AATCC Review

20 November 2024: Received
05 February 2025: Revised
03 March 2025: Accepted
06 March 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Principal Component Analysis of Chilli (*Capsicum annum* L.) Genotypes for Quality Traits under Temperate Condition of Kashmir Valley

Majid Rashid, Khursheed Hussain, Ajaz Ahmad Malik, Gowhar Ali, Syed Mazahir Hussain, Ishfaq Ayoub,Ghulam Jeelani, Tajamul Hussain, Tanveer Ahmad, Insha Javaid, Zeenat Fayaz and Javeid Ahmad Dar*

Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar Jammu and Kashmir, India

ABSTRACT

The PCA of the chilli parents and crosses revealed that the five traits have been loaded on first two and three components accounting for about 78.92% and 72.48% variance in chilli parents and crosses respectively. The Eigen values ranged from 2.60 for first PC to 1.34 for second PC for chilli parents and 1.49 for first PC to 1.03 for third PC for the chilli crosses. Concerning chilli parents the first two principal components with eigen values greater than 1 were found to contribute 52.10% and 26.82% of variance respectively, explaining a cumulative variation of 72.98% andin case of the chilli crosses the first three principal components with eigen values greater than 1 were found to contribute 29.92%, 21.91% and 20.65% of variance respectively, explaining a cumulative variation of 72.48%. The results of the principal component analysis employed in the study have demonstrated the high degree of genetic variation and the traits contributing to the variance, therefore this population panel can be used for trait development in breeding programs for the traits contributing to major variation.

Keywords: *Chilli, CrossesPCA, Quality, Variance.*

Introduction

Chilli is a popular tropical and subtropical vegetable cum spice crop. It is native to Tropical America and the West Indies, and the Portuguese brought it to India in the 17th century. Since then, it has become a common condiment and vegetable all throughout the world, including India. Due to its position as both a vegetable and a spice, its production and consumption have steadily increased over the twentieth century, and it has become an essential component of a broad range of cuisines.The name capsicum is derived from Greek word 'kapto' meaning "to bite" or "to swallow. It is cultivated for its two important commercial qualities viz., pungency and red colour. Some cultivars are renowned for biting pungency attributed to crystalline acrid volatile alkaloid capsaicin ($C_{18}H_{27}NO_3$) others are famous for red colour because of the pigment capsanthin ($C_{40}H_{56}O_3$). Kashmir has been known for its dark red coloured chillies. Kashmiri Red Chilies or Kashmiri Laal Mirch are characterized by their ability to give a dark red colour to food, capable of colouring and adding flavour, while at the same time not allowing the food to become too pungent or spicy. It also possesses important health benefits due to their antioxidant and anti-inflammatory properties because of the presence of various bioactive molecules like volatile oils, fatty acids, carotenoids and capsaicinoids [1]. The present investigation was carried out to identify the best genotypes concerning various quality traits, particularly for capsanthin content as there is a huge demand for dark red colour chillies, particularly of Kashmiri origin with mild pungency in national and international markets. Dark red colour chillies are widely used in broad range of cuisines for imparting colour and flavour to the foods.

*Corresponding Author: ***Javeid Ahmad Dar***

DOI: https://doi.org/10.21276/AATCCReview.2025.13.01.574

Materials and Methods

The experimental material for present study consisted of ten diverse genotypes of chilli (*Capsicum annuum* L.) maintained by Division of Vegetable Science, SKUAST-Kashmir, Shalimar. 45 F_1 crosses were generated through 10 x 10 diallel mating design (Model-I and Method-II) at Vegetable Experimental Field, Division of Vegetable Science, SKUAST- Kashmir shalimar during *kharief* 2022. A set of 55 genotypes *viz.,* crosses (45) along with their parents(10) were evaluated in Randomized Block Design at Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar, during *kharief* 2022. The row -to-row and plant to plant spacing was maintained at 60 x 45 cm. Recommended package of practices were adopted to raise a healthy crop. The observations were recorded for dry matter content (%), Ascorbic acid (vitamin C)content (mg $100g^{-1}$) by titration method, Capsaicin content (mg g^{-1}) by colourimetric method, Capsanthin (ASTA) Units and Total phenols (mg100 g^{-1}) by Spectrophotometric method.The PCA was carried out in R-software.

Results and Discussion

Principal component analysis is a statistical procedure which is used for reducing the dimension of presentation without losing much information of the original data. The original large data set, which involves many variables can be interpreted in just few variables called the principal components. The criteria followed for selecting the principal components to be included in further analysis was based on Eigen values of principal components. The fact that Eigen values are above unity indicates that the evaluated principal component weight is reliable [2].

The PCA used to eliminate the redundancy in the data set revealed that the five traits have been loaded on first two components accounting for about 78.92% variance in chilli parents under study (Table 1). The Eigen values ranged from 2.60 for first PC to 1.34 for second PC. The first two principal components with eigen values greater than 1 were found to contribute 52.10% and 26.82% of variance respectively, explaining a cumulative variation of 72.98%. From PC1, total phenols followed by dry matter; from PC2 capsaicin followed by capsanthin showed maximum trait contribution meaning that these traits were most important.

The PCA of chilli crosses revealed that the five traits have been loaded on first three components accounting for about 72.48% variance in chilli crosses under study (Table 2). The Eigen values ranged from 1.49 for first PC to 1.03 for third PC. The first three principal components with eigen values greater than 1 were found to contribute 29.92%, 21.91% and 20.65% of variance respectively, explaining a cumulative variation of 72.48%. From PC1, vitamin-C followed by dry matter; from PC2 total phenols followed by capsanthin; from PC3 capsanthin followed by vitamin-C showed maximum trait contribution meaning that these traits were most important.

Among parentsSKAU-331, SKAU-353, SKAU-323, SKAU-316, SKAU-398, SKAU-340,SKAU-395 and SKAU-383 showed maximum positive contribution towards quality traits (Fig. 2). For component 1 we have to see contribution based on colour i,e red colour is related to positive contribution and blue colour is related to negative contribution. In our study, all crosses showed positive contribution except, SKAU-316 X SKAU-398, SKAU-323 X SKAU-362, SKAU-331 X SKAU-374, SKAU340- X SKAU-383, SKAU-340 X SKAU-398, SKAU-353 X SKAU-362, SKAU-353 X SKAU-383, SKAU-362 X SKAU-395, SKAU-383 X SKAU-395, SKAU-383 X SKAU-398 and SKAU-395 X SKAU-398 crosses showed negative contribution (Fig.4).This method has been used by many workers in elucidating genotypic differentiations in gene bank collections [3], [4], [5], [6].The results of the present investigation are supported by the findings of [7].

Conclusion

Principal component analysis has identified few characters that plays prominent role in classifying the variation existing in the germplasm set. The first two principal components accounted for 78.92 % to the total variation in parents and the first three components accounted for 72.48% to the total variation in crosses. Principal component analysis reflects the importance of largest contributor in each principal component. The first PC accounted for the maximum variability in the data i.e., 52.10% followed by second PC 26.82% in chilli parents and in case of crosses the first PC account for 29.92% variability. The analysis of the parentsidentified that from PC1, total phenols followed by dry matter; from PC2 capsaicin followed by capsanthin showed maximum trait contribution meaning that these traits were most important traits while in case of crosses from PC1, vitamin-C followed by dry matter; from PC2 total phenols followed by capsanthin; from PC3 capsanthin followed by vitamin-C showed maximum trait contribution meaning that these traits were most important traits. Thus, the PCA results revealed significant genetic variation among the genotypes, with specific traits contributing to this variation. This population panel can thus be effectively utilized in breeding programs to improve traits with major variations.

Acknowledgement

It is a great pleasure for me to express my deep sense of gratitude and indebtedness to my noble, able and sincere Advisor, Dr. Khursheed Associate Professor, FOH Division of Vegetable Science, SKUAST-Kashmir who guided me with his perfect knowledge and experience, which paved the way for me in the completion of this task.

Table 1: Eigen values obtained from PCA for quality traits of parents in chilli(Capsicum annuumL.)

Principle components	Eigen value	Percentage of variance	Cumulative percentage of variance
PC 1	2.60	52.10	52.10
PC 2	1.34	26.82	78.92

Table 1.1: Contribution of quality traits of parents towards each PC's in chilli (Capsicum annuum L.)

Characters	PC 1	PC 2
Dry matter	0.52	0.14
Vitamin-C	-0.51	-0.15
Capsanthin	0.37	0.54
Total Phenols	0.55	0.23
Capsaicin	-0.10	0.77

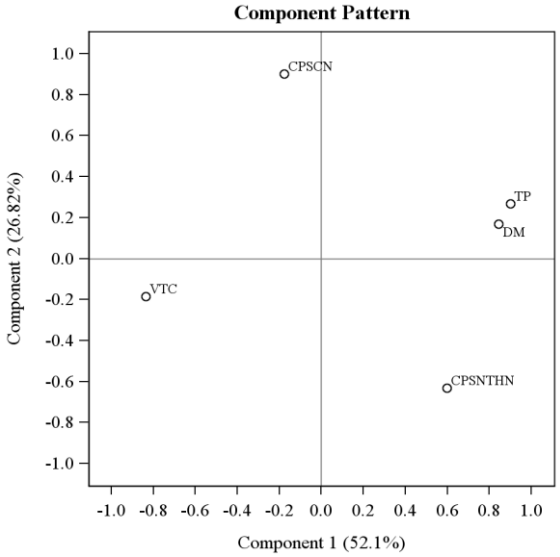


Fig. 1: Relationship among five quality characters of Chilli parents. DM; dry matter, VTC; Vitamin-C, CPSNTHN; Capsanthin, TP; Total Phenols, CPSCN; Capsaicin

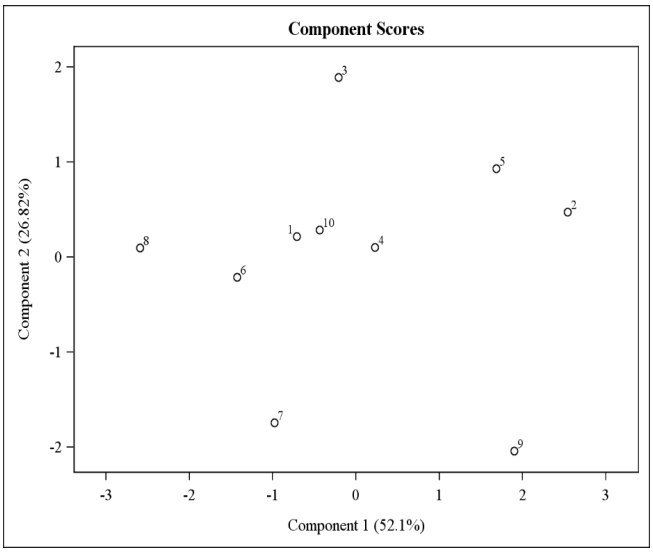


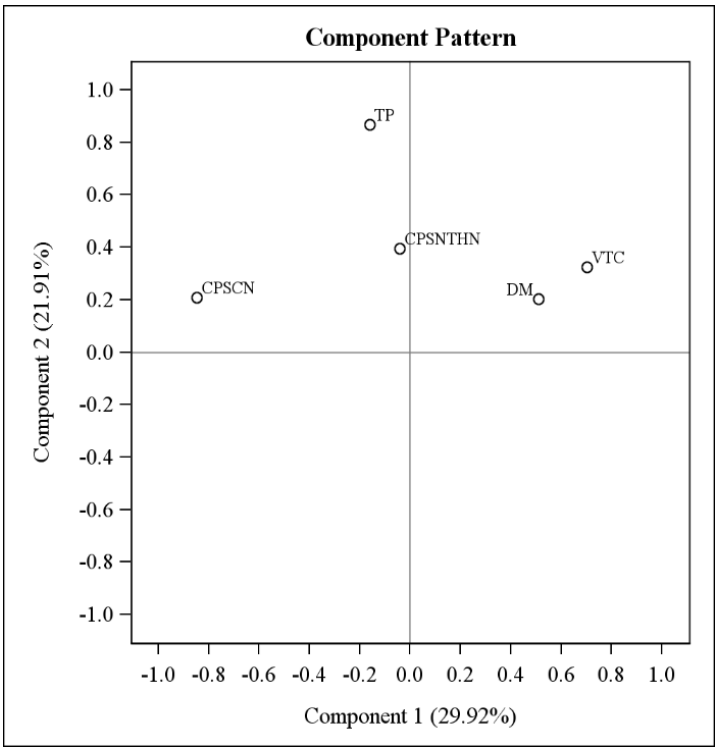
Fig. 2: Distribution of various parents among two PCs explaining trait combinations
1; SKAU-316, 2; SKAU- 323, 3; SKAU-331, 4; SKAU-340, 5; SKAU-353, 6; SKAU-362, 7; SKAU-374, 8; SKAU-383, 9; SKAU-395, 10; SKAU-398,

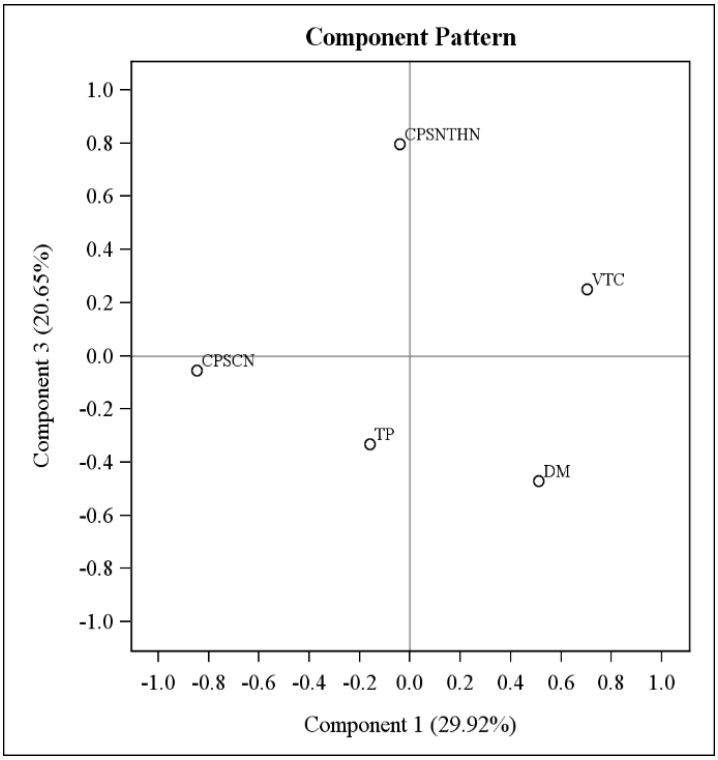
Table 2: Eigen values obtained from PCA for quality traits of crosses in chilli(Capsicum annuumL.)

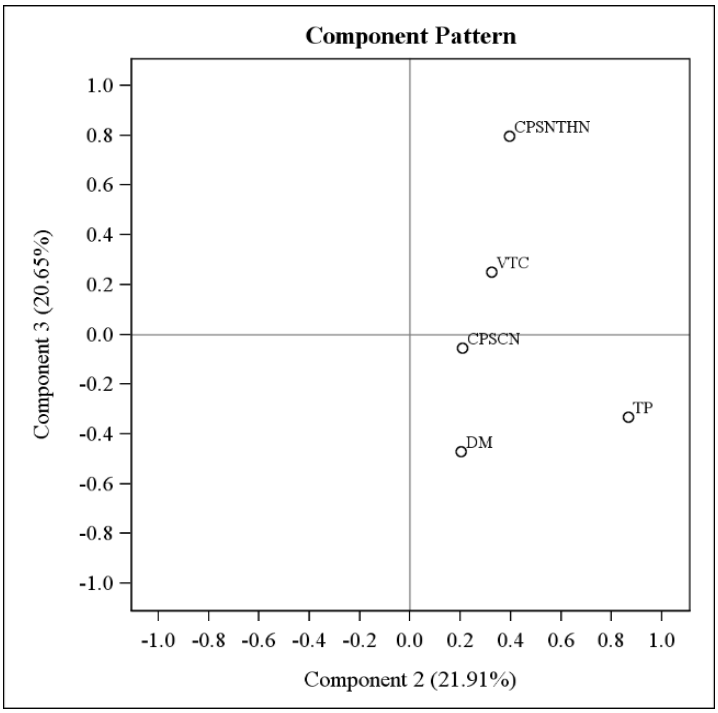
Principle components	Eigen value	Percentage of variance	Cumulative percentage of variance
PC 1	1.49	29.92	29.92
PC 2	1.09	21.91	51.84
PC 3	1.03	20.65	72.48

Table 2.1: Contribution of quality traits of crosses towards each PC's in chilli (Capsicum annuum L.)

Characters	PC 1	PC 2	PC 3
Dry matter	0.41	0.19	-0.46
Vitamin-C	0.57	0.30	0.24
Capsanthin	-0.03	0.37	0.78
Total Phenols	-0.12	0.82	-0.32
Capsaicin	-0.69	0.19	-0.05







DM; dry matter, VTC; Vitamin-C, CPSNTHN; Capsanthin, TP; Total Phenols, CPSCN; Capsaicin

Fig. 3.1,3.2,3.3: Relationship among five quality characters of Chilli crosses.

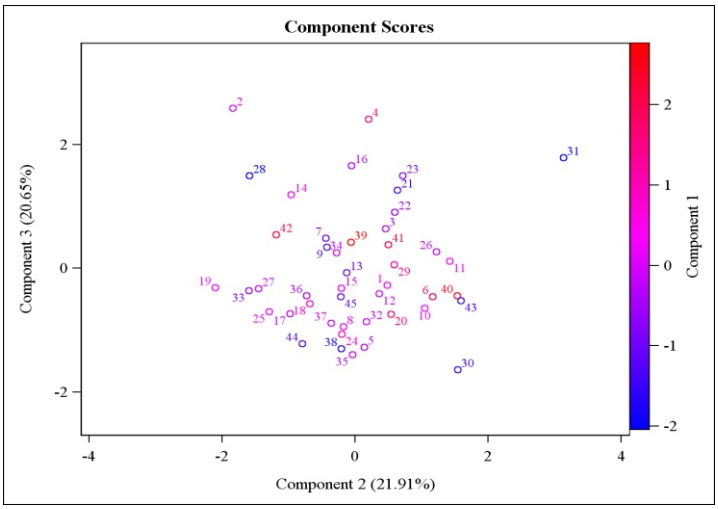


Fig. 4: Distribution of various crosses among three PCs explaining trait combinations

References

1. Wahba, N. M., Ahmed, A. S. & Ebraheim, Z. Z. Antimicrobial effects of pepper, parsley, and dill and their roles in the microbiological quality enhancement of traditional Egyptian Kareish cheese. Food borne Pathog. Dis. 2010;7(4),411–418.

2. Mohammadi, S. A., and Prasanna, B. M. (2003).*Analysis of genetic diversity in crop plants—salient statistical tools and considerations.* Crop Science, 43(4): 1235–1248. DOI: 10.2135/cropsci2003.1235

3. Antunes, I., Teixeira, M., Zimmermann, M.J.O., and Costa, J.G.C. (1981). Exploration of regional populations in common beans - concepts and procedures adopted at the national research centre for rice and beans-CNPAF/Brazil. Annual Report of the Bean Improvement Cooperative, 24: 24-27

4. Acquaah, G., Adams, M.W., and Kelly, J.D. (1992). A factor analysis of plant variables associated with architecture and seed size in dry bean. Euphytica, 60: 171-177

5. Brithers, M.E., and Kelly, J.D. (1993). Interrelationship of plant architecture and yield components in the pinto bean ideotype. Crop Science, 33: 1234-1238

6. Vasic, M., Obradovic, A., and Milosevic, M. (2008). Multivariate analysis for characterization of common bean genotypes. Genetika, 40(1): 43-5

7. Janaki M, Naidu LN, Ramana CV, Rao MP. Assessment of genetic variability, heritability and genetic advance for quantitative traits in chilli (Capsicum annuum L.). The bioscan. 2015;10(2):729-733.