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Genetic diversity studies of bottle gourd [*Lagenaria siceraria* (Mol.) Stand.] genotypes using PCA

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Abstract

The investigation was conducted to evaluate the genetic architecture and diversity among 24 bottle gourd [*Lagenaria siceraria* (Mol.) Stand.] genotypes, comprising 15 advance lines, six local cultivars, and three released varieties. The experiment was laid out in a Randomized Block Design (RBD) with three replications during the spring season of 2024 at GBPUA&T, Pantnagar. Principal Component Analysis (PCA) was employed to simplify the multidimensional data into significant components. Results revealed that the first nine principal components, with eigenvalues ranging from 1.93 to 0.85, accounted for the majority of the phenotypic variation. PC1 (22.01%) was predominantly associated with vine length (0.4655), internodal length (0.3794), and fruit yield per plant (0.3272). PC2 (15.02%) was primarily influenced by phenological traits such as days to first fruit harvest (0.3468) and biochemical parameters like antioxidant activity (0.3084). The PCA biplot exhibited a uniform distribution of genotypes across all four quadrants, with accessions situated further from the origin indicating higher genetic divergence. This study underscores the efficacy of PCA in identifying stable, superior genotypes and character combinations. These findings provide a strategic framework for breeders to select diverse parental lines for hybridization, aiming to develop high-yielding recombinants with improved nutritional profiles.

Keywords: *Lagenaria siceraria*, bottle gourd, PCA, genetic diversity, principal component.

1. Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Stand.] belonging to the family Cucurbitaceae is a warm season crop cultivated for its fruits. The cultivated species is commonly known as bottle gourd or white flowered gourd. It is a cross pollinated crop with large amount of variation for many economically important traits. India is the secondary center of origin of bottle gourd endowed with a variety of diverse germplasm (Sultana *et al.*, 2018) [7]. The average day temperature of 20 - 27 °C with lower night temperature of 18 - 23 °C is optimal for growth and fruiting. The relative contribution of different traits to the total divergence helps to select a particular trait or a combination of traits for inter-crossing which avoids wastage to time and labor. Principal component analysis (PCA) is a powerful technique which allows the visualization of natural grouping of the genotypes and is precise indicator of differences among genotypes (Uddin *et al.*, 2019) [8]. More stable genotypes are believed to generate a superior recombinants through crossing as there is less environmental influence on them. Keeping all these points in mind, the present investigation was undertaken to evaluate the genetic diversity among the bottle gourd genotypes collected from diverse locations and to identify a superior genotypes for future use.

Material and Methods

The experimental material for the present investigation, which included twenty-three genotypes and one check, was sown in a randomized block design with three replications during the spring season of 2024. Fifteen advance lines from GBPUA&T, Pantnagar were taken under the study including the check variety *i.e.* Pant Lauki-3. One local cultivar from Uttarakhand, five local cultivars from Uttar Pradesh and three released varieties from IIVR, Varanasi (Kashi Ganga, Kashi Kirti, Kashi Kiran) were also taken under study. A spacing of 3.0 m × 1.0 m was maintained, recommended and uniform agronomical practices were adopted to raise the crop. Observations were recorded on 5 randomly selected and tagged

Plants from each genotype for all the characters. The mean values measured from these 5 plants were used for further statistical analysis, were carried out using R Studio software.

Result and Discussion

The principal component analysis is a precise statistical technique to present the large set of data in smaller components method. The large original set of data, containing many sets of variables can be reduced to a few numbers of components, termed as principal components. The first principal component contributes to the maximum variation in the data as possible, and every succeeding component account for a much of the remaining variability

as possible (Singh and Narayanan, 2013) [6]. In present study, the principal component analysis of twenty-four genotypes of bottle gourd explained the genetic diversity, presented in table 1 and fig. 1. The highest variation was explained by PCA 1 (22.01%) with an eigen value of 1.93. The principal components PCA 2 (15.02%) with an eigen value of 1.59, PCA 3 (13.61%) with an eigen value of 1.52, PCA 4 (11.61%) with an eigen value of 1.40, PCA 5 (8.49%) with an eigen value of 1.20, PCA 6 (6.16%) with an eigen value of 1.02, PCA 7 (5.71%) with an eigen value of 0.99, PCA 8 (4.70%) with an eigen value of 0.89, and PCA 9 (4.30%) with an eigen value of 0.85 explained the variation.

Table 1: Eigan value and associated variation for principal components in bottle gourd

Traits	PCA 1	PCA 2	PCA 3	PCA 4	PCA 5	PCA 6	PCA 7	PCA 8	PCA 9
DFMF	0.2111	0.3031	0.1805	0.2388	-0.1268	-0.1036	-0.2529	-0.5268	0.1181
DFFF	0.2303	0.3019	0.2137	0.355	0.0332	-0.0066	-0.3122	0.1743	-0.1164
NFMF	0.0687	-0.0831	-0.2511	0.3912	0.1576	0.4692	-0.1248	0.2798	0.4268
NFFF	-0.0621	-0.3397	0.1585	-0.1436	0.291	0.1005	-0.3677	0.3319	-0.4765
DFH	0.2892	0.3468	0.1401	0.1206	-0.0243	0.2277	-0.1373	0.1633	-0.3571
F L	-0.0271	0.3015	-0.4331	-0.1483	0.3361	0.2354	-0.1633	-0.1244	-0.0577
F D	-0.0052	-0.2886	0.4584	0.2421	-0.1656	0.1618	0.1957	0.0255	0.0158
AFW	0.2556	-0.1344	-0.122	0.2883	0.336	-0.4747	0.121	-0.0577	-0.1551
NFP	0.1793	-0.3829	-0.1953	0.1002	-0.3939	0.1145	-0.3027	-0.0072	0.1835
NPP	0.1951	0.018	-0.2497	-0.269	-0.5068	0.1428	-0.137	-0.0475	-0.2477
NNP	0.371	-0.0252	-0.267	-0.0403	0.1506	0.1016	0.3366	-0.0218	-0.0195
VL	0.4655	0.011	-0.0005	-0.1914	0.0333	0.0642	0.3018	0.0988	0.0011
IL	0.3794	0.0393	0.2506	-0.264	-0.1089	0.0795	0.1819	0.1605	0.0576
As A	-0.1123	-0.1517	-0.0552	0.353	-0.0044	0.4436	0.3476	-0.3979	-0.4512
An A	-0.1541	0.3084	-0.0674	0.2557	-0.1818	-0.074	0.3223	0.4755	0.0489
D M	0.1795	-0.0914	0.3396	-0.189	0.3724	0.2514	-0.0571	-0.1842	0.318
F Y	0.3272	-0.3263	-0.2092	0.2213	-0.0006	-0.2836	-0.1162	0.0311	-0.0472

DFMF: days to first male flower anthesis, DFFF: days to first female flower anthesis, NFMF: node at which first male flower appears, NFFF: node at which first female flower appears, DFH: days to first fruit harvest, F L: fruit length (cm), F D: fruit diameter (cm), AFW: average fruit weight (g), NPP: number of primary branches per plant, NNP: number of nodes per plant, VL: vine length (m), IL: internodal length (cm), NFP: number of fruits per plant, As A: ascorbic acid in fruit (mg/100 g), An A: antioxidant activity in fruit (%), D M: dry matter in fruit (%), and F Y: fruit yield per plant (kg).

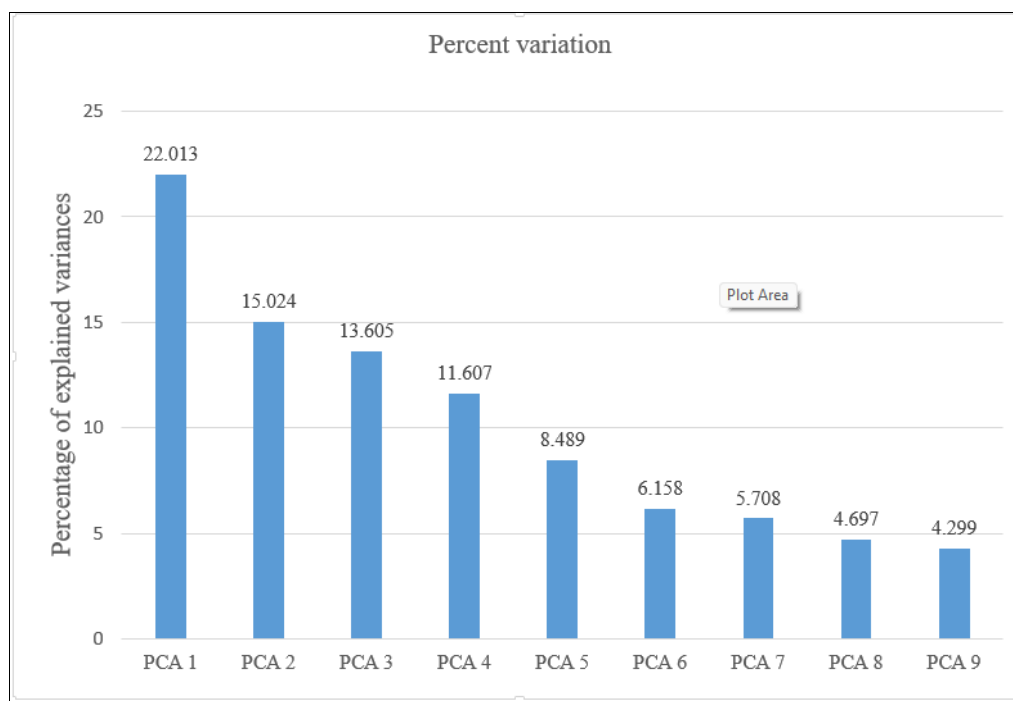


Fig 1: Scree graph for percent variation of PC on yield traits in bottle gourd

(6) and second quadrant (5). The principal component PCA 1 had positive effect with variables vine length (0.4655), internodal length (0.3794), number of nodes per plant (0.371), fruit yield per plant (0.3272), days to first fruit harvest (0.2892), average fruit weight (0.2556), days to first female flower anthesis (0.2303), days to first male flower anthesis (0.211), number of primary branches per plant (0.1951), dry matter content in fruits (0.1795), number of fruits per plant (0.1793) and node to first male flower appearance (0.0687), while negative correlation with variables fruit diameter (-0.0052), fruit length (-0.0271), node to first female flower appearance (-0.0621), ascorbic acid in fruits (-0.1123), and antioxidant activity in fruits (-0.1541).

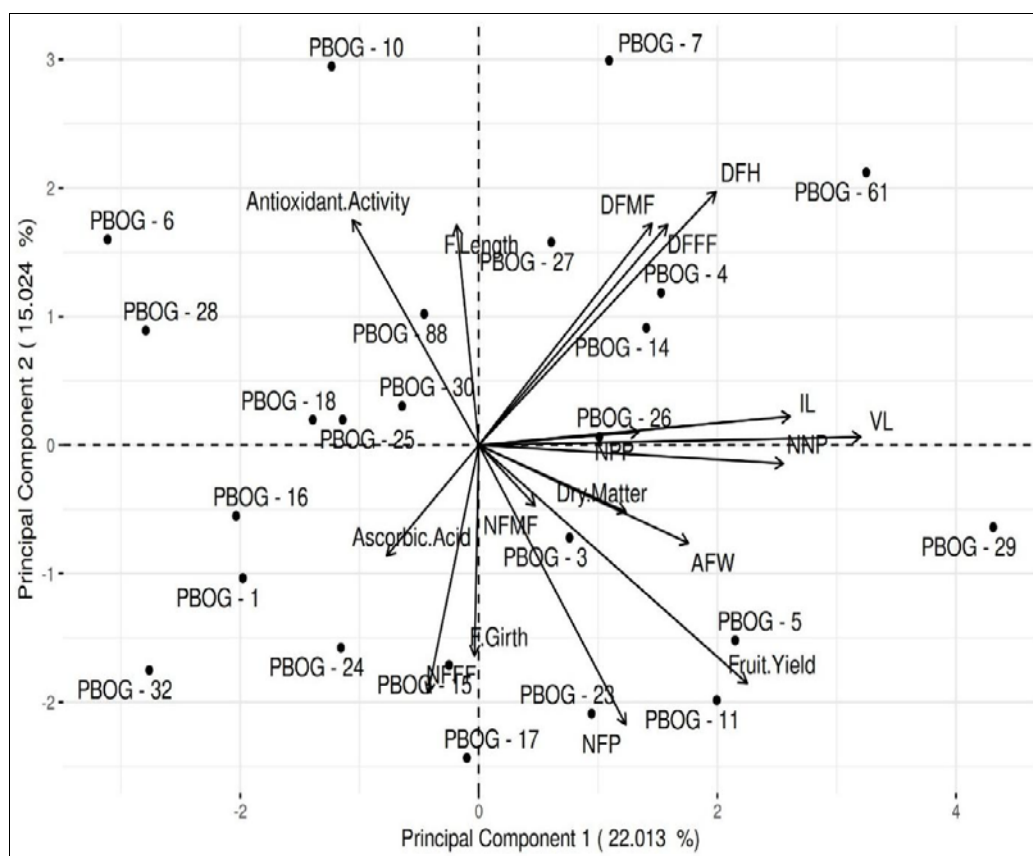


Fig 2: PCA biplot for different traits in bottle gourd accessions

(0.1805), node to first female flower appearance (0.1585) and days to first fruit harvest (0.1401), while negative correlation with variables vine length (-0.0005), ascorbic acid in fruits (-0.0552), antioxidant activity in fruits (-0.0674), average fruit weight (-0.122), number of fruits per plant (-0.1953), fruit yield per plant (-0.2092), number of primary branches per plant (-0.2497), node to first male flower appearance (-0.2511), number of nodes per plant (-0.267), and fruit length (-0.4331).

The principal component PCA 4 had positive effect with variables node to first male flower appearance (0.3912), days to first female flower anthesis (0.355), ascorbic acid in fruits (0.353), average fruit weight (0.2883), antioxidant activity in fruits (0.2557), fruit diameter (0.2421), days to first male flower anthesis (0.2388), fruit yield per plant (0.2213), days to first fruit harvest (0.1206) and number of fruits per plant (0.1002), while negative correlation with

variables number of nodes per plant (-0.0403), node to first female flower appearance (-0.1436), fruit length (-0.1483), dry matter content in fruits (-0.189), vine length (-0.1914), internodal length (-0.264), and number of primary branches per plant (-0.269).

The principal component PCA 5 had positive effect with variables dry matter content in fruits (0.3724), fruit length (0.3361), average fruit weight (0.336), node to first female flower appearance (0.291), node to first male flower appearance (0.1576), number of nodes per plant (0.1506), vine length (0.0333) and days to first female flower anthesis (0.0332), while negative correlation with variables fruit yield per plant (-0.0006), ascorbic acid in fruits (-0.0044), days to first fruit harvest (-0.0243), internodal length (-0.1089), days to first male flower anthesis (-0.1268), fruit diameter (-0.1656), antioxidant activity in fruits (-0.1818), number of fruits per plant (-0.3939), and number of primary branches per plant (-0.5068).

The principal component PCA 6 had positive effect with variables node to first male flower appearance (0.4692), ascorbic acid in fruits (0.4436), dry matter content in fruits (0.2514), fruit length (0.2354), days to first fruit harvest (0.2277), fruit diameter (0.1618), number of primary branches per plant (0.1428), number of fruits per plant (0.1145), number of nodes per plant (0.1016), node to first female flower appearance (0.1005), internodal length (0.0795) and vine length (0.0642), while negative correlation with variables days to first female flower anthesis (-0.0066), antioxidant activity in fruits (-0.074), days to first male flower anthesis (-0.1036), fruit yield per plant (-0.2836), and average fruit weight (-0.4747).

The principal component PCA 7 had positive effect with variables ascorbic acid (0.3476), number of nodes per plant (0.3366), antioxidant activity (0.3223), vine length (0.3018), fruit diameter (0.1957), internode length (0.1819), average fruit weight (0.1210), while negative correlation with variables dry matter content in fruit (-0.0571) fruit yield (-0.1162), node of first male flower (-0.1248), days to first harvest (-0.1373), number of primary branches (-0.1370), fruit length (-0.1633), days to first male flower (-0.2529), number of fruits per plant (-0.3027), days to first female flower (-0.3122), and node of first female flower -0.3677).

The principal component PCA 8 had positive effect with variables antioxidant activity (0.4755), node at first female flower (0.3319), node at first male flower (0.2798), days to first female flower (0.1743), days to first harvest (0.1633), internode length (0.1605), vine length (0.0988), fruit yield (0.0311), fruit diameter (0.0255), while negative correlation with variables number of nodes per plant (-0.0218), number of primary branches per plant (-0.0475), average fruit weight (-0.0577), number of fruits per plant (-0.0072), fruit length (-0.1244), dry matter content in fruit (-0.1842), ascorbic acid (-0.3979), and days to first male flower (-0.5268).

The principal component PCA 9 had positive effect with variables node at first male flower (0.4268), dry matter content in fruit (0.3180), number of fruits per plant (0.1835), days to first male flower (0.1181), internode length (0.0576), antioxidant activity (0.0489), fruit diameter (0.0158), vine length (0.0011), while negative correlation with variables number of nodes per plant (-0.0195), fruit yield (-0.0472), fruit length (-0.0577), days to first female flower (-0.1164), average fruit weight (-0.1551), number of

primary branches per plant (-0.2477), days to first harvest (-0.3571), ascorbic acid (-0.4512), node at first female flower (-0.4765).

The results of the current inquiry are supported by the findings of Kalyanrao *et al.* (2016) ^[1], who observed five principal components PC1, PC2, PC3, PC4 and PC5 with Eigen values 3.89, 2.75, 1.75, 1.47 and 1.36, respectively, accounting for 80.28% of the total variation. The first two principal components PC1 and PC2 with a proportion of 27.84% and 19.60%, respectively, contributed more to the overall variation. In further support to our findings, Shubha *et al.* (2019) ^[5] reported that the first two components were responsible for 36.77% of the phenotypic variability. The first principal component (PC1) accounted for 24.11% followed by second principal component (PC2) which accounted for 12.64% of the total variability.

Principal component analysis (PCA) was carried out for factor extraction. The main advantage of using PCA over cluster analysis is to assign each accession to only one group (Mohammadi, 2002) ^[3]. The traits with the largest absolute value closer to unity within the first component influence the clustering than those with a lower absolute value closer to zero. Thus, in the present study differentiation of accessions into different components was because of the high contribution of the few traits rather than a small contribution of each trait. Our findings are useful, because it furnishes information about the groups, where certain traits are more important in allowing the breeder to execute the specific breeding program with a higher yield, other quality traits and mineral nutrients. Similarly, Morimoto *et al.* (2005), Mashilo *et al.* (2017) ^[2, 4] performed the principal component analysis for various qualitative and quantitative traits in bottle gourd landraces.

Conclusion

This study utilized Principal Component Analysis (PCA) to evaluate genetic diversity among twenty-four bottle gourd genotypes. Nine principal components were identified, with PCA 1 and PCA 2 contributing the most to the total variation (22.01% and 15.02%, respectively). Key traits such as vine length, fruit yield, and flowering patterns significantly influenced the clustering of accessions. These findings provide a precise framework for breeders to select superior genotypes based on specific yield and quality traits, facilitating more targeted and effective breeding programs.

Keywords: Bottle gourd, genetic diversity, principal component analysis (PCA)

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