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Morphological and biochemical characterization of onion (*Allium cepa* L.) germplasm by principal component analysis

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Abstract
The present study was conducted to observe the variability source structure for 14 different morpho-biochemical characters towards yield in onion at the 'C' Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India during the winter (*rabi*) season of 2017-18 and 2018-19. The results revealed that the first four principal components exhibited eigen-value more than 1 and above with 71.53% cumulative variance. Traits *viz.*, number of leaves at 60 DAT, equatorial diameter, the average weight of ten bulbs, number of scales per bulb, total sugar percentage, dry matter percentage, total soluble solids, vitamin C, phenol, pyruvic acid in PC1, days to maturity in PC2, plant height at 60 DAT in PC3, polar diameter in PC4 exhibited positive contribution towards yield. Different variables were loaded on the three principal component indicated that the traits number of leaves at 60 DAT, equatorial diameter, the average weight of ten bulbs, number of scales per bulb, total sugar percentage, vitamin C, phenol, pyruvic acid, dry matter percentage and total yield exhibited maximum proportion of the total variability. So, a breeder must put special emphasis on these traits while conducting selection in a hybridization programme of onion.

Keywords: Onion, *Allium cepa*, West Bengal

Introduction
Worldwide, Onion (*Allium cepa* L.) is grown as one of the important vegetable crop across the world (DIEA 2010) [8]. It had its primary centre of domestication in South-west Asian gene centre and Mediterranean gene centre as its secondary centre of origin (Vavilov 1926) [20]. Onion is rich source of carbohydrates, proteins, minerals (Ca, P, and Fe), vitamins (B and C), and dietary fibres (Bal *et al.*, 2019) [3]. Besides, Quercetin, an alachrymatic agent is believed to have, anti-cholesterol, anti-inflammatory, antioxidant, anticancer and properties is present in onion (Bal *et al.*, 2019) [4]. It is also valued for earning foreign exchange for the country (Bal *et al.*, 2020) [5]. Despite having such importance, the crop remained unexploited as far as its genetic potential is concerned (Pal *et al.*, 2017) [16]. This may probably be due to lack of proper evaluation (Bal *et al.*, 2020) [6] and data classification for various parameters including yield (Pal *et al.*, 2017) [17] which imparts an appreciable gap in the actual and expected yield of this crop. Genetic improvement is a continuous process and its success depends on the variability present in the germplasm. Thus Principal Component Analysis (PCA) helps in the identification of the most relevant characters through a maximum proportion of the genetic variation to the final yield. PCA analysis provides improvement of those traits having low heritability in earlier generations (Ahmadizadeh and Felenji, 2011; Golparvar *et al.*, 2006) [1, 9] and also provides an ease in demonstration of traits which is critical in variation (Dangi *et al.*, 2018) [7]. Besides, Principle Component Analysis helps in determining the effects and association among different traits providing a proper explanation to them. So, the present experiment has been formulated to study the effect of yield on morphological and biochemical traits through principle Component Analysis in onion.

Materials and Methods
The study was conducted using twenty-three genotypes (Table 1) including twenty open-pollinated varieties, two hybrids and one local variety as standard check at the 'C' Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India during the winter (*rabi*) season of 2017-18 and 2018-19. The layout of the experiment was laid out in a Randomized Complete Block Design replicated thrice with a plot size of 2 × 1.5 m^2 with spacing of 15 × 10 cm^2 between the rows and plants respectively. Standard cultural practices were followed for healthy crop stand.

The observations were recorded on 14 parameters *viz.*, plant height at 60 Days After Transplanting (DAT) (cm), number of leaves at 60 DAT, number of days to maturity, polar diameter (mm), equatorial diameter (mm), the average weight of ten bulbs (kg), number of scales per bulb, total sugar percentage, dry matter percentage, TSS (°Brix), vitamin C (mg/g), phenol (mg/g), pyruvic acid (µ mole/g), total yield (kg/plot). For each character except total yield, data were recorded on ten randomly selected plants from each replication. The statistical analysis was carried out using software IBM.SPSS.v.20.0 software packages. The principal component (PC) was used to know the extent of genetic variation. Here, the eigen-values which were obtained from the principal component used in determining relative discriminative power of the axes and their character association. (Pradhan *et al.*, 2011) [18].

Table 1: List of the genotypes used in present study along with their sources

Sl. No.	Name of the genotype	Sources
1	Arka Bheem	ICAR-IIHR, Bangalore, Karnataka
2	Arka Kirtiman	ICAR-IIHR, Bangalore, Karnataka
3	Arka Lalima	ICAR-IIHR, Bangalore, Karnataka
4	Arka Niketan	ICAR-IIHR, Bangalore, Karnataka
5	Akola Safed	PDKV, Akola, Maharashtra
6	Agrifound Light Red	NHRDF, Nasik, Maharashtra
7	Bhima Dark Red	DOGR, Rajgurunagar, Maharashtra
8	Bhima Kiran	DOGR, Rajgurunagar, Maharashtra
9	Bhima Raj	DOGR, Rajgurunagar, Maharashtra
10	Bhima Red	DOGR, Rajgurunagar, Maharashtra
11	Bhima Safed	DOGR, Rajgurunagar, Maharashtra
12	Bhima Shakti	DOGR, Rajgurunagar, Maharashtra
13	Bhima Subhra	DOGR, Rajgurunagar, Maharashtra
14	Bhima Super	DOGR, Rajgurunagar, Maharashtra
15	Bhima Sweta	DOGR, Rajgurunagar, Maharashtra
16	Hisar-2	HAU, Hisar, Haryana
17	Hisar-4	HAU, Hisar, Haryana
18	Kalyanpur Red Round	CSAUAT, Kanpur, Uttar Pradesh
19	L-28	NHRDF, Nasik, Maharasthra
20	Onion HO-3	HAU, Hisar, Haryana
21	PRO-6	PAU,Ludhiana, Punjab
22	Punjab Naroya	PAU,Ludhiana, Punjab
23	Sukhsagar	Local market, West Bengal

Results and Discussion

Significant differences were observed for all the traits under study. Figure 1 depicts the scree plot between component number and eigen-values and the corresponding data presented in Table 2 which reveal that about 96.53% of the total variability present by first ten principal components among twenty-three onion genotypes studied. The first four principal components out of ten components exhibited eigen-values more than 1 and above with 71.53% cumulative variance. The first principal component (PC1) had eigen-value 4.049 with 28.923% of total variability. Whereas, the other principal components *viz.*, PC2, PC3 and PC4 exhibited eigen-values of 2.946, 1.776, 1.241 with a total variability of 21.043%, 12.686%, 8.867% respectively. As per Guttmans lower bound principle, the principle component with eigen-value less than 1 were ignored (Kaiser 1958)[11]. PC1 *i.e.*, the first principal component depicts the traits number of leaves at 60 DAT, equatorial diameter, the average weight of ten bulbs, number of scales per bulb, total sugar percentage, dry matter percentage, total soluble solids, vitamin C, phenol, pyruvic acid and total yield. So, in PC1, except days to maturity and polar diameter all other traits had positive contribution towards yield. The trait days to maturity, plant height at 60 DAT and polar diameter explained the principal component 2 (PC2), principal component 3 (PC3) and principal component 4 (PC4) respectively. So, all the above-mentioned traits in each component represented a positive contribution towards yield. Therefore, a breeder has to carry out positive selection for those traits which exhibit positive contribution towards yield. Sometimes negative selection can also be conducted for those traits which had negative contribution towards yield for genetic improvement in onion. Arya *et al.*, (2017) [2] in onion, Pal *et al.*, (2018) [17] and Olfati *et al.*, (2010) [15] in cucumber, Hayder *et al.*, (2007) [10] in potato reported such similar results.

Table 2: Eigen-value and contribution of the principal component axes towards total genetic variation in onion genotypes under study

Principal component	Eigen value	Variability (%)	Cumulative variability (%)
PC1	4.049	28.923	28.923
PC2	2.946	21.043	49.966
PC3	1.776	12.686	62.652
PC4	1.241	8.867	71.519
PC5	0.891	6.368	77.887
PC6	0.747	5.334	83.220
PC7	0.641	4.581	87.801
PC8	0.540	3.859	91.660
PC9	0.435	3.106	94.766
PC10	0.247	1.763	96.530
PC11	0.201	1.437	97.967
PC12	0.142	1.016	98.983
PC13	0.084	0.601	99.584
PC14	0.058	0.416	100.000

Table 3: Contribution of different morpho-biochemical traits of onion towards the major principal components

Traits	PC1	PC2	PC3	PC4
Plant height at 60DAT(PH60DAT)	0.150	-0.255	0.609	-0.554
Number of Leaves at 60DAT(NOL60DAT)	0.519	0.469	-0.118	0.401
Days to maturity (DTM)	-0.328	0.817	0.274	-0.186
Polar Diameter (PD)	-0.037	-0.380	0.404	0.613
Equatorial Diameter (ED)	0.527	0.386	-0.464	-0.116
Average weight of ten bulbs (AWB)	0.620	0.306	-0.586	-0.032
Number of scales per bulb (NOS)	0.605	-0.520	0.173	-0.096
Total sugar percentage (TS)	0.715	0.353	0.261	-0.035
Dry matter percentage (DM)	0.544	0.410	0.471	0.162
Total Soluble Solids (TSS)	0.756	-0.223	0.043	0.135
Vitamin C (VITC)	0.711	-0.010	-0.143	-0.319
Phenol (PHENOL)	0.480	-0.515	0.029	-0.324
Pyruvic Acid (PA)	0.635	0.275	0.431	0.189
Total yield (TY)	0.318	-0.808	-0.258	0.228

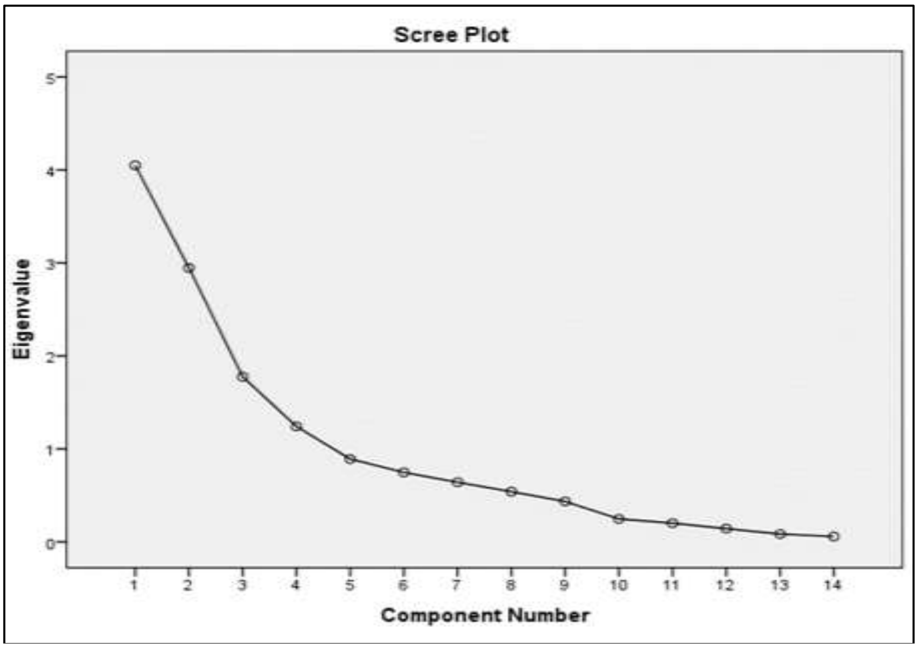

Fig 1: Principal scree plot between component number and corresponding eigen-value.

Different variables were loaded on the three principal component indicated that the traits number of leaves at 60 DAT, equatorial diameter, the average weight of ten bulbs, number of scales per bulb, total sugar percentage, vitamin C, phenol, pyruvic acid, dry matter percentage and total yield exhibited maximum proportion of the total variability and the trait days to maturity contributed the least. So, a breeder must look upon these traits while performing genetic improvement in onion. In earlier Kumar *et al.*, (2014) [13] in cucumber; Portis *et al.*, (2006) [19] in peppers and Koutos *et al.*, (2000) [12] in okra, Dangi *et al.*, (2018) [7] in onion observed similar results.

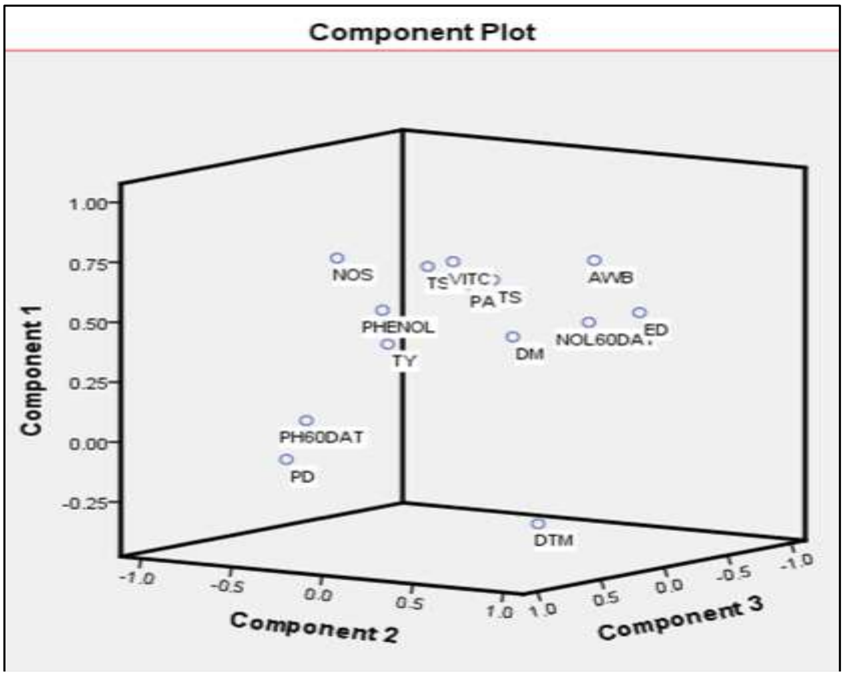

Fig 2: Loading of different characters based on the first three principal components.

Where, PH60DAT- Plant Height at 60DAT, NOL60DAT- Number of Leaves at 60DAT, DTM- Days to Maturity, PD- Polar Diameter, ED-Equatorial Diameter, AWB- Average Weight of ten Bulbs, NOS- Number of Scales per Bulb, TS- Total Sugar percentage, DM- Dry Matter, TSS- Total Soluble Solids, VITC-Vitamin C, PHENOL- Phenol, PA- Pyruvic Acid, TY- Total Yield.

Conclusion

Based on the above findings it can be concluded that the traits number of leaves at 60 DAT, equatorial diameter, the average weight of ten bulbs, number of scales per bulb, total sugar percentage, vitamin C, phenol, pyruvic acid, dry matter percentage and total yield exhibited maximum proportion of the total variability.

So, a breeder must look upon these traits while undergoing improvement in onion.

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