98 **	2.51 **
PPU-7	1.65 **	0.76	0.06 **	-0.13 **	0.61 **	-0.09 **	0.43 **	2.77 **
PPU-8	2.25 **	-0.75	-0.11 **	0.23 **	-0.58 **	0.16 **	0.10 **	-4.22 **
S.E. (gi)	0.37	0.39	0.009	0.02	0.05	0.02	0.03	0.13
S.E. (gi-gj)	0.56	0.60	0.01	0.04	0.08	0.03	0.05	0.21

*, ** : Significant at 0.05 and 0.01 probability level, respectively

B. SCA effect of crosses

The SCA effects indicate how non-additive gene action contributes to the characters' expression. It shows that some of the specific cross combinations perform best due to their highly specific combining ability. Good combiners and poor combiners can also result in crosses with high SCA effects. Table 3 lists the specific combining ability (SCA) effects of the twenty-eight crosses for various traits.

Six cross-combinations out of twenty-eight displayed significant negative SCA effects, and ten displayed significant positive estimates for the number of days until the first female flower anthesis. The PPU-2 × PPU-8 (-4.32), PPU-3 × PPU-4 (-4.19), PPU-2 × PPU-6 (-3.96), PPU-2 × PPU-5 (-3.62), PPU-1 × PPU-7 (-3.60) and PPU-3 × PPU-6 (-2.95) crosses showed the highest negative SCA estimate, respectively (Table 3). Ten cross combinations out of the 28 hybrids showed notable negative SCA effects for the number of days until the first fruit harvest. The cross-combinations PPU-5 × PPU-8 (-13.06), PPU-5 × PPU-7 (-8.19), PPU-4 × PPU-8 (-6.46), PPU-2 × PPU-5 (-5.06), PPU-2 × PPU-6 (-4.50) and PPU-1 × PPU-8 (-3.29) showed the highest negative SCA effects. The crosses for these two parameters were, respectively, good × good and poor × good combining parents. The findings aligned with the research carried out on pumpkin by Kumar *et al*.

(2018); Tamilselvi and Jansirani (2016); Harshini *et al*. (2024).

For the average fruit weight, eight crosses displayed positive significant values. PPU-2 × PPU-4 & PPU-2 × PPU-8 (0.37), PPU-6 × PPU-8 (0.34), PPU-2 × PPU-6 (0.28), PPU-7 × PPU-8 (0.27) and PPU-3 × PPU-6 (0.26) were the crosses that displayed positive estimates. The range of values for the SCA estimate for the number of fruits per plant was 1.61 (PPU-4 × PPU-8) to -1.19 (PPU-2 × PPU-6). For this character, eight crosses (PPU-4 × PPU-8 (1.61), PPU-2 × PPU-5 (1.48), PPU-1 × PPU-3 (1.38), PPU-6 × PPU-7 (1.27) and PPU-5 × PPU-7 (0.94) displayed positive significant values. Table 3 shows PPU-1 × PPU-4 (0.32), PPU-3 × PPU-6 (0.35), and PPU-2 × PPU-3 (0.38). Good × poor, poor × poor, and good × good general combiners were involved in the crosses for these two parameters, respectively. Similar results in pumpkin were reported by Nisha and Veeraragavathatham (2014) ; Kumar *et al*. (2018).

The fruit yield per vine SCA effect ranges from -0.59 (PPU-2 × PPU-3) to 1.34 (PPU-2 × PPU-5). Nine of the twenty-eight crosses had a positive, statistically significant yield value per vine. PPU-2 × PPU-5 (1.34), PPU-5 × PPU-7 (1.20), PPU-2 × PPU-6 (0.75), PPU-1 × PPU-3 (0.59), PPU-3 × PPU-8 (0.43), PPU-4 × PPU-6 (0.38), PPU-5 × PPU-8 (0.36), PPU-1 × PPU-4 (0.23) and PPU-3 × PPU-4 (0.18) are among the crosses that displayed positive estimates. Good × poor, poor × poor, and general combiners were involved in the crosses for these two parameters, respectively. Hosen *et al*. (2022); Hatwal *et al*. (2018) both reported similar findings in case of pumpkin.

Fifteen of the twenty-eight crosses had positive significant values for the number of primary branches according to SCA estimates. PPU-2 × PPU-7 (1.05), PPU-3 × PPU-6 (1.01), PPU-4 × PPU-5 (0.94), PPU-5 × PPU-8 (0.77) and PPU-1 × PPU-7 (0.76) are the best-performing crosses for this characteristic. Regarding vine length, the SCA estimates varied from -9.16 (PPU-1 × PPU-5) to 12.27 (PPU-2 × PPU-6). For vine length, eleven crosses (PPU-2 × PPU-6 12.27), PPU-5 × PPU-6 (8.93), PPU-5 × PPU-7 (8.62), PPU-1 × PPU-3 (8.19) and PPU-1 × PPU-4 (7.11) demonstrated a significant positive value. For root length, the SCA estimates varied from -13.12 (PPU-2 × PPU-4) to 18.14 (PPU-1 × PPU-2). For this parameter, 12 crosses namely PPU-1 × PPU-2 (18.12), PPU-6 × PPU-8 (13.65), PPU-2 × PPU-8 (7.94), PPU-1 × PPU-6 (7.20) and PPU-2 × PPU-5 (6.08) showed positive significant values. The general combiners good × poor, good × good and poor × poor are among the crosses for these parameters. Maurya *et al*. (2004); Pradeepika *et al*. (2017) have reported similar results in bottle gourd and pumpkin, respectively. They found that the majority of crosses exhibiting a significant SCA effect involved two or at least one good general combiner, indicating additive × dominance or additive × additive gene action.

Due to the monoecious nature of flowers, hybridization is possible in the crop, and this could be used to exploit non-additive gene effects, which could explain the higher SCA effect observed in the poor × poor general combiners cross. In a later generation, the cross involving poor × good general combiners can yield good transgressive segregants (Mule *et al*., 2012).

Table 3: Estimation of specific combing ability effects (SCA).

Parents	DFF	FFH	AFW	NFP	FYP	NPP	VL	RL
PPU-1 × PPU-2	3.51 **	0.17	-0.03 *	0.05	-0.42 **	-0.15	-5.27 **	18.14 **
PPU-1 × PPU-3	4.61 **	-2.96 *	-0.22 **	1.38 **	0.59 **	0.17 *	8.19 **	-1.79 **
PPU-1 × PPU-4	-1.48	-0.97	0.23 **	0.32 **	0.23 **	-0.72 **	7.11 **	3.92 **
PPU-1 × PPU-5	0.95	-2.26	0.14 **	-0.04	-0.29 **	-0.56 **	-9.16 **	-8.12 **
PPU-1 × PPU-6	-0.04	0.52	-0.11 **	0.12	-0.28 **	0.48 **	-8.40 **	7.20 **
PPU-1 × PPU-7	-3.60 **	7.90 **	0.17 **	-0.68 **	-0.08	0.76 **	-1.45	-2.55 **
PPU-1 × PPU-8	-2.08	-3.29 *	0.24 **	-0.08	-0.33 **	-0.34 **	-7.08 **	1.78 **
PPU-2 × PPU-3	2.74 *	0.2	-0.18 **	0.38 **	-0.59 **	0.08	-8.47 **	-10.54 **
PPU-2 × PPU-4	2.51 *	4.23 **	0.37 **	-0.63 **	-0.49 **	0.53 **	2.54 *	-13.12 **
PPU-2 × PPU-5	-3.62 **	-5.06 **	0.03 **	1.48 **	1.34 **	0.68 **	4.86 **	6.08 **
PPU-2 × PPU-6	-3.96 **	-4.50 **	0.28 **	-1.19 **	0.75 **	-0.33 **	12.27 **	-12.10 **
PPU-2 × PPU-7	-1.03	-2.78 *	-0.29 **	-0.50 **	-0.12 **	1.05 **	-3.81 **	-9.87 **
PPU-2 × PPU-8	-4.32 **	3.56 **	0.37 **	-1.16 **	-0.43 **	-1.15 **	-5.27 **	7.94 **
PPU-3 × PPU-4	-4.19 **	2.53 *	0.22 **	-0.32 **	0.18 **	0.40 **	-3.49 **	-11.25 **
PPU-3 × PPU-5	1.62	8.90 **	0.14 **	-0.30 **	-0.24 **	-0.64 **	-5.69 **	-0.35
PPU-3 × PPU-6	-2.95 *	-2.86 *	0.26 **	0.35 **	-0.27 **	1.01 **	-2.28	-3.24 **
PPU-3 × PPU-7	1.05	3.90 **	0.23 **	-0.58 **	-0.05	-0.64 **	6.85 **	3.64 **
PPU-3 × PPU-8	1.09	3.65 **	-0.43 **	-0.17	0.43 **	-0.88 **	-1.58	-11.95 **
PPU-4 × PPU-5	4.77 **	9.83 **	0.16 **	-0.25 **	-0.44 **	0.94 **	-0.24	-2.04 **
PPU-4 × PPU-6	6.72 **	-0.13	-0.34 **	0.11	0.38 **	-0.60 **	-1.71	1.14 *
PPU-4 × PPU-7	2.44 *	-2.78 *	-0.25 **	-0.82 **	-0.26 **	0.09	-4.67 **	-1.47 **
PPU-4 × PPU-8	-1.32	-6.46 **	-0.25 **	1.61 **	-0.03	0.17 *	-2.09	5.28 **
PPU-5 × PPU-6	2.89 *	5.10 **	0.10 **	-1.02 **	-0.12 **	0.59 **	8.93 **	5.48 **
PPU-5 × PPU-7	1.02	-8.19 **	0.11 **	0.94 **	1.20 **	-1.06 **	8.62 **	-2.33 **
PPU-5 × PPU-8	0.62	-13.06 **	0.08 **	-0.17	0.36 **	0.77 **	4.92 **	1.62 **
PPU-6 × PPU-7	6.43 **	-1.56	-0.22 **	1.27 **	-0.31 **	-0.53 **	-2.26	-8.25 **
PPU-6 × PPU-8	1.69	-1.23	0.34 **	0.13	-0.02	0.48 **	2.87 *	13.65 **
PPU-7 × PPU-8	5.15 **	5.70 **	0.27 **	-0.83 **	-0.52 **	0.16 *	2.56 *	-5.92 **
SE (gii)	0.99	1.06	0.02	0.07	0.15	0.06	0.09	0.37
SE (gij)	1.14	1.22	0.02	0.08	0.17	0.07	0.10	0.42

Note—DFF-Days to anthesis of first female flower, NFF-Node number of first female flower, FFH- First fruit harvest, AFW-Average fruit weight (kg), NFP- Number of fruits per plant, FYP- Fruit yield per vine (kg), NPP- Number of primary branches per plant, VL- Vine length (m), RL-Root length (cm), *Significant at 0.05% level of Probability, ** Significant at 0.01% level of Probability.

CONCLUSIONS

Following critical testing, the hybrids PPU-2 × PPU-5, PPU-5 × PPU-7, PPU-2 × PPU-6, and PPU-3 × PPU-6 could be effectively utilized at the commercial level. Furthermore, these heterotic hybrids' superior segregates would probably produce desirable progenies in the next generation. Based on the aforementioned results, it can be inferred that heterosis breeding would enhance the characteristics of early maturity and yield in pumpkins.

The inclusion of at least one good combining parent in the production of superior hybrids is indicated by the SCA effect of these three crosses. On the other hand, a previous fourth cross featured parents who were not very good at combining. This implies that the GCA effects of the parental lines involved are not always a prerequisite for any cross combination to have a high SCA effect. According to Patel and Desai (2008); Purohit *et al.* (2007), the superiority of SCA effects may be caused by complementary types of gene action or by non-allelic interactions of fixable and non-fixable genetic variance.

FUTURE SCOPE

From this investigation it is suggested that parental lines PPU-2, PPU-5 and PPU-7, can be selected as a parents in future breeding programmes due to high GCA effect in positive direction. The cross PPU-2 × PPU-5 showed significant positive SCA effect for most of the characters so this can be considered for further breeding programmes

Author contributions. Conceptualization of research (SKM, LB), Designing of the experiments (SKM, DS, LB); Contributed data or analysis tools (AB, DS, BP), Collected the data (AB), Performed the analysis (SKM, AB), Wrote the paper (AB).

Acknowledgement. I would like to express my gratitude to Dr. S.K. Maurya, my major advisor, and my advisory committee members for their guidance throughout my course of study. I am also deeply thankful to G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, (India) for providing all the necessary facilities and financially supporting my research. And I would also like to thank AICRP, Vegetable Science for providing labour and necessary facilities regarding research trial.

Conflict of Interest. None.

REFERENCES

Allard, R. W. (1960). Principles of plant breeding. John Wiley and Sons Inc, New York, USA. 485p.

Baker, R. J. (1978). Issues in diallel analysis. *Crop science*, *18*(4), 533-536.

Caili, F., Huan, S. and Quanhong, L. (2006). A review on pharmacological activities and utilization technologies of pumpkin. *Plant Food Human Nutrition*, *61*, 73–80.

Dhiman, A. K., Sharma, K. D. and Attri, S. (2009). Functional constituents and processing of pumpkin: A review. *Journal of Food Science and Technology, 46*(5), 411.

Griffing, B. R. U. C. E. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. *Australian Journal of Biological Sciences*, *9*(4), 463-493.

Harshini, M., Shanthi, A. and Manikandan, M. (2024). Combining Ability Analysis of Yield and Quality Traits in Pumpkin (*Cucurbita moschata* Duch. Ex Poir). *Journal of Experimental Agriculture International*, *46*(6), 286-292.

Hatwal, P. K., Yadav, V. S., Thakur, R. and Mahawar, A. K. (2018). Estimation of heterosis in relation to combining ability for earliness, yield and quality attributes in pumpkin (*Cucurbita moschata* Duch. ex Poir). *Indian Journal of Agricultural Research*, *52*, 548–553.

Hosen, M., Rafii, M. Y., Mazlan, N., Jusoh, M., Chowdhury, M. F. N., Yusuff, O., Ridzuan, R., Karim, K. M. R., Halidu, J. and Ikbal, M. F. (2022). Estimation of heterosis and combining ability for improving yield, sweetness, carotenoid and antioxidant qualities in pumpkin hybrids (*Cucurbita moschata* Duch. Ex Poir.). *Horticulturae*, *8*(10), 863.

Jha, A., Pandey, S., Rai, M., Yadav, D. S. and Singh, T. B. (2009). Heterosis in relation to combining ability for flowering behaviours and yield parameters in pumpkin (*Cucurbita moschata* Duch. ex. Poir). *Vegetable Science*, *36*(3), 332-335.

Kumar, R., Rajasree, V., Praneetha, S., Savithiri, S. R. N. and Jayalakshmi, K. (2018). Combining Ability Analysis in Pumpkin (Cucurbita moschata Duch. ex Poir.) for Small Size, Thick Flesh, High Yield and Beta Carotene Content. *Indian Journal of Pure & Applied Biosciences*, *6*(3), 729-734.

Kumar, V., Maurya, S. K., Singh, N. K., Singh, D., and Verma, A. (2023). Assessment of general and specific combining abilities for yield related traits in bitter gourd (*Momordica charantia* L.). *Biological Forum-An International Journal*, *15* (8a), 365-370.

Maurya, S. K., Ram, H. H. and Singh, D. K. (2004). Combining Ability Analysis in Bottle gourd. *Progressive Horticulture, 36*, 67-72.

Mule, P. N., Khandelwal, V., Lodam, V. A., Shinde, D. A., Patil, P. P. and Patil, A. B. (2012). Heterosis and combining ability in cucumber (*Cucumis sativus* L.). *Madras Agricultural Journal*, *99*(7-9), 420-423.

Murtadha, M. A., Ariyo, O. J. and Alghamdi, S. S. (2018). Analysis of combining ability over environments in diallel crosses of maize (*Zea mays*). *Journal of the Saudi Society of Agricultural Sciences*, *17*(1), 69-78.

Nehe, A. S., Banger, N. D. and Chavan, B. H. (2007). Combining Ability Study in cucumber (*Cucumis sativus* L.). *Journal of Maharashtra Agricultural Universities*, *32*, 340-342.

Nisha, S. K. and Veeraragavathatham, D. (2014). Heterosis and combining ability for fruit yield and its component traits in pumpkin (*Cucurbita moschata* Duch. ex. Poir). *Advances in Applied Science Research*, *6*(2), 158-162.

Norshazila, S., Irwandi, J., Othman, R. and Yumi Zuhanis, H. H. (2014). Carotenoid content in different locality of pumpkin (*Cucurbita moschata* Duch. ex Poir.) in Malaysia. *International Journal of Pharmacy and Pharmaceutical Sciences, 6*(3), 29-32.

Pandey, S., Jha, A., Kumar, S. and Rai, M. (2010). Genetics and heterosis of quality and yield of pumpkin. *Indian Journal of Horticulture*, *67*(3), 333-338.

Patel, S. R. and Desai, D. T. (2008). Heterosis and combining ability studies in sponge gourd [*Luffa cylindrica* (Roem) L.]. *Vegetable Science*, *35*, 199-200.

Pooja and Maurya, S. K. (2022). Assessment of genetic divergence in pumpkin (*Cucurbita moschata* L.). *Indian Journal of Agricultural Sciences*, *92* (6), 726-731.

Pradeepika, C., Gasti, V. D., Kumari, T. V., Evoor, S. C., Rathod, V. and Shabarish, R. P. (2017). Heterosis and combining ability analysis for productivity traits in pumpkin (*Cucurbita moschata* Duch. ex. Poir.). *Environment and Ecology*, *35*(1), 45-50.

Purohit, V. L., Mehta, D. R., Dhaduk, L. K. and Gajipara, N. N. (2007). Combining ability for fruit yield and its attributes in ridge gourd (*Luffa acutangula*, (Roxb.) L.). *Vegetable Science*, *34*, 84-85.

Sirohi, P. S. and Ghorui, S. (1993). Gene effects of certain quantitative characters in pumpkin. *Vegetable Science*, *20*(2), 158-162.

Solanki, S. S. and Shah, A. (1990). Line × Tester analysis of combining ability for yield and its components in cucumber (*Cucumis sativus* L.). *Progressive Horticulture*, *22*, 87- 91.

Tamilselvi, N. A., Jansirani, P. and Pugalendhi, L. (2015). Estimation of heterosis and combining ability for earliness and yield characters in pumpkin (*Cucurbita moschata* Duch. ex. Poir). *African Journal of Agricultural Research*, *10*(16), 1904-1912.

Tamilselvi, N. A. and Jansirani, P. (2016). Heterosis in pumpkin for earliness, yield and yield related characters. *International Journal of Vegetable Science*, *22*(2), 170-182.

Yunli, W., Yangyang, W. A. N. G., Wenlong, X., Chaojie, W., Chongshi, C. and Shuping, Q. (2020). Genetic diversity of pumpkin based on morphological and SSR markers. *Pakistan Journal of Botany*, *52*(2), 477-487.

Zongo, A., Konate, A. K., Koïta, K., Sawadogo, M., Sankara, P., Ntare, B. R. and Desmae, H. (2019). Diallel analysis of early leaf spot (*Cercospora arachidicola* Hori) disease resistance in groundnut. *Agronomy*, *9*(1), 15.

How to cite this article: Akshita Bisht, S.K. Maurya, Lalit Bhatt, Dhirendra Singh and Birendra Prasad (2024). Combining Ability Analysis in Pumpkin [*Cucurbita moschata* Duch. Ex Poir.] for Earliness and Yield Related Traits. *Biological Forum – An International Journal, 16*(7): 135-140.