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Principle Component Analysis of Tomato (*Solanum lycopersicum* L.) Genotypes for Yield and Quality Traits

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ABSTRACT

In the present study fifty three 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. Out of 24 studied traits, 20 qualitative and 4 quantitative characters were studied. The first seven principle component (PCs) with eigen values greater then 1were accounted for 88.75% of the total variance and proportionate contributed of each PC was 21.43, 17.322, 16.581, 10.112, 7.941, 7.077, 5.325, and 2.964, respectively. The first principal component explained maximum variability of the total variation presented with Primary branches per plant, Secondary branches per plant, Fruit pericarp thickness, Days taken to first flowering, Days to first picking, Plant height at first picking, flower cluster per plant, fruit set %, Leaf area and TSS, 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.

Keyword:- Tomato, Principle component Analysis, Eigen value, Genetic Diversity

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the important vegetable that grown throughout the world due to its wider adaptability and good yield potential. The origin place of tomato is Peru Ecuador Bolivia region (Reddy *et al.*, 2013). It is also known as protective food due to its high nutritional value and anti-oxidents properties with the available sources of bioactive substances (Vitamin, minerals, and organic acid) (Buhroy *et al*., 2017). Tomato has a greater variability on the genetic level (Fooled 2007). Systematic study and assessment of germplasm is crucial for existing and anticipated agronomic and genetic advancement of the crop (Anuradha *et al*., 2018). Crop Improvement initiative are predicted on yield and its contributing traits, which are influenced by a wide range of variables and the environment, therefore a technique called principle component analysis (PCA) was used for determination and reduce the number of attributes for appropriate selection. Principal component analysis is frequently used to determine the relative significance of different variables of classification, prior to cluster analysis (Jackson, 1991). Additionally PCA also gives a reduced dimension model that would point out the measured differences among different groups and leads to understanding of variables by telling how much of the total variance is explained by each one.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. 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

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et al., 2021) . The aim of the study was finding correlations between the characteristics of fifty three tomato genotypes and also assessing the usefulness of applying principle component analysis to evaluate morphological traits which utilize in hybridization programme for choice of parent would lead to improvement in yield and quality of tomato.

MATERIAL AND METHODS

The present investigation was carried out at Vegetable Research Centre (V.R.C.), Govind Ballabh Pant University of Agriculture & Technology (GBPUAT). The experimental material consist of fifty three genotypes were evaluated in an augmented block design at G B P U A & T Pantnagar. The experiment laid out in five block and the three varieties *i.e.* Arka Vikas, Roma and Pant T-3 are used as checks are planted at a spacing of 60 X 50cm in a single row. Due to limited germplasm of each genotype the experiment is laid out in augmented block design second. Observation were recorded for twenty four qualitative and quantitative characters viz., Days to first flowering, Internodal length (cm), Plant height at first flowering (cm), Plant height at first picking (cm), Number of primary branches, Number of secondary branches, Leaf area (cm^2), Node number of first flowering, Number of flower clusters per plant, Number of flowers per cluster, Fruit set percentage, Days to first picking, Fruit length (cm), Fruit diameter (cm), Fruit pericarp thickness (mm), Number of fruit locules, Fruit weight (g), Fruit volume (cm^3), Number of fruits per plant, Fruit yield per plant (g), Specific gravity of fruits (g/cm^3), Total soluble solids (%), pH (^{0}Brix), and Titratable acidity (%). Mean values of all observations were used for principle component analysis.

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Table 1 : Eigen root and associated variation for principal component analysis in tomato based on different traits.

Character	Principal Components							
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Primary branches per plant	0.091	0.168	0.102	0.002	0.397	0.191	0.190	0.514
Secondary branches per plant	0.263	0.051	0.121	0.028	-0.011	0.333	0.243	-0.457
Internodal length (cm)	-0.302	0.102	-0.003	0.099	0.000	-0.271	0.001	0.327
Fruit locules	-0.070	0.011	-0.014	-0.029	-0.266	-0.437	-0.362	-0.274
Fruit length (cm)	-0.095	-0.189	-0.315	0.302	0.181	0.067	-0.176	-0.066
Fruit diameter (cm)	-0.164	-0.112	-0.295	0.177	0.299	0.086	0.002	-0.161
Fruit pericarp thickness (mm)	0.207	0.082	-0.350	-0.192	-0.256	0.008	0.092	0.069
Days taken to first flowering	0.302	-0.038	-0.064	0.310	0.105	-0.162	-0.248	-0.056
Days to first picking	0.245	0.109	0.185	0.344	0.246	0.038	-0.094	-0.164
Node number at first flowering	-0.093	0.003	0.417	-0.134	0.070	-0.126	-0.104	-0.054
Plant height at first flowering (cm)	-0.265	-0.143	0.296	0.012	0.201	0.127	-0.125	-0.139
Plant height at first picking (cm)	0.358	0.052	-0.161	0.172	-0.184	0.066	-0.061	0.050
Flower clusters per plant	0.393	-0.054	0.036	-0.020	0.050	-0.185	-0.194	0.123
Flowers per cluster	-0.192	-0.234	-0.345	-0.075	-0.069	0.083	0.055	-0.085
Fruit set (%)	0.124	-0.248	-0.030	-0.343	0.241	-0.212	-0.270	0.205
Leaf area (cm^2)	0.176	-0.191	-0.101	-0.440	0.201	0.120	0.048	-0.071
Fruit weight (g)	-0.127	0.429	-0.117	0.062	0.093	-0.092	0.003	0.000
Fruit volume (cm^3)	-0.187	0.380	-0.078	0.054	0.074	-0.113	0.103	-0.177
Specific gravity of fruit (g/cm^3)	-0.141	-0.028	-0.354	0.003	0.320	0.080	-0.182	-0.018
Fruits per plant	-0.204	-0.281	0.047	-0.015	-0.317	0.212	0.087	0.075
pH	-0.181	0.234	0.088	-0.014	-0.143	0.386	-0.454	0.069
Tritratable acidity (%)	-0.063	-0.243	0.064	0.182	0.107	-0.414	0.487	-0.083
TSS (°Brix)	0.031	-0.187	0.000	0.429	-0.277	0.092	0.031	0.370
Fruit yield per plant (g)	-0.042	-0.393	0.223	0.159	0.037	0.102	-0.149	-0.022
Eigen root	5.145	4.157	3.979	2.427	1.906	1.698	1.278	0.711
Per cent variation	21.437	17.322	16.581	10.112	7.941	7.077	5.325	2.964
Cumulative per cent variation	21.437	38.759	55.340	65.452	73.393	80.469	85.795	88.758

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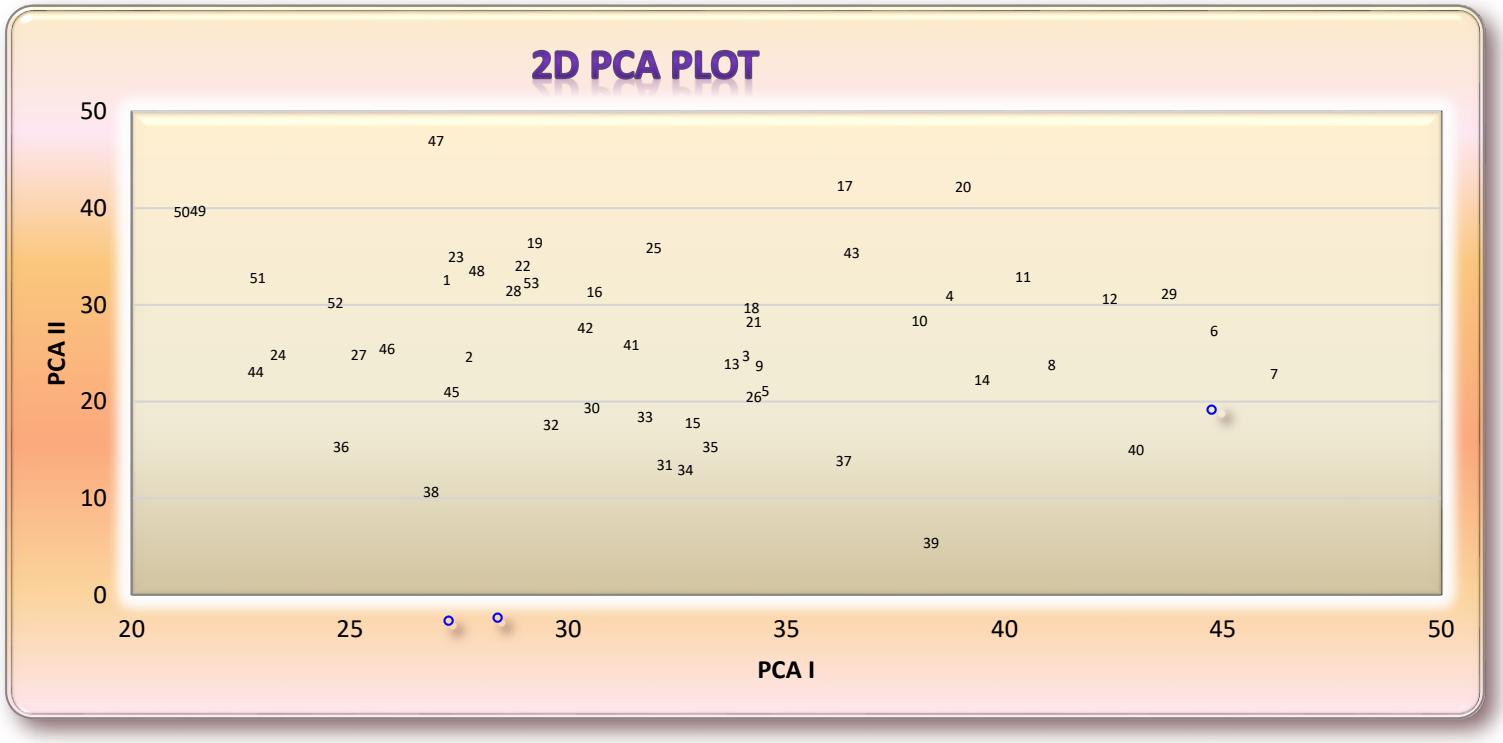

Fig. : 1

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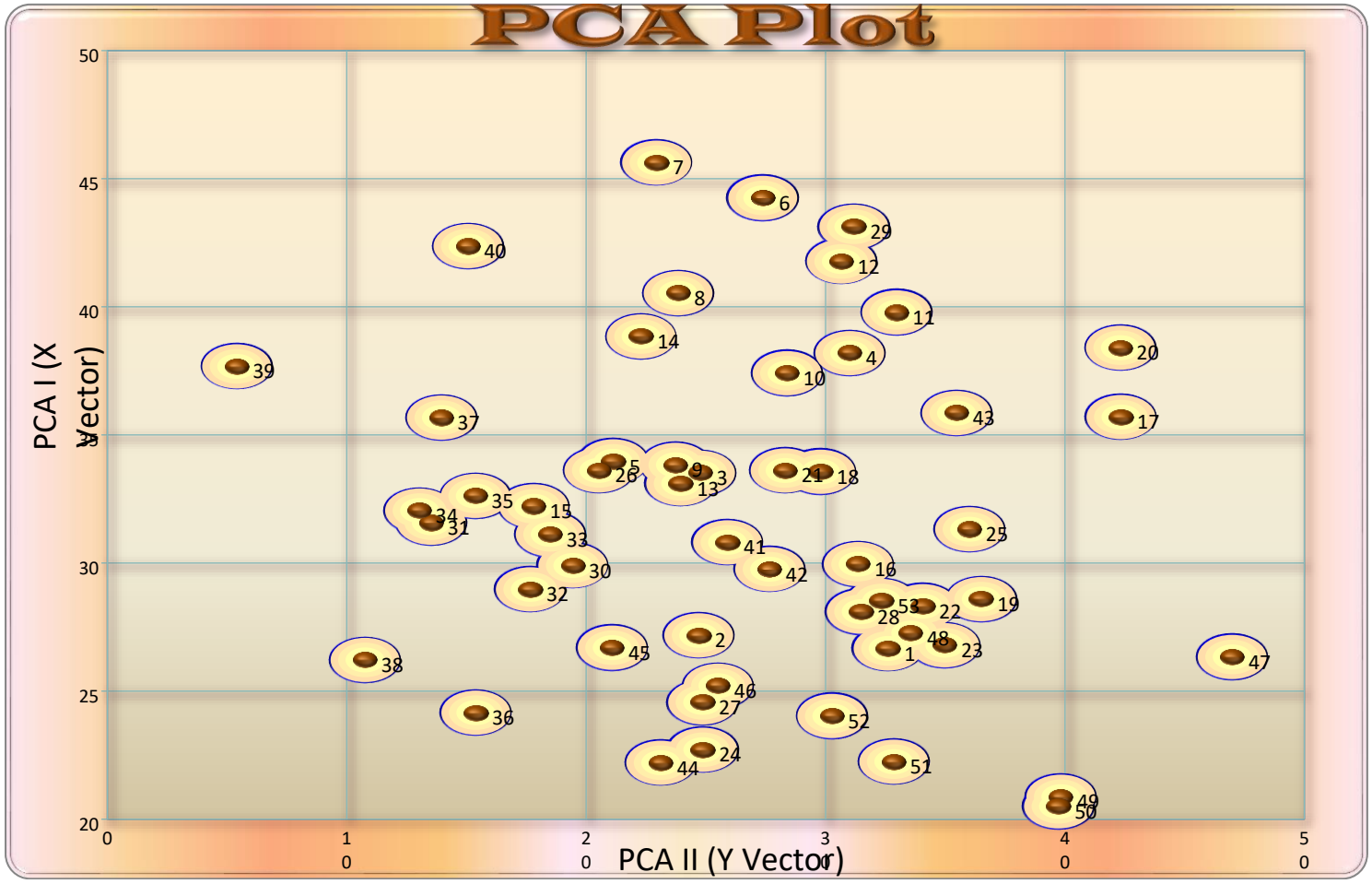

Fig. : 2

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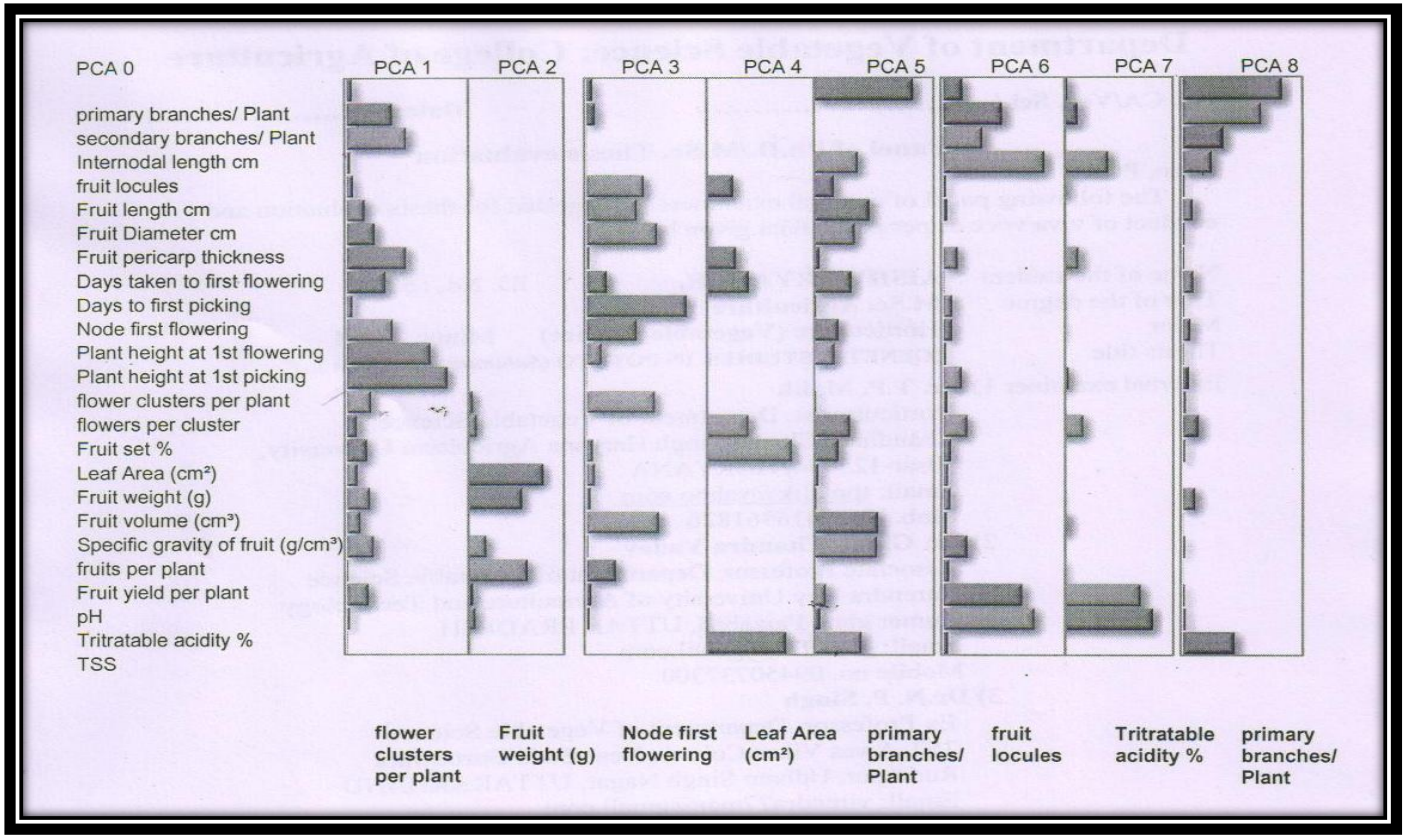

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RESULT AND DISCUSSION

The principal component analysis of 53 tomato genotypes based on correlation matrix of agronomic and quality traits, yielded 8 eigen roots (eigen value) and eigen vectors. These values and associated per cent of variation explained by eigen root have been presented in Table 1. Out of 24 studied traits, 20 qualitative and 4 quantitative characters were studied. The first seven principle component (PCs) with eigen values greater then 1were accounted for 88.75% of the total variance and proportionate contributed of each PC was 21.43, 17.322, 16.581, 10.112, 7.941, 7.077, 5.325, and 2.964, respectively

According to Mukul *et al*. (2022) 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%. Brejda *et al*., (2000) 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) ; Chernet *et al*., (2014) ; Iqbal *et al*., (2014) ; Rai *et al*., (2017); Tsagaye *et al*., (2019) ; Ibrahim and El-Mansy (2021) and Sinha *et al*. (2021). Based on the average of two year mean data the eigen root of first principal component accounted approximately 21.437 per cent variation of total variation followed by 2^{nd} to 8^{th} principal components which accounted for 17.322, 16.581, 10.112, 7.941 and 7.077 per cent variation of total variation present among the genotypes, respectively. Approximately 80.47

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per cent variation was accounted by the first 6 principal components, however, the principal components 7 and 8 contributed very small amount of per cent variation. Based on the average of two year mean data, the first principle component had high positive weight to flower cluster per plant (0.393) followed by plant height at first picking (0.358) and days taken to first flowering (0.302). It had high negative weight to plant height at first flowering (-0.265), fruits per plant (-0.204) and flower per cluster (-0.192). Based on the average of two year mean data, the second principle component had high positive load to fruit weight (0.429), fruit volume (0.380) and pH (0.234). It had high negative weight to fruit yield per plant (-0.393), fruits per plant (-0.281) and fruit set (-0.248). Based on the average of two year mean data, the third principle component had high positive weight to node number at first flowering (0.417), plant height at first flowering (0.296) and fruit yield per plant (0.223). It had high negative weight to specific gravity of fruit (-0.354), fruit pericarp thickness (-0.350) and flower per cluster (-0.345). Based on the average of two year mean data, the fourth principle component had high positive loading to TSS (0.429), days to first picking (0.344) and days taken to first flowering (0.310). It had high negative weight to leaf area (-0.440), fruit set (-0.343), and fruit pericarp thickness (-0.192). Based on the average of two year mean data, the fifth principle component had high positive weight to primary branches per plant (0.397), specific gravity of fruit (0.320) and fruit diameter (0.299). It had high negative weight to fruits per plant (-0.317), TSS (-0.277) and fruit locules (-0.266). Based on the average of two year mean data, the sixth principle component had high positive weight to pH (0.386), secondary branches per plant (0.333) and fruit set (0.212). It had high negative weight to fruit locules (-0.437), tritratable acidity (-0.414) and days taken to first flowering (-0.162). Based on the average of two year mean data, the seventh principle component had high positive weight to tritratable acidity (0.487), secondary branches per plant (0.243) and primary branches per plant (0.190). It had high negative weight to pH (-0.454), fruit locules (-0.362) and fruit set (-0.270). Based on the average of two year mean data, the eighth principle component had high positive weight to primary branches per plant (0.514), TSS (0.370) and intermodal length (0.327). It had high negative weight to secondary branches per plant (-0.457), fruit locules (-0.274) and fruit volume (-0.177). In the present investigation 7 principle components had extracted eigen value of >1. This contributed 85.795% of

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the variation among the 53 genotypes of tomato. Principle component I, contributed for 21.437 % to the total variability. The variation on principle component I was mainly attributed due to flower cluster per plant , plant height at first picking, days taken to first flowering , plant height at first flowering , secondary branches per plant, days to first picking , fruit pericarp thickness and leaf area. The principle component II contributed for 17.322% to the total variability and was depicted mainly by fruit weight, fruit volume, pH, primary branches per plant, days to first picking, internodal length, fruit pericarp thickness, plant height at first picking and secondary branches per plant. The principle component III contributed for 16.581% of the total variability and was mainly attributed to node number at first flowering, fruit yield per plant, plant height at first flowering, days to first picking, secondary branches per plant, primary branches per plant, pH, tritratable acidity and fruits per plant. Character having relatively higher value in the first principle component had more contribution to the total genetic diversity and these were responsible for the differentiation of tomato genotypes into different cluster. The first principle components exhibited for the traits under study and therefore good scope for tomato crop improvement may be accomplished through inter varietal development.

Kaiser (1958) suggested to used only first three principle components because other components have eigen root more than unity but in present investigation first 3 components accounted only 55.340% of variation. Based on 2 year average of mean data correlation matrix of important economic traits. However Rao (2002) reported that covering 90% variation is useful. In line with the present finding Mohanty *et al.*,(2002) found that Ist three principle component accounted for 57.1% of the total variation for 143 processing tomato lines. Similarly Ara *et al.*, (2009) also reported that Ist three principle component explained more than 70% of total variation in the 35 genotypes studied. Fig. 1 shows three dimensional ordinates of 53 genotypes of tomato which reveals that there are enough genetic variability among the genotypes under study, also Fig. 2 indicate two dimensional ordinates which shows genetic diversity of tomato genotypes under study.

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SCORE PLOT

Fig. 1 showed the principle component scatter plot of the tomato genotypes depicted that the genotypes those were close together were perceived as being similar when rated based on the variables. Thus genotypes H-816 and AC-05-06 were close to each other on both PC I and PC II respectively. The genotype PT-42 and EC-519972 were separated from other genotypes. The genotypes in the positive ordination may be utilized for heterosis breeding programme.

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