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Genetic Variability in High Yielding Tomato (*Solanum lycopersicum*) Lines

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Abstract: Tomato (*Solanum lycopersicum* L.) is considered the most valuable crop because of its high consumption in both developed and developing countries. Due to climatic and agronomic factors, there has been a gradual decrease in tomato production and quality in the world including Pakistan. In this research, an experiment was conducted at the research farm of MNS-UAM. Thirty tomato genotypes were sown under Randomize Complete Block Design with three replications and five plants per replication. The genotypes were planted in nursery trays in October 2023 and after one month, tomato seedlings were transferred to the field. The data were recorded for germination percentage (%), plant height(cm), stem pubescence, number of branches per plant, days to flowering(days), days to fruiting(days), fruit length(cm), fruit diameter (cm), fruit weight(g), number of fruits per plant, fruit yield per plant. The collected data was subjected to analysis of variance, correlation, and biplot analysis. There was a significant difference among all genotypes regarding all traits. Correlation analysis showed positive and negative associations among genotypes. The biplot analysis showed that LY06, LY48, CW04, CW06, and Naqeeb have the highest yield related to all other genotypes and are selected as high-yielding genotypes.

Keywords: Tomato, Genetic Variability, Yield, Biplot, Correlation

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1. Introduction

Tomato (*Solanum lycopersicum* L.; 2n=24) is the world's second most significant and widely grown vegetable crop, cultivated in fields, greenhouses, and tunnel sheets all over the world (Serio *et al.,* 2006). It holds an important economic position around the world (Ashish et al., 208). It is a multipurpose crop that is grown for fresh markets and also processed into juices and pastes (Thapa, 2014). It belongs to the genus Solanum. It is a member of the third most productive crop family Solanaceae. In some countries, it is also known as poor man's orange (Akhter et al., 2021). It is an important ingredient in sauces, pickles, ketchup, and juices. It is highly nutritionally important due to its high concentration of carotenoid substances. Lycopene and anthocyanin give red and purple colors to the tomato fruits. The world consumption of tomatoes has increased significantly as a result of their uses in raw, cooked, and processed forms. Its fruit consists of polyphenols, carotenoids, lycopene, vitamin C, vitamin A, antioxidants, and β-carotenes. Vitamins A, C, and E, as well as minerals that are excellent for the immune system and guard against illness, are all found in tomatoes (Taylor, 1987). This crop holds significant value in horticulture globally. Its impact on the global economy is substantial. They are indigenous to South and Middle America (Rick, 1976; Gebhardt, 2016; Ashish et al., 2017). The most widely produced vegetable crop in the world is the tomato (*Solanum lycopersicum L*.). Tomatoes are indigenous to South America. With a global production of about 164 million tonnes, tomatoes rank as the second most favored vegetable globally, following potatoes. While tomato cultivation in both the dry and wet seasons significantly contributes to the nation's tomato production needs, almost all of the crop is produced during the period of dryness, especially in the southern regions. Due to the lack of advanced growing techniques, agricultural equipment, and effective pesticides, there is a huge gap in the annual tomato production in Pakistan. The yield and quality of tomatoes have been reduced due to climate change. It has become much more important to produce high-yielding and good-quality tomato varieties that can adapt to changing environments (Mittler, 2006). This crop's high yield and quality can be secured through genetic improvement (Akram et al., 2019). Characterization and estimation of genetic diversity for the selection of high-yielding genotypes is very important in plant species because these have an important role in the identification of genetic information of genotypes. The ability of genotypes to produce high-yielding cultivars is important for crop improvement in both yield and quality perspectives. Now, researchers have been taking initiatives towards the selection of desirable high-yielding and good-quality inbred lines for the development of F1 hybrids.

2. Materials and Methods

The tomato germplasm was collected from the University of Agriculture Faisalabad Pakistan, and imported from China. Thirty genotypes were sown in plug trays in October 2023 with two check varieties i.e. Sahil and TO1057. Following a month, seedlings were moved into three replications using the randomized complete block design (RCBD) at the study area of MNS University of Agriculture, Multan (MNSUAM). The transplantation process was carried out utilizing a planter, ensuring a spacing of 45 cm between individual plants and 75 cm between the beds. The climatic conditions in this area are characterized as subtropical, featuring an average annual precipitation of 175 mm, with 88% of this rainfall concentrated between July and September. The average monthly temperature fluctuates between 21˚ C and 38˚ C during the period from January to April. The calculation of the germination percentage was performed utilizing the subsequent formula;

$$Germination\ (\%) = \left[\frac{\text{Number of germinated seeds}}{\text{total number of seeds}}\right] \times 100$$

Stem pubescence in tomatoes refers to the presence and density of tiny hairs or trichomes on the stem Days to fruit were counted from the time it takes to produce ripe fruit after flowering. Fruit length was measured as the distance from the base to the tip of the tomato fruit along its longest axis in cm while fruit diameter was measured as the widest part of the tomato fruit across its circumference in mm) using a digital Vernier caliper. The mature fruits of the five designated plants were harvested, enumerated, and aggregated during each collection, with their average data carefully documented. After harvesting, the weight of five randomly selected fruits from each replication was measured using a digital balance having a readability of about 0.01 grams. Fruit yield per plant was measured as the total weight or count of harvestable fruits produced by an individual tomato plant during its growing season. Analysis of variance (ANOVA) was done to find major differences among the genotypes (Steel *et al.*, 1997) using software “R-Studio” . Correlation analyses were performed to check the connectivity of several yield-relevant characteristics. Biplot analysis was performed to find out the best high-yielding genotypes for their trait association in different environments (Rohlf, 2000).

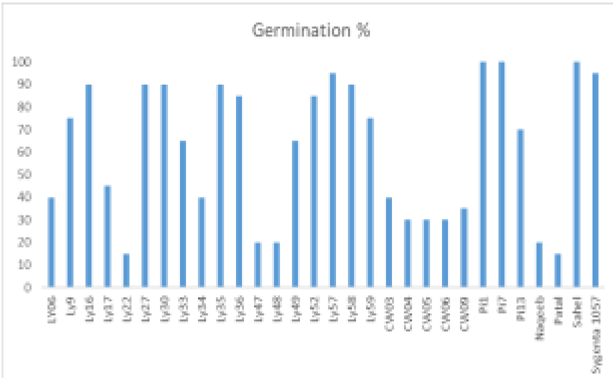

Fig. 1. Germination percentage of different tomato genotypes

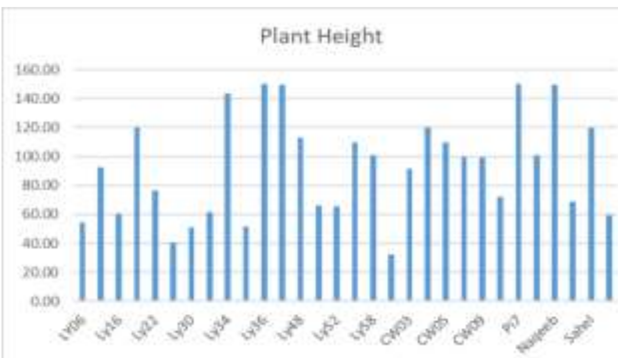

Fig. 2. Plant Height of different tomato genotypes

3. Results and Discussion

3.1. Phylogenetic analysis and chromosomal location

A Tomato uses are diverse, ranging from culinary applications to industrial processing, making it one of the most important crops worldwide. It is used in different forms either fresh or processed. The farming of tomatoes has gained popularity since the mid-19th century due to food requirements. The increasing population needed high-yielding and better-quality varieties because of the increasing population and their concern for nutrition. So as a result, tomato breeding techniques that focus on improving both quality and fruit production are of much concern. Pi1 and Pi7 stand out highest germination percentage (>95%) among all genotypes. Other genotypes, such as Ly16, Ly27, Ly30, Ly33, and Ly58, also show high germination percentages, ranging from 90% to 95% (Fig. 1). LY36 and LY48 had highest plant height of 150 cm (Fig. 2). CW05 showed highest number of branches i.e. 12, significantly higher than other genotypes, while CW06 and Ly36 also exhibit high branch numbers of 8 and 9, respectively (Fig. 3). Ly06 produces the longest fruits at 6.90 cm, followed by Ly34 at 6.53 cm, and Ly48 at 5.60 cm. Ly48 has the largest fruit with a diameter of 6.17 cm, closely followed by CW04 with a 6.00 cm diameter (Fig. 4). The number of fruits (NOF) is highest in Pi1, with 395.67 fruits, followed by Pi13 with the same number, and Ly9 with 360.00 fruits, showing that these genotypes are highly productive in terms of fruit yield. Ly48 emerges as the superior genotype, demonstrating the highest yield potential (747 g), followed closely by Ly06 (717 g) and CW04 (600 g) (Fig. 5). The analysis of variance shows a significant difference in genotypes (Table 1). Al-Aysh et al. (2012) also found highly significant differences among the tomato genotypes for all the traits studied.

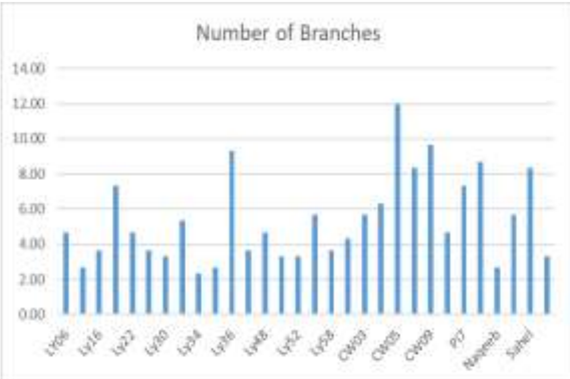

Fig. 3. Branches data of different tomato genotypes

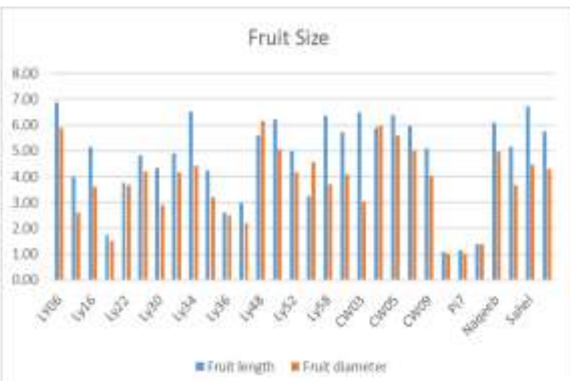

Fig. 4. Fruit size of different tomato genotypes

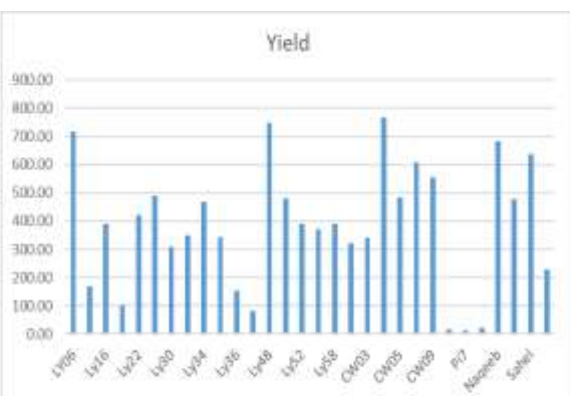

Fig. 5. Fruit Yield of different tomato genotypes.

The correlation analysis of the provided data reveals several key relationships between the variables. The correlation analysis shows that plant yield is highly positively correlated with fruit length and fruit diameter. The number of fruits (NOF) is moderately positively correlated with fruit length (FL) and fruit diameter (FD), suggesting that plants with more fruits also tend to have longer and slightly larger fruits. There is also a positive relationship between NOB and NOF, supporting the idea that more branches lead to more fruits. While the number of branches (NOB) has a weak positive correlation with plant yield (PY), it is not as strong as the correlation between germination percentage and yield. Plant height (PH) shows a moderate positive correlation with the number of branches (NOF), indicating that higher values tend to favor a greater number of fruits. On the other hand, plant height is moderately negatively correlated with fruit length (FL), implying that higher plant height might slightly reduce fruit length. The relationship between PH and plant yield (PY) is very weak, indicating that plant height has minimal impact on yield in this dataset. Both fruit length and fruit diameter exhibit a strong positive correlation with each other, meaning that as fruits grow longer, they also tend to be wider. However, fruit length (FL) and plant yield (PY) show a very weak positive correlation, indicating that fruit size alone may not strongly influence overall yield. Similarly, fruit diameter (FD) has a weak positive correlation with plant yield (PY), suggesting that fruit size has a minimal impact on yield. Manjo and Dudi (2011) found a positive correlation between the number of fruits, fruit weight, and sugar content. Ashish et al. (2017) reported yield per hectare is positively correlated with the number of fruits per plant, pericarp thickness, and average fruit weight and suggested that average fruit weight and number of fruits per plant should be considered as important traits for tomato selection (Kumar et al., 2013; Ashish et al., 2018).

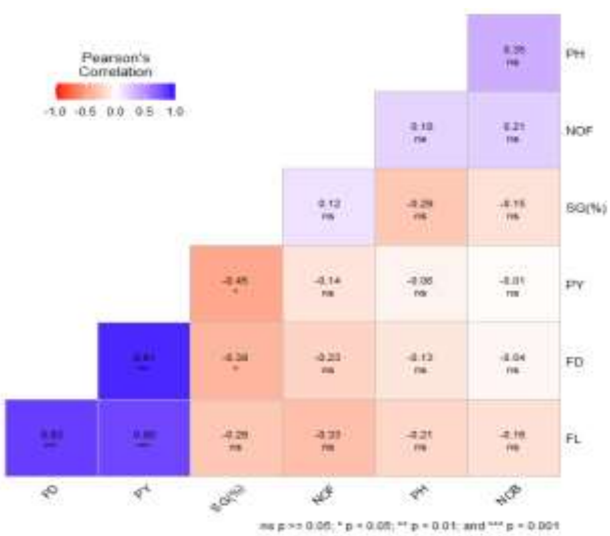

Fig. 6. Blue color indicates a positive and red color indicates a negative correlation between yield related traits, SG (Seed Germination %), PH (Plant height), NOB (No of branches), NOF (No of fruit), FL (Fruit length), FD (Fruit diameter), and PY (Plant Yield).

The biplot analysis reveals several key insights into the genotypes' performance across various traits. Pi1 and Pi7 are the top performers in terms of germination percentage, showing the highest germination rates among all genotypes. Ly06 stands out as the top long fruit-bearing genotype, followed by Ly34 and Ly48, which also produce relatively long fruits. In terms of fruit diameter, Ly48 exhibited the largest fruit diameter followed by CW04 and Ly06. It is one of the key parameters used to describe the size and shape of tomato fruits. CW05 exhibits the highest number of branches, followed by Ly36 and CW06, which also show significant branching. In terms of number of fruits, Pi1 ranks highest, with Pi13 and Ly9 following closely behind. ILy48 emerges as the superior genotype, demonstrating the highest yield potential (747 g), followed closely by Ly06 (717 g) and CW04 (600 g). It’s a crucial metric that directly measures the productivity and efficiency of tomato cultivation. Biplot analysis highlights the significant role of germination percentage in influencing both plant yield and other traits like branching and fruiting. Optimizing germination could be key to improving both the quantity and quality of the plants, while traits like fruit size and number may have a more limited direct impact on yield. Similar reports were presented by Ghorbanpour et al. (2018), Naher et al. (2020) and Ene eat al. (2022).

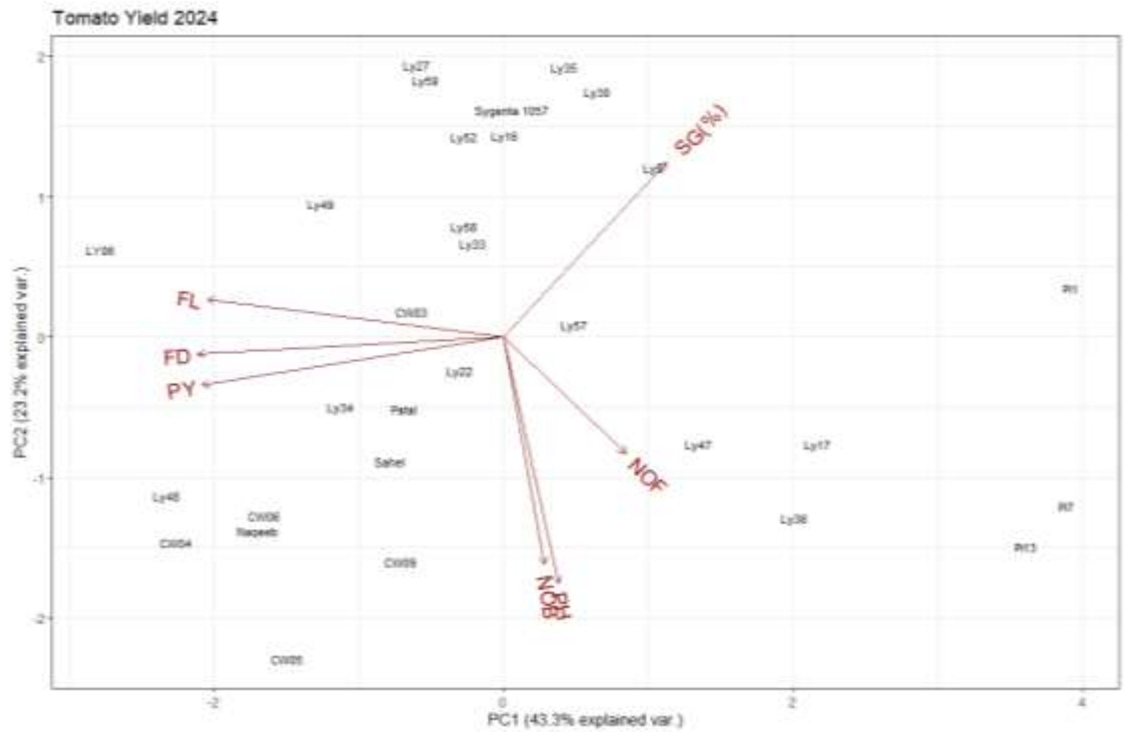

Fig. 7. Biplot analysis of tomato genotypes for morphological traits.

Table 1. Analyses of variance showing significant variation among studied traits of tomato genotypes

Source	DF	PH	NOB	NO-FL	NO-FR	FL	FD	FW
Genotypes	29	108335 **	18.3989 **	20804.6 **	18809.9 **	9.20566 **	6.06569 **	142803 **
Block	2	44	0.4333	61.2	18878.5	1.684	0.00178	2
Error	58	314	0.4563	6.8	163.1	0.947	0.01626	33
Total	89							

^{Ns}Non significant, *Significant (P<0.05), ** Highly significant (P<0.01).

4. Conclusion

In this study, 30 tomato genotypes were evaluated to identify high-yielding varieties with desirable traits. There was a significant difference among all genotypes regarding all traits. Pi1 and Pi7 are ideal for achieving high germination percentages, while CW05 is notable for its superior branching ability. Each genotype's strengths make them suitable for different breeding or cultivation objectives, depending on the desired traits. Ly48 emerges as the most well-rounded genotype, excelling in both plant yield (747 g) and fruit characteristics. These traits are critical for optimizing tomato production, and the identified genotypes offer valuable prospects for improving both the quantity and quality of tomato yields. The results from this study provide a strong foundation for future breeding efforts aimed at enhancing the productivity and resilience of tomato crops.

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Conflict of Interest

All authors declared that there is no conflicts of interest with respect to research, publication and authorship of this research paper.

References

Bano Akhter, A., A. Nabi, B. Afroza, N. Nazir, P.A. Sofi, S.A. Indrabi, A. Sultan, I. Javeed and M. Rashid. 2021. Evaluation of cherry tomato (*Solanum lycopersicum* L. var. cerasiforme) genotypes for yield and quality traits. Journal of Community Mobilization and Sustainable Development. 16:72-76.

Akram, W., H. Aslam, S.R. Ahmad, T. Anjum, N.A. Yasin, W.U. Khan, A. Ahmad, J. Guo, T. Wu, W. Luo and G. Li. 2019. Bacillus megaterium strain A12 ameliorates salinity stress in tomato plants through multiple mechanisms. Journal of Plant Interactions 14:506-518.

Al-Aysh, F., H. Kutma, M. Serhan, A. Al-Zoubai and M.A. Al-Nasser.2012. Genetic Analysis and Correlation Studies of Yield and Fruit Quality Traits in Tomato (*Solanum lycopersicum* L.). New York Sciences Journals 5:142-145.

Ashish, K., S. Anita, C. Akshay, N. Lalit, Y. Rajeev and K. Maheesh. 2017. Variability and correlation study in tomato (*Solanum lycopersicum* L.). International Journal of Agriculture Sciences 9:4391-4394.

Ashish K.S., S.S. Solankey, S. Akhtar, P. Kumari and J. Chaurasiya. 2018. Correlation and path coefficient analysis in tomato (*Solanum lycopersicum* L.). International Journal of Current Microbiology and Applied Sciences 7:4278-4285.

Ene, C.O., W.G. Abtew, H.O. Oselebe, F.U. Ozi and U.N. Ikeogu. 2022. Genetic characterization and quantitative trait relationship using multivariate techniques reveal diversity among tomato germplasms. Food Science and Nutrition 10:2226-2242.

Gebhardt, C. 2016. The historical role of species from the Solanaceae plant family in genetic research. Theor. Appl. Genet., 129, 2281-2294.

Ghorbanpour, A., A. Salimi, M.A.T. Ghanbary, H. Pirdashti and A. Dehestani. 2018. Relationship between fruit yield and its components in tomato (*Lycopersicon esculentum* Mill.) cultivars using multivariate statistical methods. Journal of Crop Breeding 9:22-29.

Kumar, D., R. Kumar, S. Kumar, M.L. Bhardwaj, M.C. Thakur, R. Kumar, K.S. Thakur, B.S. Dogra, A. Vikram and P. Kumar. 2013). Genetic variability, correlation and path coefficient analysis in tomato. International Journal of Vegetable Science 19:313–323.

Mittler, R. 2006. Abiotic stress, the field environment and stress combination. Trends in Plant Sciences 11:15–19

Naher, N., M.K. Uddin, K.U. Ahamed and A.K.M.M. Alam. 2020. Performances of tomato cultivars in coastal areas based on GGE biplot analysis. Progressive Agriculture 31:94-103.

Rick C.M. 1976. In Tomato. Evaluation of Crop Plant. London. 268-273pp

Rohlf, F.J. 2000. NTSYS-pc: numerical taxonomy and multivariate analysis system, version 2.1. Exeter Software: Setauket, NY

Serio, F., O. Ayala, A. Bonasia, and P. Santamaría. 2006. Antioxidant Properties and Health Benefits of Tomato.

Steel, R.G., J.H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics: a biometrical approach.

Taylor, J. H. 1987. Text of lectures delivered at the national workshop on fruit and vegetable seedlings production held at NIHORT.

Thapa, R. 2014. Genetic Variability and Fruit Morphological Diversity in the Tomato Germplasm.

Manjo, K. and B. S. Dudi. 2011. Study of correlation for yield and quality characters in tomato (*Lycopersicon esculentum* Mill.). Electronic Journal of Plant Breeding. 2:453-460.