Research Article

Principal Component Analysis Approach for Yield Attributing Traits in Chilli (*Capsicum annum* L.) Genotypes

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Abstract

The present investigation entitled was carried out at Horticulture Complex, Maharajpur, Jabalpur (M.P) during *Rabi* season of 2015-16 with eighteen genotypes in order to study the genetic diversity for different yield attributing characters of chilli by principal component analysis. In this study, out of ten principal components, only five components exhibited >0.5 eigenvalue and showed about 88.85% variability among the traits within the axes exhibited great influence on the phenotype of genotypes. The PC1 accounted for the highest variability (36.93%) to the total variability, followed by 22.87% (PC2), 15.62% (PC3), 7.46% (PC4) and 5.97% (PC5). Thus the results of the principal component analysis revealed, wide genetic variability exists in this chilli genotype accessions.

Keywords: Chilli, Genotype, Principal Component Analysis, Variability

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Introduction

Chilli (*Capsicum annuum* L.) (2n = 24) is one of the most important vegetables as well as spice crop of the Solanaceae family is a dicotyledonous flowering plant grown worldwide [1] and the fruits are rich in vitamin A, E, C and P [2]. Green fruits of chilli are used as a vegetable whereas ripe dried fruits as a spice because of its pungency and pleasant flavour [3] and the green fruits are one of the richest sources of anti-oxidant. The origin of this spice and vegetable crop can be traced to South and Central America [4]. The capsaicin present in the placenta and pericarp is responsible for chilli pungency. Capsaicin has high diverse prophylactic and therapeutic uses in Allopathic and Ayurvedic medicine values [5]. It has very high export potential as a spice crop. Its export value is due to the presence of 69 % capsaicin with 22 % DHC (dihydro-capsaicin). India ranks first in the world in terms of production, consumption and exports. The average productivity of chilli is very low (1.11 t/ha dry chilli) as compared to countries like the USA, China, South Korea, Taiwan, where the average yield ranged from three to four tons per hectare.

The lack of improved genotypes is the main constraint to low yield. On the other hand, a wide range of variability is observed in respect of morpho-physiological traits in chilli. Assessment of different desirable traits spread over diverse genotypes is important to rapid advance in yield improvement of any crop. A logical way to start any breeding program is to collect precise information on the nature and degree of genetic divergence that would help the plant breeder in choosing the right type of parents for purposeful hybridization in heterosis breeding [6]. The genetic diversity may arise due to the environmental influence and may be determined by the magnitude and nature of their genetic variability in which they are grown [7]. Wide variability in chilli fruit morphology, pungency, bearing habit and crop duration is found throughout India [8]. Moreover, the evaluation of genetic diversity is important to know the source of genes for a particular trait within the available germplasm [9]. Principal component analysis (PCA) involves a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal component [10]. PCA is an important statistical method through which we can easily identify important polygenic characters which are of great importance in a plant breeding programme. PCA provides an idea for how to reduce a complex data set to a lower dimension to reveal the sometimes hidden, simplified structures that often underlie it. The eigenvalue of a particular principal component depicts the amount of variation present in traits and explained by that principal component which is very useful for the further breeding programme.

Materials and Methods

The present experiment was conducted under the Horticulture Complex, Maharajpur, Jabalpur (M.P.) during *Rabi* season of 2015- 2016. The nursery was raised during the first week of September and the seedlings were transplanted at a spacing of 60 cm × 50 cm in a row during the last week of October. Principal component analysis (PCA) is an important multivariate method in modern data analysis because it is a simple, non-parametric method for extracting relevant information from confusing data sets and it was applied for assessment of genetic diversity within chilli genotypes. Data were recorded on ten different traits *viz.* plant height (cm) 150 DAT, number of primary branches/plant at harvest, days to 1st flowering, days to 50% flowering, days to 1st picking, fruiting span, number of fruit/plant, fruit length (cm), fruit width (cm) and average fruit weight (g). The data on yield traits were statistically analyzed on the basis of a randomized complete block design. The PCA analysis reduces the dimensions of a multivariate data to a few principal axes, generates an eigenvector for each axis and produces component scores for the characters [11, 12].

Results and Discussions

PCA is a well-known method of dimension reduction that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set [11, 12]. The result of the PCA explained the genetic diversity of the chilli genotypes. There are no standard tests to prove the significance of proper values and coefficients. Principal component analysis has shown the genetic diversity of the germplasm lines. **Table 1** indicated that out of ten principal components, only five components exhibited >0.5 eigenvalues and showed about 88.85% variability among the traits studied. The PC1 had the highest variability (36.93%), followed by 22.87% (PC2), 15.62% (PC3), 7.46% (PC4) and 5.97% (PC5).

A Scree plot (**Figure 1**) explained the percentage of variance associated between eigenvalues and principal components with each principal component (PC) obtained by drawing a graph. PC 1 indicated the highest variation of 36.93% with eigenvalue 3.69 which then declined gradually in other principal components. Semi curve line is obtained which after the fifth PC tended to straight with little variance observed in each PC. From the graph, it is clear that maximum variation was observed in PC1 in comparison to the other four PCs, therefore the selection of lines for characters under PC1 may be desirable.

Table 1 Eigenvalues, % variance and cumulative Eigenvalues of germplasm

Traits	PC	Eigenvalue	Percentage of variation	Cumulative %
Plant height (cm) 150 DAT	PC1	3.69	36.93	36.93
No. of primary branches / plant	PC2	2.29	22.87	59.80
Days to 1st flowering	PC3	1.56	15.62	75.42
Days to 50% flowering	PC4	0.75	7.46	82.88
Days to 1st picking	PC5	0.60	5.97	88.85
Fruiting span	PC6	0.44	4.43	93.28
Number of fruits per plant	PC7	0.28	2.82	96.11
Fruit length (cm)	PC8	0.23	2.30	98.41
Fruit width (cm)	PC9	0.13	1.25	99.66
Average fruit weight (g)	PC10	0.03	0.34	100.00

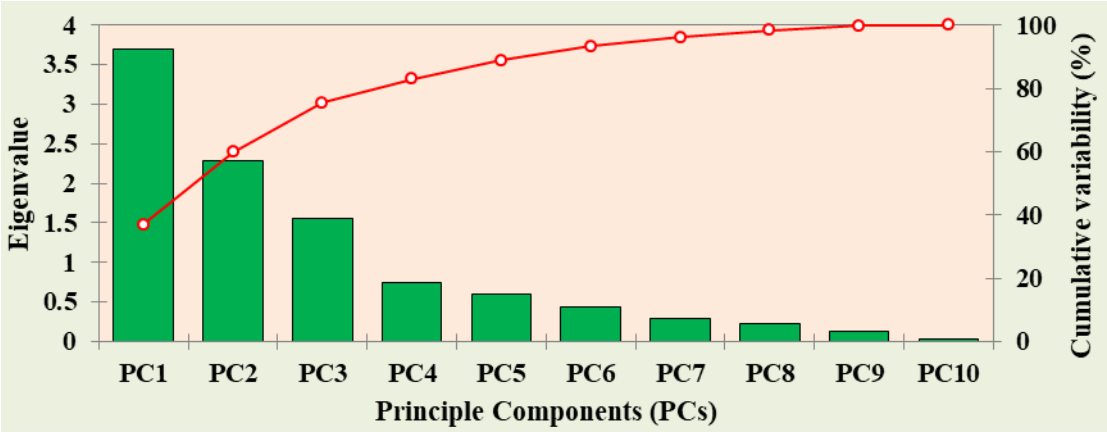

Figure 1 Scree plot

Rotated component matrix revealed that five PCs are representing maximum variability (88.85%) hence, the traits falling in these PCs may be given due importance in chilli breeding. It revealed that the first principal component (PC1) which accounted for the highest variation (36.93%) was mostly related to yield, days to 1st flowering, days to 50% flowering and days to 1st picking. Thus, PC1 allows for the simultaneous selection of phenological traits.

The second principal component PC2 was dominated by number of primary branches/plant, fruiting span, fruit length (cm), fruit width (cm) and average fruit weight (g) while PC3 consists plant height (cm) 150 DAT, whereas PC4 was more related with the number of fruits per plant (**Tables 2** and **3**). On the basis of PCA, most of the important yield attributing and quality traits were present in PC1 and PC2. The result of the present findings is similar to the findings of [13] who had revealed that fruit length, fruit breadth, average fruit weight and fruit yield per plant resulted in the highest positive values. Similar results were reported by [14, 15] studied the first principal component (PC1) contributed maximum towards the total variability (25.059%). This study used in the utilization of principal component analysis in genetic divergence studies in chilli.

Table 2 Principal Components for 10 yield contributing traits of chilli

Traits	Principal components			
	PC1	PC2	PC3	PC4
Plant height (cm) 150 DAT	0.163	0.486	0.710	-0.076
No. of primary branches / plant	0.293	0.683	-0.009	0.575
Days to 1st flowering	0.918	0.106	-0.021	-0.085
Days to 50% flowering	0.850	-0.036	-0.345	0.029
Days to 1st picking	0.930	0.136	-0.093	-0.029
Fruiting span	-0.823	0.141	0.122	-0.085
Number of fruits per plant	-0.430	-0.450	-0.599	0.324
Fruit length (cm)	-0.474	0.675	0.077	0.075
Fruit width (cm)	-0.090	0.550	-0.565	-0.527
Average fruit weight (g)	-0.237	0.757	-0.481	0.073

Table 3 Rotated matrix results of yield and its related traits of chilli

PC1	PC2	PC3	PC4
Days to 1st flowering	No. of primary branches/plant	Plant height (cm) 150 DAT	Number of fruits per plant
Days to 50% flowering	Fruiting span		
Days to 1st picking	Fruit length (cm)		
	Fruit width (cm)		
	Average fruit weight (g)		

PC scores of genotypes

The PC scores of each component (PC1, PC2, PC3 and PC4) had positive and negative values (**Table 4**). These scores can be utilized to propose precise selection indices whose intensity can be decided by variability explained by each principal component. A high PC score for a particular genotype in a particular component denotes high values for the variables in that particular genotype.

Based on the highest PC scores promising genotypes were categorized in **Table 5**. Here, genotype Guljar obtained the highest PC score, followed by 2014/CHIVAR – 10, KA – 2 (C), LCA – 334 (C) and 2014/CHIVAR – 7 indicated that these genotypes possess high values of traits *viz.* days to 1st flowering, days to 50% flowering and days to 1st picking. In PC2 the highest PC score obtained by 2014/CHIVAR – 6, followed by 2013/CHIVAR – 2, 2014/CHIVAR – 7, 2014/CHIVAR – 9 and 2014/CHIVAR – 10 were mainly related with number of primary branches/plant, fruiting span, fruit length (cm), fruit width (cm) and average fruit weight (g) are mainly yield attributing traits. The highest PC score was obtained by 2014/CHIVAR – 8, 2014/CHIVAR – 9, 2014/CHIVAR – 5 and 2014/CHIVAR – 6 in PC3 for plant height (cm) 150 DAT, whereas 2014/CHIVAR – 1 had the maximum PC score in PC4 for the number of fruits per plant.

In PC1, the positive scores ranged from 4.172 (Guljar) to 1.293 (2014/CHIVAR – 7), in PC2, the positive values ranged from 2.769 (2014/CHIVAR – 6) to 1.193 (2014/CHIVAR – 10). In PC3, the positive value of the components ranged from 2.169 (2014/CHIVAR – 8) to 1.075 (2014/CHIVAR – 6) while in PC4 only one genotype *i.e.* (2014/CHIVAR – 1) 1.049 had selected. The PC scores of each component (PC1, PC2, PC3 and PC4) had positive values.

Table 4 PCA scores of chilli genotypes

Genotype	PC1	PC2	PC3	PC4
2014/CHIVAR – 1	0.099	-1.417	-0.062	1.049
2014/CHIVAR – 2	-1.517	-1.366	-0.232	-0.661
2014/CHIVAR – 3	-1.908	-0.876	0.196	-0.631
2014/CHIVAR – 4	-0.716	-0.407	0.130	0.101
2014/CHIVAR – 5	-1.170	0.950	1.382	0.540
2014/CHIVAR – 6	-0.568	2.769	1.075	0.873
2014/CHIVAR – 7	1.293	2.085	-0.591	-1.825
2014/CHIVAR – 8	-1.841	-1.017	2.169	0.250
2014/CHIVAR – 9	-0.931	1.771	1.763	-1.759
2014/CHIVAR – 10	3.181	1.193	0.250	0.691
2013/CHIVAR – 1	-0.344	-1.528	-0.130	0.703
2013/CHIVAR – 2	-2.663	2.455	-3.780	0.534
2013/CHIVAR – 3	-0.838	-0.958	-0.570	0.187
2013/CHIVAR – 4	-0.945	0.335	0.441	0.755
Guljar	4.172	0.209	-0.020	0.006
Pusa Jwala	-0.829	-2.416	-1.019	-0.845
LCA – 334 (C)	2.514	-0.185	-0.087	0.842
KA – 2 (C)	3.010	-1.597	-0.917	-0.810

Table 5 Genotypes selected on the basis of PC score in each component having highest positive values

S.NO	PC1	PC2	PC3	PC4
1	Guljar	2014/CHIVAR – 6	2014/CHIVAR – 8	2014/CHIVAR – 1
2	2014/CHIVAR – 10	2013/CHIVAR – 2	2014/CHIVAR – 9	
3	KA – 2 (C)	2014/CHIVAR – 7	2014/CHIVAR – 5	
4	LCA – 334 (C)	2014/CHIVAR – 9	2014/CHIVAR – 6	
5	2014/CHIVAR – 7	2014/CHIVAR – 10		

Genotypes showing maximum positive PC scores and common in PC1, PC2, PC3 and PC4 which are mostly related to yield traits are 2014/CHIVAR – 10, 2014/CHIVAR – 10, 2014/CHIVAR – 6 and 2014/CHIVAR – 9. An intensive selection procedure can be designed to bring about rapid improvement of dependent traits i.e., yield traits in chilli by selecting lines from PC1, PC2, PC3 and PC4. Thus, the selection of these lines can help in the further development of new high yielding and good quality varieties of chilli.

Conclusions

The phenotypic value of each trait measures the importance and contribution of each component to the total variance. The component contributed the maximum for phenological traits, plant height, number of fruits per plant, fruit yield per plant are the chief contributors towards genetic divergence in chilli genotypes. Thus, the prominent characters coming together in different principal components and contributing towards explaining the variability and have the tendency to remain together this may be kept into consideration during the utilization of these characters in the breeding program.

Acknowledgment

I extend my reverence and gratitude to Dean, College of Agriculture, Jabalpur. I am very much thankful to Dr. P.K. Jain, University Professor and Head, Department of Horticulture, JNKVV, Jabalpur, for providing valuable suggestions and for extending the required facilities during the course of research work.

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Publication History
Received 23.12.2019
Revised 15.01.2020
Accepted 17.01.2020
Online 31.01.2020