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Mukul
Seed Officer, Krishi Pant Bhavan Jaipur, Rajasthan, India

Sandhya
Assistant Professor, Department of Genetics and Plant Breeding, Agriculture University, Kota, Rajasthan, India

Manoj Kumar
Assistant Professor, Department of Genetics and Plant Breeding, Agriculture University, Kota, Rajasthan, India

RK Agarwal
Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Corresponding Author:
Mukul
Seed Officer, Krishi Pant Bhavan Jaipur, Rajasthan, India

Principal component analysis based on yield and its attributing traits in tomato (*Solanum lycopersicum* L.) Genotypes

Mukul, Sandhya, Manoj Kumar and RK Agarwal

Abstract
In the present study thirty genotypes were assessed with principal component analyses (PCA) based on yield and its attributing traits to select genotypes and existence of variability for future breeding program. Based on the PCA with twenty traits, twenty components were formed however, 6 PCs had more than 1 Eigen value with the variability of 78.73%. So, these six PC were used for further relevant information and individual contribution of PC1, PC2, PC3, PC4, PC5 and PC6 were 25%, 17%, 13%, 9%, 8% and 7% respectively. The first principal component explained maximum variability of the total variation presented. Primary branches, secondary branches, clusters per plant, locule number, and average fruit weight, juice-pulp ratio, fruit yield per plan, lycopene and carotene etc. traits showed maximum positive contribution towards genetic divergence in PC1. Therefore, the important traits gather collectively from diverse PCs and influence towards dimorphism may be kept into consideration during utilization of these traits in improvement of tomato breeding programme.

Keywords: Tomato, principal component analysis, Eigen value, variability

Introduction

Tomato (*Solanum lycopersicum* L.) is one of Important and versatile vegetable that grown throughout the world due to its wider adaptability and good yield potential. Tomato is a native of Peru Equador region (Reddy *et al*., 2013) [13]. It is known as "Protective Food" [2], because of its high nutritive and anti- oxidants, and widely available source of bioactive substances (vitamins, minerals, and organic acids) (Buhroy *et al*., 2017) [3]. Tomato has a great variability on the level of genetics and genomics (Foolad, 2007). Systematic study and assessment of germplasm is crucial for existing and anticipated agronomic and genetic advancement of the crop (Anuradha *et al*., 2018) [1].

Crop improvement initiatives are predicated on yield and its contributing traits, which are influenced by a wide range of variables and the environment, therefore a technique called principal component analysis (PCA) was used to determine and reduce the number of attributes for appropriate selection. PCA is an analytical technique for assessing significant attributes that contribute the majority of the variability among genotypes from a large number of observations, which is impossible to accomplish through selective breeding in order to meet the required and emerging challenges of global food security (Vanaja *et al*., 2006) [20]. PCA enables researchers to transform a group of mutually associated traits (variables) into a new set of characteristics known as principle components, which are not correlated (Sinha *et al*., 2021) [17]. The generated variables can also be used for subsequent analysis if no co-linearity assumption is enforced (Rymuza *et al*., 2012) [14]. The aim of the study was finding correlations between the characteristics of twenty tomato genotypes and also assessing the usefulness of applying principle component analysis to evaluate morphological and biochemical traits which utilize in hybridization programme for choice of parent would lead to improvement in yield and quality of tomato.

Materials and Methods

The present investigation was carried out during post rainy season at vegetable research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (UP), India. The experimental material consist of 30 genotypes / cultivars (Table 1), fifteen exotic lines and fifteen indigenous lines, of tomato received from various sources, including Indian Institute of Vegetable Research, Varanasi and National Bureau of Plant Genetic Resources, New Delhi, and maintained at Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University. Thirty tomato genotypes were evaluated for sixteen yield and its attributing parameters in a randomized block design with three replications. Four week old seedlings were planted per replication at a spacing of 60 cm × 45 cm and the observations were recorded for various yield and its attributing parameters *viz*. days to first flowering, day to 50% flowering and days to 50% fruiting was taken on plot basis. Five plants, excluding border plants, were randomly selected for recording of data on various yield and fruit quality traits such as number of primary branches (PB), secondary branches (SB), plant height (PH), clusters per palnt (Cl/ P), flowers per cluster (Fl/Cl), fruits per cluster (Fr/Cl), fruits per plant (Fr/P), Pericarp thickness (PT), pericarp thickness (PT) (mm), locule number per fruit (LN), Seed Index (SI), average fruit weight (AFW), fruit yield per plant (FY/P), Juice-pulp ratio (JPR), Total soluble solid (TSS), Fruit yield per plant (FY/P), Lycopene and Carotene for statistical analysis (Table 2). Mean values of all observations were used for Principal Components Analysis using STAR software.

Results and Discussion

Principal component analysis is a simple nonparametric method. The purpose of the PCA is to obtain a small number of factors which account for maximum variability out of the total variability. Based on the PCA with 20 traits of 100% diversity, it formed 20 components, however, 6 PCs had more than 1 Eigen value which signify maximum variation among the variables with the diversity percentage of 78.73% (Table 3). Brejda *et al*., (2000) [2] suggested that the Eigen value more than 1 showed at least 10% variation thus elevated Eigen values were measured as best representative of system attribute in principal components. Saputra *et al*., (2021) also found twenty components in their study. Six PCs i.e., PC 1 (5.040), PC 2 (3.204), PC 3 (2.685), PC 4 (1.858), PC 5 (1.550) and PC 6 (1.408) showed greater than 1 Eigen values. So, these six PC were used for further explanation. The first principal component explained 25.20% while 2, 3, 4, 5 and 6 principal components exhibited 16.94%, 13.43%, 9.29%, 7.75% and 7.04% of the total variation respectively. The graphical views of the 6 principal components are shown in Fig. 1. Similar finding were also reported by Merk *et al*., (2012) [11]; Chernet *et al*., (2014) [4]; Iqbal *et al*., (2014) [8]; Rai *et al*., (2017); Tsagaye *et al*., (2019) [19]; Ibrahim and El-Mansy (2021) [17] and Sinha *et al*. (2021) [17].

Further, the Scree plot (Fig. 1) explains the % of variation related with each principal component and demonstrated that the first six PCs explained most of the variation, with less variation accounted by the remaining PCs. Thus, the qualities derived from six PCs exhibit a significant degree of genetic variation and contribute to genetic diversity among genotypes used in crop improvement programmes. Table 4 shows the contributions of yield and its attributing traits to the PC. Traits such as primary branches (0.223), secondary branches (0.014), clusters per plant (0.034), locule number (0.316), and average fruit weight (0.147), juice-pulp ratio (0.224), fruit yield per plan (0.060), lycopene (0.230) and carotene (0.264) showed maximum positive contribution towards genetic divergence and the remaining parameters showed negative loadings in PC 1. In PC 2, secondary branches (0.126) and seed index (0.111) represent maximum positive factor loading. In PC 3, positive factor loading observed with primary branches (0.337), secondary branches (0.413), plant height (0.448), clusters per plant (0.061), and flower per clusters (0.136), fruits per clusters (0.151), fruits per plant (0.192), pericarp thickness (0.009), juice-pulp ratio (0.306), total soluble solid (0.198), lycopene (0.073), carotene (0.002) and negative contribution by rest of the traits. PC 4 reflected positive factor loading by all the traits other than clusters per plant, flower per cluster, fruits per clusters, fruits per plant, pericarp thickness, fruit shape index and juice-pulp ratio. PC 5 correlated with secondary branches (0.230), plant height (0.196), flower per clusters (0.016), fruits per clusters (0.182), locule number (0.068), average fruit weight (0.163), fruit shape index (0.257), total soluble solid (0.152) and fruit yield per plant (0.052) with positive contribution whereas negative contribution by rest of the traits. In PC 6, days to first flowering (0.034), days to 50% flowering (0.036), primary branches (0.296), flower per clusters (0.333), fruits per clusters (0.188), pericarp thickness (0.384), locule number (0.232), seed index (0.407), average fruit weight (0.114) and juice-pulp ratio (0.144) showed positive contribution. Positive contribution indicated significant variation in flowering and fruiting time so it plays important role for selection on the basis of duration. Glogovac *et al*., (2012) [18]; Hussain *et al*., (2018) [6] and Sehgal *et al*., (2021) [16]; were also reported the similar finding for these traits that contributed more positively to PC.

Positive contribution indicates importance of these traits for altering quality of fruits so it plays important role for selection on the basis of fruit quality. Kumar *et al*., (2017) [10] and Sehgal *et al*., (2021) [16] reported that the traits such as lycopene and pericarp thickness contributed more positively to PC.

Table 1: List of Tomato genotypes collected from different region of India

Sr. No.	Genotype/Code	Sr. No.	Genotype/Code
1	EC - 168283	16	Angurlata
2	EC - 20510	17	Azad T-5
3	EC - 538148	18	Co-3
4	EC - 538380	19	DT-10
5	EC - 538408	20	H-86
6	EC - 538419	21	Kajela
7	EC - 538422	22	Kashi Amrit
8	EC - 538423	23	Kashi Sharad
9	EC - 538455	24	Pant T-3
10	EC - 62025	25	PM-1
11	EC - 620530	26	Punjab Upama
12	EC - 620536	27	Selection-7
13	EC - 620538	28	Shalimar-2
14	EC - 620541	29	Superbug
15	EC - 620578	30	Swarna Naveen

Table 2: Simple Statistics for yield and related traits in Tomato genotypes

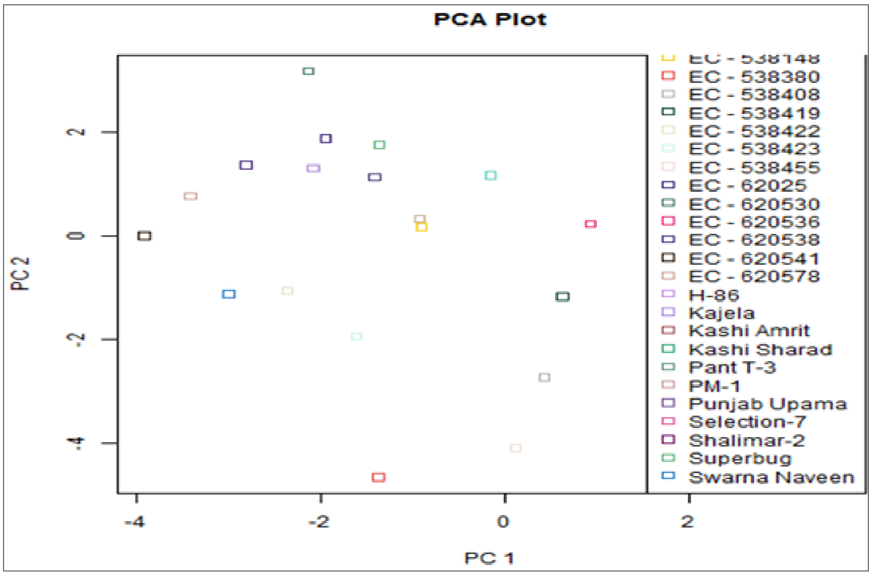
Variables	Mean ± S.E.	Minimum	Maximum
Days to first flowering	40.66 ± 1.18	28.33	49.00
Days to 50% flowering	48.24 ± 1.31	39.67	56.33
Days to 50% fruiting	60.63 ± 1.03	53.00	68.33
Primary branches	3.43 ± 0.25	2.07	4.70
Secondary branches	6.17 ± 0.62	2.33	13.03
Plant height (cm)	80.71 ± 2.6	46.17	116.20
Clusters/plant	4.89 ± 0.33	3.83	8.53
Flower/clusters	5.29 ± 0.33	3.50	8.85
Fruits/clusters	3.58 ± 0.29	2.16	6.14
Fruits/plant	31.71 ± 1.72	19.00	54.67
Pericarp thickness (mm)	0.5 ± 0.02	0.24	0.71
Locule number	3.03 ± 0.21	2.00	4.40
Seed index	0.27 ± 0.01	0.13	0.40
Average fruit weight (g)	39.26 ± 4.35	21.00	71.67
Fruit shape index	0.98 ± 0.04	0.69	1.28
Juice-pulp ratio	0.65 ± 0.08	0.32	1.11
Total soluble solid(ºBrix)	4.66 (12.44 ± 0.35)	3.88	5.47
Fruit yield/ plant (kg)	1.47 ± 0.12	0.63	3.20
Lycopene (mg/100 g)	0.19 ± 0.01	0.01	0.61
Carotene (mg/100 g)	0.56 ± 0.02	0.06	1.20

Table 3: Eigen vectors and Eigen values of 6 principal components for 20 characters of Tomato genotypes

Statistics	PC1	PC2	PC3	PC4	PC5	PC6
Standard deviation	2.245	1.790	1.638	1.363	1.245	1.186
Proportion of Variance	25.20	16.94	13.43	9.29	7.75	7.04
Cumulative Proportion	25.20	41.22	54.65	63.94	71.69	78.73
Eigen Value	5.040	3.204	2.685	1.858	1.550	1.408

Table 4: Eigen values and cumulative variability in different PCs for yield and related traits in Tomato genotypes

Variables	PC1	PC2	PC3	PC4	PC5	PC6
Days to first flowering	-0.3591	0.0102	-0.0284	0.2394	-0.3227	0.0343
Days to 50% flowering	-0.3678	-0.0164	-0.0555	0.2633	-0.2603	0.0367
Days to 50% fruiting	-0.4087	-0.0136	-0.0088	0.0860	-0.1572	-0.0401
Primary branches	0.2232	0.0654	0.3372	0.0866	-0.0354	0.2963
Secondary branches	0.0142	0.1260	0.4132	0.2880	0.2309	-0.0468
Plant height	-0.1353	-0.1613	0.4486	0.1921	0.1966	-0.0207
Clusters/plant	0.0343	-0.3143	0.0619	-0.1219	-0.3982	-0.3320
Flower/clusters	-0.0225	-0.3325	0.1367	-0.3307	0.0165	0.3338
Fruits/clusters	-0.1383	-0.4318	0.1517	-0.1200	0.1824	0.1888
Fruits/plant	-0.0702	-0.4572	0.1922	-0.0379	-0.1122	-0.1631
Pericarp thickness	-0.0015	0.0250	0.0093	-0.1612	-0.3985	0.3847
Locule number	0.3160	-0.1385	-0.1695	0.2444	0.0682	0.2320
Seed index	-0.2134	0.1119	-0. 1843	0.2262	-0.0607	0.4075
Average fruit weight	0.1477	-0.2588	-0.3961	0.2129	0.1636	0.1141
Fruit shape index	-0.2567	0.0633	-0.1230	-0.1154	0.2576	-0.4009
Juice-pulp ratio	0.2249	0.1105	0.3069	-0.0984	-0.3067	-0.0415
Total soluble solid	-0.2540	-0.0994	0.1988	0.2485	0.1523	0.1441
Fruit yield/ plant	0.0601	-0.4605	-0.2326	0.1482	0.0529	-0.0531
Lycopene	0.2301	-0.0419	0.0733	0.4836	-0.0387	-0.1662
Carotene	0.2645	-0.0956	0.0021	0.2752	-0.3517	-0.1643


PCA Plot
PC 2
PC 1
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EC - 538380
EC - 538408
EC - 538419
EC - 538422
EC - 538423
EC - 538455
EC - 62025
EC - 620530
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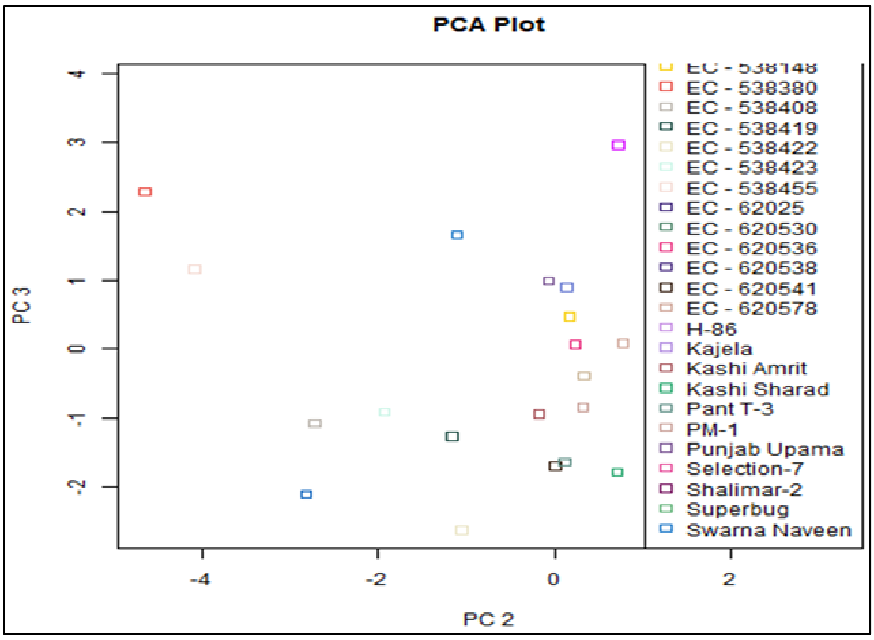
PCA Plot
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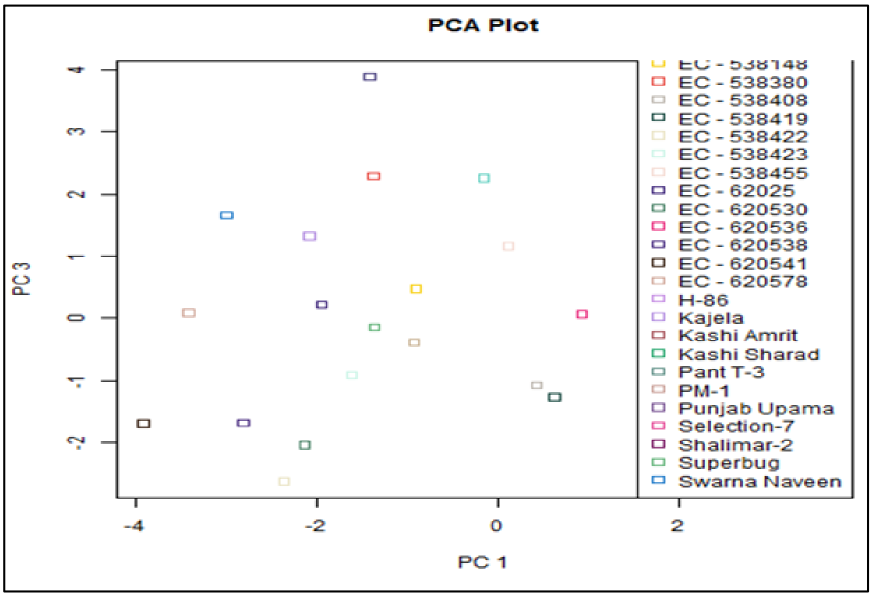
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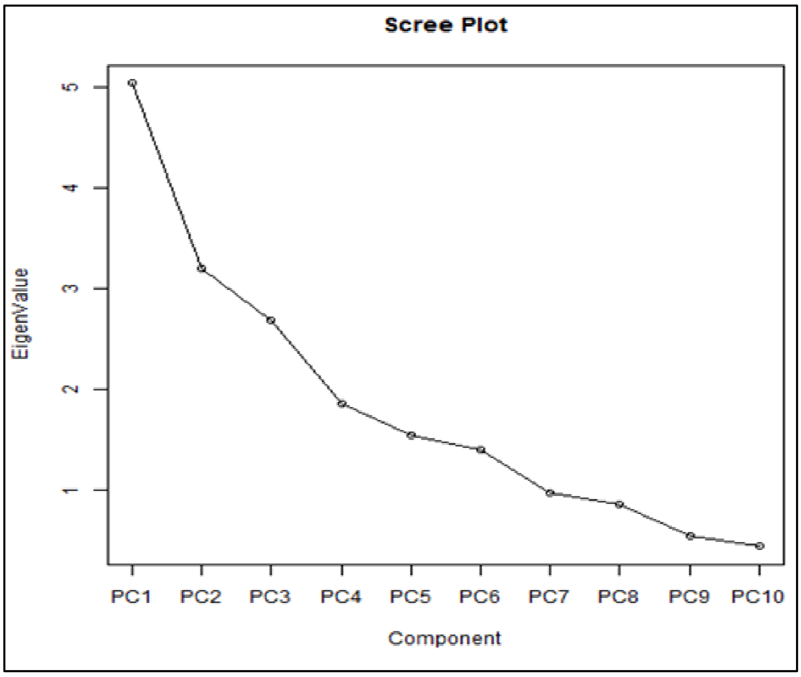

Fig 1: Principal components displaying contribution of variability to the total variance of Tomato

Conclusion

The present research revealed six principal components, explained 78.73% of the total variations, thus suggesting that traits such as days to first flowering, days to 50% flowering, days to 50% fruiting, primary branches, secondary branches, plant height, clusters per plant, flower per cluster, fruits per clusters, fruits per plant, pericarp thickness, locule number, seed index, average fruit weight, fruit shape index, juice-pulp ratio, fruit yield per plant, lycopene and carotene were the principal discriminatory characteristics. Consequently, when using these traits in a tomato breeding program, essential traits that come together from multiple PCs and contribute to phenotypic variability should indeed be included in the equation.

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Competing interests

Authors have declared that no competing interests exist.

Reference

1. Anuradha B, Saidaiah P, Sudini H, Geetha A, Reddy KR. Correlation and path coefficient analysis in tomato (*Solanum lycopersicum* L.). Journal of Pharmacognosy and Phytochemistry. 2018;7(5):2748-2751.
2. Brejda JJ, Moorman TB, Karlen DL, Dao TH. Identification of regional soil quality factors and indicators. I. Central and Southern High- Plains. Soil Science Society of America Journal. 2000;64:2115-2124.
3. Buhroy S, Arumugam T, Manivannan N, Vethamoni PI, Jeyakumar P. Correlation and path analysis of drought tolerance traits on fruit yield in tomato (*Solanum lycopersicum* L.) under drought stress condition. Chem Sci Rev Lett. 2017;6(23):1670-1676.
4. Chernet S, Belew D, Abay F. Genetic diversity studies for quantitative traits of tomato (Solanum lycopersicon L.) genotypes in Western Tigray, Northern Ethiopia. Journal of Plant Breeding and Crop Science. 2014;6(9):105-113.
5. Foolad MR. Genome mapping and molecular breeding of tomato. Int. J Plant Genomics, 2007, 1-52.
6. Hussain I, Khan SA, Ali S, Farid A, Ali N, Ali S, *et al*. Genetic diversity among tomato accessions based on agro-morphological traits. Sains Malaysiana. 2018;47(11):2637-2645.
7. Ibrahim M, El-Mansy AB. Screening of tomato genotypes under high temperature in north sinai. Journal of Plant Production Mansoura University. 2021;12(2):161-169.
8. Iqbal Q, Saleem MY, Hameed A, Asghar M. Assessment of genetic divergence in tomato through agglomerative hierarchical clustering and principal component analysis. Pakistan Journal of Botany. 2014;46(5):1865-1870.
9. Krasteva L, Dimova D. Evaluation of a canning determinate tomato collection using cluster analysis and principal component analysis (PCA). Acta Hort. 2007;729:89-93.
10. Kumar PA, Reddy NN, Lakshmi NJ. Screening tomato genotypes for salt tolerance. InternationalJournal of Current Microbiology and Applied Sciences. 2017;6:1037-1049.
11. Merk HL, Yarnes SC, Deynez AV, Tong N, Menda N, Mueller LA, *et al*. Trait diversity and potential for selection indices based on variation among regionally adapted processing tomato germplasm. J. Am. Soc. Hort. Sci. 2012;137(6):427-437.
12. Rai AK, Vikram A, Pal S. Genetic characterization of tomato (*Solanum lycopersicum* L.) germplasm for yield and quality traits through principal component analysis. Research Journal of Agricultural Sciences. 2017;8:1171.
13. Reddy BR, Reddy MP, Reddy DS, Begum H. Correlation and path analysis studies for yield and quality traits in tomato (*Solanum lycopersicum* L.). IOSR Journal of Agriculture and Veterinary Science. 2013;4(4):56-59.
14. Rymuza K, Turska E, Wielogórska G, Bombik A. Use of

principal component analysis for the assessment of spring wheat characteristics. Acta Sci. Pol., Agricultura. 2012;11(1):79-90.
15. Saputra HE, Syukur M, Aisyah SI. Characterization and similarity analysis of 15 tomato genotypes in lowlands based on morphological characters. Agrotech journal. 2017, 1-6.
16. Sehgal N, Chadha S, Kumar S, Ravita. Variability and traits association analyses in bacterial wilt resistant F4 progenies of tomato, *Solanum lycopersicum* L. for yield and biochemical traits. Indian Journal of Experimental Biology. 2021;59:617-625.
17. Sinha A, Singh P, Bhardwaj A, Verma RB. Principal component cnalysis cpproach for comprehensive screening of tomato germplasm for polyhouse condition. Journal of Experimental Agriculture International. 2021;43(9):67-72.
18. Svetlana Glogovac S, Adam Takač A, Tepić A, Šumić Z, Gvozdanović-Varga J, Červenski J. Principal Component Analysis of tomato genotypes based on some morphological and biochemical quality indicators, Ratar. Povrt. 2012;49(3):296-301.
19. Tsagaye D, Gedebo A, Aklilu S. multivariate studies for fruits yield and quality components in diverse tomato (*Solanum lycopersicum* L.) genotypes. International Journal of Research in Agricultural Sciences. 2019;6(6):2348-3997.
20. Vanaja T, Babu LC. Variability in grain quality attributes of high yielding rice varieties (*Oryza sativa* L.) of diverse origin. Journal of Tropical Agriculture. 2006;44:61-63.