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Unlocking the Genetic Potential of Chili Through Combining Ability Studies

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ABSTRACT Using a 6x6 diallel mating design that eliminates reciprocals, this study examines the genetic potential of six genotypes of chilies (Capsicum annuum). Evaluation of the types of gene action controlling important yield-related traits, such as fruit length, fruit width, fruit weight, number of seeds per fruit, number of fruits per plant, plant height, and yield per plant, as well as general and specific combining abilities (GCA and SCA) were the main objectives of the study. Significant variations were found between genotypes for every variable under investigation, according to analysis of variance, suggesting that there is a great deal of genetic diversity. Fruit length, width, weight, plant height, and yield were among the attributes for which GCA effects were substantial, indicating the additive nature of the gene effects. On the other hand, the number of seeds per fruit and the number of fruits per plant were mostly affected by SCA effects, indicating the significance of non-additive gene activity. P4 is a possible choice for breeding programs since it showed the strongest favorable GCA impacts for fruit weight and length among the parents. On the other hand, P3 showed lower suitability as seen by negative GCA impacts on plant height and yield. Promising hybrid combinations, such P1×P5 and P3×P6, were also found in the study. These combinations showed notable favorable SCA effects and might be used to increase yield. The results provide useful information for future breeding methods by highlighting the significance of both additive and non-additive gene activities in the development of yield attributes in chili.

Keywords: *Chili (Capsicum annuum); Combining Ability; Diallel Cross; General Combining Ability (GCA); Specific Combining Ability (SCA); Yield-Related Traits*

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INTRODUCTION Chili (Capsicum annuum L.) is a vital horticultural crop grown extensively across the world, prized for its culinary, nutritional, and medicinal values. As a member of the Solanaceae family, chili exhibits significant diversity in morphology, pungency, and adaptability, making it an essential component of various agricultural systems (Ahmed et al., 2023; Aiswarya, Vijeth, Sreelathakumary, & Kaushik, 2020; Datta & Jana, 2010). Globally, chili contributes significantly to both local and international economies, and its production is steadily increasing to meet the rising demand. However, challenges such as biotic and abiotic stresses, coupled with limited genetic potential in existing cultivars, constrain the yield and quality of chili. This highlights the urgent need for genetic improvement in this crop, focusing on traits that directly impact yield and fruit quality (Amit, Ahad, Kumar, & Thakur, 2014; Bendale, Palsuledesai, Bhave, Sawant, & Desai, 2006). The yield and quality of chili are influenced by several key agronomic traits, including fruit length, fruit width, fruit weight, number of seeds per fruit, number of fruits per plant, plant height, and overall yield per plant. Each of these traits plays a critical role in determining the marketability, consumer preference, and adaptability of chili cultivars to varying environmental conditions (Chakrabarty, Islam, Mian, & Ahamed, 2019; Chattar, Sharma, Kumari, & Rana, 2016).

Fruit length, fruit width, and fruit weight are directly linked to market preferences and consumer demand. Longer and broader fruits are often associated with higher commercial value, particularly in markets where chili is sold fresh. Fruit weight, a composite trait influenced by both length and width, is a key determinant of yield per plant. Improvements in these traits can significantly enhance the economic returns from chili cultivation (Do Rêgo, Do Rêgo, Finger, Cruz, & Casali, 2009; Farhad, Hasanuzzaman, Biswas, Azad, & Arifuzzaman, 2008). The number of seeds per fruit is another important trait, as it affects both the reproductive potential and the overall fruit quality. While high seed content can contribute to the propagation of the species, it can also negatively impact fruit weight and market acceptance. Hence, understanding the genetic control of seed number is essential for balancing yield and fruit quality (Hasanuzzaman, Hakim, Fersdous, Islam, & Rahman, 2012; Hegde, Pant, Thilak, & Punetha, 2019).

The number of fruits per plant is perhaps the most crucial yield component. It reflects the plant's reproductive efficiency and is influenced by both genetic factors and environmental conditions. Breeding for higher fruit set without compromising fruit size and quality is a primary goal in chili improvement programs. Plant height is an important agronomic trait that influences crop management practices, including planting density, harvesting methods, and susceptibility to lodging (Istiqlal, Syukur, & Wahyu, 2018; Jagadeesha & Wali, 2008). Tall plants may yield more fruit but are often prone to lodging under heavy fruit loads or adverse weather conditions. Conversely, shorter plants are easier to manage and harvest but may produce fewer fruits. Yield per plant integrates the effects of all the above traits and is the ultimate measure of a genotype's performance. It reflects the cumulative contribution of genetic and environmental factors to the overall productivity of the plant. Enhancing yield per plant while maintaining or improving fruit quality is the central objective of chili breeding programs (Jindal, Kaur, Dhaliwal, & Chawla, 2015; Jogi, Madalageri, Pujari, & Mallimar, 2015; Khan, Yousaf, Ahmed, Fatima, & Alam, 2024).

Genetic improvement in chili can be effectively achieved through hybridization, which leverages heterosis or hybrid vigor to enhance yield and other agronomic traits. Combining ability analysis is a powerful tool in plant breeding that helps identify parents with superior genetic potential for hybridization. General combining ability (GCA) represents additive gene effects, which are crucial for traits that can be fixed through selection, while specific combining ability (SCA) reflects non-additive gene effects, including dominance and epistasis, which are important for hybrid performance (Li et al., 2024; Nagaraju & Sreelathakumary, 2016; Padhar & Zaveri, 2010). A comprehensive understanding of both GCA and SCA is vital for selecting the best parental combinations and developing high-yielding hybrids. Diallel cross analysis is an effective method for assessing the genetic architecture of yield and its components in chili. This approach allows breeders to analyze the GCA and SCA effects of different genotypes, thereby identifying promising parents and hybrids. The identification of superior parental combinations based on their combining ability not only accelerates the breeding process but also ensures the development of cultivars with enhanced yield, fruit quality, and stress tolerance (Pandey, Srivastava, Singh, & Dutta, 2003; Pandiyaraj, 2017; Patil, Sawant, & Jadhav, 2018).

This study was undertaken to evaluate the combining ability of six diverse chili genotypes for key yield-related traits, using a 6×6 diallel mating design excluding reciprocals. The primary objectives were to assess the genetic variability among the genotypes, determine the GCA and SCA effects for yield parameters, and identify superior parent combinations for future breeding programs. The results of this study will contribute to the strategic selection of genotypes in chili breeding, facilitating the development of high-yielding, stress-tolerant cultivars with desirable fruit characteristics. The inclusion of these yield-related traits in the analysis is crucial for understanding the genetic mechanisms that control them and for guiding the selection of parent combinations that can enhance these traits in future breeding efforts (Prasath & Ponnuswami, 2008; Reddy, Kumar, & Salimath, 2008). With the global demand for chili increasing, particularly for high-quality, high-yielding cultivars, this research provides valuable insights into the genetic basis of these important agronomic traits. The findings are expected to have significant implications for the development of new chili varieties that meet both the production needs of farmers and the quality preferences of consumers.

MATERIAL AND METHODS

In this study, six chili genotypes underwent a diallel crossing scheme, excluding reciprocal crosses. These genotypes had been self-pollinated for over six generations. Parental seeds were initially sown in trays and later transplanted to the field under standard conditions. Crosses were executed in a 6×6 diallel pattern without reciprocals. Mature F_1 fruits were harvested, dried, and their seeds were stored for subsequent use. In the following growing season, seeds from the six parental lines and their 15 F_1 hybrids were sown in seedling trays. The seedling medium was a blend of 50% coconut coir, 25% ash, and 25% decomposed cow dung. Once the seedlings developed 4 to 5 leaves, they were transplanted to field plots. Raised beds, 1.5 meters wide, were prepared for transplanting, with plant spacing of 50 cm and row spacing of 70 cm, separated by 1.0-meter-wide beds serving as drains. The following fertilizers had been applied at different rates per hectare: urea, zinc oxide, cow dung, triple super phosphate (TSP), muriate of potash (MP), gypsum, and 200 kg, 300 kg, 200 kg, 110 kg, and 5 kg. During the last land preparation, the whole amount of cow dung, TSP, zinc oxide, gypsum, and one-third of the urea and MP were applied. The remaining urea and MP were applied in two equal amounts at 25 and 50 days after transplanting. Weeding took performed every twenty days, and irrigation was given as needed. For data collection, ten randomly selected plants were taken from each plot (replication) including the parents and F1 hybrids. Fruit length, breadth, weight, number of seeds per fruit, number of fruits per plant, height of plant, and yield per plant were all recorded. For analysis, technique 2 (parents and one set of F1s, eliminating reciprocals) and model 1 (fixed effects model) were used to examine the diallel crosses' combining capacity (Griffing, 1956).

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) revealed significant differences among the genotypes for all traits studied, indicating substantial genetic variability ($p < 0.01$). The mean square values for genotype were significantly higher than the error variance for all traits, confirming the presence of genetic diversity among the chili genotypes. The genotypes exhibited a highly significant variation ($p < 0.01$) in fruit length, with a mean square value of 3.01, while the coefficient of variation (CV) was 4.55%. Significant differences ($p < 0.01$) were also observed for fruit width, with a mean square value of 1.92 and a CV of 7.55%. Fruit weight showed significant variation among genotypes ($p < 0.01$) with a mean square value of 2.71 and a CV of 7.7%. A highly significant difference ($p < 0.01$) was noted in the number of seeds per fruit, with a mean square value of 513.87 and a CV of 8.35%. The number of fruits per plant displayed significant variation ($p < 0.01$) with a mean square value of 11,195.3 and a CV of 6.02%. The genotypes differed significantly ($p < 0.01$) for plant height, reflected by a mean square value of 217.80 and a CV of 6.45%. Significant genetic variability was also observed for yield per plant ($p < 0.01$), with a mean square value of 136,950 and a CV of 7.7%.

The high genetic variability for yield per plant and the number of fruits per plant highlights the potential for selecting superior genotypes with enhanced yield traits. The significant variation in fruit length, width, and weight among genotypes reflects the influence of genetic factors on these traits, making them promising candidates for selection in breeding programs targeting fruit size improvement. Similarly, the number of seeds per fruit showed a high level of variation, indicating the possibility of enhancing seed production through selective breeding (Saeed et al., 2024; Saritha, Kulkarni, Rao, & Manjunath, 2005; Shirshat, Giritammannavar, & Patil, 2007). The substantial variation in yield per plant, combined with other traits, suggests that these genotypes have the potential to contribute to future breeding efforts focused on yield enhancement and overall plant performance.

The analysis of variance (ANOVA) for combining ability in different yield parameters of chili (Capsicum annuum) revealed significant differences for both general combining ability (GCA) and specific combining ability (SCA) across most traits. Highly significant effects were observed for GCA (7.91) and SCA (0.88), with GCA contributing more to variation in Fruit Length. In Fruit Width (FWD), Significant effects were noted for GCA (3.97), while SCA was not significant (0.53). Both GCA (4.94) and SCA (1.15) showed significant variation, with GCA contributing a larger proportion for Fruit Weight. For the traits Number of Seeds per Fruit (NSF), GCA and SCA both showed highly significant effects, with mean squares of 308.56 and 546.17, respectively. Number of Fruits per Plant (NFP) traits showed both GCA (10,018.34) and SCA (12,125.87) showed significant effects, with SCA contributing slightly more to variation. GCA (478.33) and SCA (79.12) both exhibited significant effects, with GCA showing a stronger impact in Plant height. The Traits Yield per Plant (YP) showed Highly significant effects were detected for both GCA (74,893.41) and SCA (164,834.25), with SCA accounting for a larger share of the variation. The ratio of additive (σ^2g) to dominance (σ^2s) variance was less than 1 for all traits except fruit width, indicating a predominance of dominance gene action in most traits. The significant GCA and SCA effects observed across various yield parameters indicate that both additive and non-additive genetic variances play important roles in the inheritance of these traits. The high GCA variance for fruit length, fruit weight, plant height, and yield per plant suggests that additive gene action is more influential for these traits, making them amenable to selection in early generations (Jagadeesha & Wali, 2008; Pandey et al., 2003).

In contrast, the higher SCA variance for traits such as the number of seeds per fruit and the number of fruits per plant suggests a greater influence of non-additive gene action, which could be exploited through hybrid breeding strategies. The dominance of SCA variance for yield per plant indicates that this trait is largely governed by dominance effects, which highlights the potential for heterosis or hybrid vigor in breeding programs targeting yield improvement. The ratio of σ^2g/σ^2s further supports the predominance of dominance gene action, as evidenced by values less than 1 for most traits. This suggests that selection strategies focusing on specific combining ability and hybridization might be more effective for improving these traits (Singh et al., 2015; Thilak, Pant, Veena, & Paliwal, 2019; Zeng et al., 2024). However, the presence of significant GCA effects also indicates that certain genotypes could serve as good general combiners, contributing positively to the improvement of yield and related traits.

The mean performance of the six chili parents for various yield parameters showed considerable variation across the different traits: Parent P4 had the longest fruit length (9.29 cm), followed by P5 (7.47 cm) and P2 (7.12 cm). The shortest fruit length was observed in P1 (5.54 cm). P4 also exhibited the highest fruit width (11.34 mm), while P5 had the lowest (7.42 mm). P4 recorded the highest fruit weight (5.89 g), whereas P5 had the lowest (1.75 g). P4 had the most seeds per fruit (88.74), followed by P1 (81.22). P3 had the fewest seeds (41.21). The highest number of fruits per plant was observed in P5 (180.34), with P4 having the lowest (75.28). The tallest plants were observed in P1 (71.87 cm), while P3 had the shortest plants (35.28 cm). P6 exhibited the highest yield per plant (372.98 g), followed by P5 (314.02 g). P1 had the lowest yield (190.12 g).

The results reveal significant variability in yield-related traits among the six chili parents, underscoring the diverse genetic background of these genotypes. Parent P4, which had the highest fruit length, width, and weight, is a standout candidate for improving fruit size and overall yield. However, despite having the highest values for these traits, P4 did not exhibit the highest yield per plant, indicating that yield is influenced by a combination of factors, including the number of fruits per plant (Chakrabarty et al., 2019; Do Rêgo et al., 2009).

Parents P5 and P6, with the highest number of fruits per plant, also showed high yield per plant, highlighting the importance of fruit number in overall yield. Interestingly, although P1 had the tallest plants, it produced the lowest yield, suggesting that plant height alone is not a reliable indicator of productivity. The variation in the number of seeds per fruit also indicates potential for selection. P4, with the highest number of seeds, could be advantageous in breeding programs focused on increasing seed production (Hasanuzzaman et al., 2012; Nagaraju

& Sreelathakumary, 2016). However, P3, despite its low seed count, had a respectable yield, suggesting that seed number per fruit does not directly correlate with yield in this case. Overall, the diverse performance of these parents across different traits suggests that combining the favorable traits from multiple parents could lead to the development of superior hybrid varieties. Parents P4 and P6, in particular, show promise for contributing positively to fruit size, weight, and overall yield in future breeding programs (Reddy et al., 2008; Shirshat et al., 2007).

***Figure 1**: Mean performance studied traits of the six different chilli parents. The inner ring showed the fruit length and continue to last ring showed the yield per plant. The sequence of the traits FL=Fruit Length, FWD=Fruit Width, FWT=Fruit Weight, NSF=Number of Seeds per Fruit, NFP=Number of Fruits per Plant, PH=Plant Height, YP=Yield per Plant. Different colors showed the different parent for respective traits.*

The general combining ability (GCA) effects for the six chili parents revealed significant positive and negative contributions to various yield-related traits: Parent P4 exhibited the highest positive GCA effect (1.05 cm), indicating its strong contribution to increasing fruit length. In contrast, P1 (-0.60 cm) and P3 (-0.51 cm) showed significant negative GCA effects. P4 again had the highest positive GCA effect (0.66 mm), while P5 (-0.52 mm) and P1 (-0.37 mm) showed negative effects for Fruit Width. P4 also contributed positively to fruit weight (0.88 g), whereas P1 (-0.48 g) and P5 (-0.29 g) had significant negative effects. P1 showed a significant positive GCA effect (6.43 seeds), while P4 (-3.35 seeds) and P3 (-2.92 seeds) had significant negative effects in Number of Seeds per Fruit. P6 had the highest positive GCA effect (18.59 fruits), followed by P3 (11.04 fruits) and P2 (10.92 fruits), while P4 had a significant negative effect (-41.09 fruits) for Number of Fruits per Plant. P1 exhibited the highest positive GCA effect (5.29 cm), while P3 (-7.54 cm) and P4 (-2.59 cm) had significant negative effects for the plant height trait. P3 had the highest positive GCA effect (77.03 g), indicating its strong potential for improving yield per plant, on the other hand, P1 (-57.81 g), P5 (-49.73 g), and P4 (-46.17 g) showed significant negative effects.

The significant GCA effects observed among the parents highlight their potential contributions to various yield-related traits, which is crucial for selecting parents in breeding programs. Parent P4 stands out with strong positive GCA effects for fruit length, width, and weight, making it a valuable parent for improving fruit size. However, its negative GCA effects for the number of fruits per plant and yield per plant suggest that while P4 is effective in enhancing fruit size, it may reduce overall yield if used in hybridization without careful selection of complementary parents (Aiswarya et al., 2020; Li et al., 2024).

Conversely, P3 and P6 demonstrated significant positive GCA effects for yield per plant, with P3 also showing positive effects for the number of fruits per plant. This suggests that these parents are strong general combiners for yield improvement. The negative GCA effects for plant height in P3 indicate that it contributes to shorter plants, which might be advantageous in certain breeding contexts where reduced plant height is desired. P1, despite showing positive GCA effects for the number of seeds per fruit and plant height, had negative effects on yield per plant, indicating that it might not be the best choice for yield improvement (Jagadeesha & Wali, 2008; Patil et al., 2018; Reddy et al., 2008). Similarly, P5, with negative GCA effects for fruit length, width, and weight, may not contribute favorably to these traits. Overall, P3 and P6 emerge as promising parents for improving yield per plant, while P4 could be utilized to enhance fruit size. The combination of these parents in a breeding program could lead to hybrids that maximize yield potential while maintaining desirable fruit characteristics (Datta & Jana, 2010; Jindal et al., 2015; Prasath & Ponnuswami, 2008).

The specific combining ability (SCA) effects for the chili crosses revealed both positive and negative contributions to various yield-related traits: The cross P1×P5 showed the highest positive SCA effect (1.18 cm), while P4×P5 had the most negative effect (-0.61 cm) in Fruit Length. The cross P5×P6 exhibited the highest positive SCA effect (1.34 mm), whereas P4×P6 had the most negative effect (-0.8 mm) in the trait for Fruit Width. The Cross P5×P6 had the highest positive SCA effect (1.54 g), while P1×P4 exhibited the most negative effect (-1.11 g) in Fruit Weight. The highest positive SCA effect was observed in P3×P6 (30.42 seeds), while P4×P6 had the most negative effect (-58.71 seeds) for Number of Seeds per Fruit. The cross P3×P6 recorded the highest positive SCA effect (195.31 fruits), while P3×P5 showed the most negative effect (-74.68 fruits) in Number of Fruits per Plant. The cross combination P2×P4 had the highest positive SCA effect (7.72 cm), while P1×P4 had the most negative effect (-10.35 cm) in Plant height. The Cross P3×P6 exhibited the highest positive SCA effect (706.88 g), whereas P3×P5 had the most negative effect (-308.96 g) in yield per plant.

The SCA effects observed among the chili crosses indicate the presence of non-additive gene action, which plays a crucial role in heterosis or hybrid vigor. Notably, the cross P3×P6 consistently showed high positive SCA effects across multiple traits, including number of seeds per fruit, number of fruits per plant, and yield per plant (Pandiyaraj, 2017; Shirshat et al., 2007; Singh et al., 2015). This suggests that P3×P6 could be a promising hybrid combination for achieving superior yield. The cross P5×P6, which demonstrated the highest positive SCA effects for fruit width, fruit weight, and yield per plant, indicates that it could be another strong candidate for developing high-yielding hybrids with desirable fruit characteristics. Meanwhile, P1×P5 and P3×P4 also displayed positive SCA effects for fruit length and fruit number, respectively, making them potentially valuable combinations for improving these traits. The current results suggest that specific crosses such as P3×P6 and P5×P6 hold significant potential for enhancing key yield parameters in chili breeding programs. The identification of these crosses with favorable SCA effects provides a strategic foundation for the development of high-yielding chili hybrids with improved agronomic traits (Chattar et al., 2016; Thilak et al., 2019).

Table 1. Analysis of variance for different yield parameters of Parents and F_1 in chili (*Capsicum annuum*)

Sources of Variation	df	FL	FWD	FWT	NSF	NFP	PH	YP
Genotype	20	3.01**	1.92**	2.71**	513.87**	11195.3**	217.80**	136950**
Replication	2	0.05	1.39	0.1	16.47	97.92*	6.468	2471.1
Error	40	0.14	0.57	0.07	30.58	98.1	13.92	1383.75
Total	62	1.19	1.07	0.95	185.15	3688.47	78.98	45188.4
CV		4.55	7.55	7.7	8.35	6.02	6.45	7.7

Table 2. Analysis of variance for combining ability of different yield parameters of chilli in F_1 Generation

SoV	df	FL	FWD	FWT	NSF	NFP	PH	YP
GCA	5	7.91**	3.97**	4.94**	308.56**	10018.34**	478.33**	74893.41**
SCA	15	0.88**	0.53	1.15**	546.17**	12125.87**	79.12**	164834.25**
Error	40	0.06	0.18	0.04	9.83	32.75	4.52	463.87
σ^2A	0	1.28	0.62	0.8	50.38	1669.51	78.23	12395.48
σ^2D	0	0.89	0.37	1.08	536.92	12078.53	74.57	164375.12
σ^2g	0	0.63	0.3	0.43	24.75	836.21	39.76	6214.09
σ^2s	0	0.89	0.37	1.08	536.92	12078.53	74.57	164375.12
σ^2g/σ^2s	0	0.77	0.88	0.36	0.06	0.08	0.54	0.05

FL=Fruit Length, FWD=Fruit Width, FWT=Fruit Weight, NSF=Number of Seeds per Fruit, NFP=Number of Fruits per Plant, PH=Plant Height, YP=Yield per Plant, GCA=general combining ability, SCA= Specific combining ability, σ^2A= additive variances, σ^2D=dominance variances, σ^2g= variances due to GCA effects, σ^2s= variances due to GCA effects, σ^2g/σ^2s= ration of additive/dominance types of gene action

Table 3: GCA effects for different yield parameters of the six different chilli parents

Parent	FL	FWD	FWT	NSF	NFP	PH	YP
P1	-0.60**	-0.37*	-0.48**	6.43**	4.61*	5.29**	-57.81**
P2	-0.13	0.11	0.09	-1.02	10.92**	4.31**	52.91**
P3	-0.51**	0.12	0.08	-2.92**	11.04**	-7.54**	77.03**
P4	1.05**	0.66**	0.88**	-3.35**	-41.09**	-2.59**	-46.17**
P5	0.35**	-0.52**	-0.29**	-1.5	-4.18*	-0.82	-49.73**
P6	-0.20*	-0.07	-0.27**	2.45*	18.59**	1.33	24.76**
S.E. (gi)	0.069	0.13	0.06	1.08	1.92	0.74	7.42

Table 4: Estimate of SCA effects for different yield parameters of chilli crosses

Cross	FL	FWD	FWT	NSF	NFP	PH	YP
P1×P2	-0.05	0.13	0.34**	-11.15**	-62.50**	-2.61	-130.13**
P1×P3	0.09	0.22	0.72**	7.23**	16.41**	3.75*	148.87**
P1×P4	-0.36*	0.29	-1.11**	-4.19	14.91**	-10.35**	-77.28**
P1×P5	1.18**	-0.07	0.35**	-2.58	43.01**	4.24*	171.35**
P1×P6	0.55*	0.09	0.35	8.61	144.17**	-0.41	338.53**

P2×P3	-0.1	-0.17	-0.06	3.21	65.42**	5.13**	172.03**
P2×P4	0.08	-0.23	0.37**	6.23*	21.55**	7.72**	205.17**
P2×5	0.69**	-0.12	0.14	4.1	55.46**	-4.75*	195.02**
P2×P6	-0.24	-0.13	0.23	-1.75	38.21**	-0.42	202.83**
P3×P4	0.65**	-0.34	0.02	3.54	34.48**	1.98	165.52**
P3×P5	-0.56**	0.5	-0.58**	-5.03	-74.68**	-0.33	-308.96**
P3×P6	0.02	0.19	0.45*	30.42**	195.31**	5.76	706.88**
P4×P5	-0.61**	0.36	0.21*	-4.71	-19.94**	3.2	-12.42
P4×P6	0.55*	-0.8	-1.64**	-58.71**	-8.75	-3.22	34.29
P5×P6	0.73**	1.34*	1.54**	19.79**	-23.73**	6.05*	194.83**

FL=Fruit Length, FWD=Fruit Width, FWT=Fruit Weight, NSF=Number of Seeds per Fruit, NFP=Number of Fruits per Plant, PH=Plant Height, YP=Yield per Plant

CONCLUSION

The study successfully elucidated the genetic basis of key yield-related traits in chili (Capsicum annuum) through a comprehensive analysis of combining ability. Significant GCA effects observed in traits like fruit length, fruit width, fruit weight, and yield per plant underscore the crucial role of additive gene action in trait inheritance. In contrast, SCA effects dominated traits like the number of seeds per fruit and number of fruits per plant, emphasizing the contribution of non-additive gene action. The identification of P4 as a superior parent due to its positive GCA effects and the discovery of promising hybrids such as P1×P5 and P3×P6 highlight potential avenues for breeding high-yielding chili varieties. The study's findings offer a robust foundation for future breeding programs aimed at enhancing the genetic potential of chili, leveraging both additive and non-additive gene actions to achieve yield improvements.

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