Journal of Agriculture and Veterinary Science
ISSN: 2959-1198 (Print), 2959-1201 (Online)

Check for updates

Research Article

Evaluation of Agronomic Performance and Yield Related Attributes of Tomato (*Lycopersicon esculentum*) Varieties under Agro-Climatic Conditions of Pothwar Region

Ayesha Manzoor[1], Muhammad Saqib Naveed[1], Rana Muhammad Azhar Ali[1], Khuram Danial Shah[2], Muhammad Farooq Ahmed[1]
[1]*Barani Agricultural Research Institute, Chakwal, Pakistan.*
[2]*Department of Plant breeding and genetics, PMAS Arid Agriculture University, Rawalpindi, Pakistan.*

ABSTRACT

Production and productivity of crop not only depends upon environmental factors or cultural practices, but also influenced by genotype adaptability to an area. Introduction of high yielding genotypes, their evaluation and acclimatization to a specific environment/location have an important role in crop improvement. Thus present study was conducted to evaluate growth and yield performance of five commercially cultivating determinate tomato varieties in the Pothwar region. Nursery raising, transplantation, growth and yield studies were done at the Vegetable section of Barani Agricultural Research Institute. From experimental findings, it was studied that Nadir variety performance was best among other varieties due to its genetic constitution along with favorable growing conditions that lead to maximum plant vigor, highest number of primary branches, number of flowers/cluster, fruit weight (g), fruit length (cm) and width (cm) and significant marketable yield (25.57 t/ha) with lowest non-marketable yield (0.68 t/ha). It also gives maximum gross return and benefit cost ratio (1.48) because of long shelf life and high market demand. Roma and Rio-grande are also considered as a potential varieties because of effective vegetative and reproductive growth, however Nagina and Naqeeb were least performing varieties as they yield more non-marketable fruit that marketable fruit along with production of smaller size fruits. On the basis of results, it is recommended that further 2-3 years performance evaluation of variety must be carried out to ensure its yield potential in Pothwar region.

Keywords: Adaptability, Fruit Weight, Marketable Yield, Performance, Tomato.

Correspondence
Ayesha Manzoor
manzoorayesha12@yahoo.com

Article History
Received: July 28, 2024
Accepted: September 10, 2024
Published: October 16, 2024

INTRODUCTION

Tomato (*Lycopersicon esculentum*), a member of Solanaceae family is originated from Mexican and Peruvian region. It is 7th most consumed crop of the world with an average increase of 0.25 kg demand per person per year (Ali et al., 2022) and ranks next to potato and sweet potato under vegetable production status (Benti et al., 2017). Tomato is widely included in human diet either fresh or in preserved form due to its nutritional profile. It contains nutrients, vitamins, secondary metabolites, organic acids, soluble and insoluble solids (5-15%) flavonoids, lycopene, β-carotene and phenolics (Basumatary et al., 2022; Sirba et al., 2022). Tomato is grown as annual or short lived perennial crop sexually propagated through seeds (Jain et al., 2022). It has been globally cultivated in tropical, subtropical and temperature regions due to high yielding potential, wider adaptability and multipurpose usage (Kumar, 2021; Sirba et al., 2022).

It has been cultivated in 144 countries producing 2.4 million hectare with Europe being top producing continent followed by Asia and Africa producing 4 million tons of tomato each year. However, only 15% tomato comes from tropical region due to climatic conditions and under developed production technology (Ali et al., 2022; Gebremeskel et al., 2016). In 2022, approximately 186.12 million tonnes tomato were produced from an area of 5 million hectare with average yield 37.84 t/ha were reported (FAOSTAT, 2022).

Tomato can be grown in different climatic zones but it is a warm season crop and required abundant sunshine for growth. It requires 25-30^{o}C temperature for optimum growth and development while temperature below 10^{o}C and above 38^{o}C negatively impacted plant growth and yield (Hassan et al., 2021). Extreme low or high temperature leads to poor fruit setting as extreme high temperature causes abortion of male gametophyte (Kaur et al., 2023). Apart from temperature, slightly acidic pH (6-6.8) with active photosynthesis 400-700nm promotes effective plant growth (Hassan et al., 2021). Tomato plants need aerated soil because of its sensitivity to water logged conditions (Kaur et al., 2023).

In Pakistan, annually two crops are produced. During fall season, nursery raising starts in November and transplantation started in February, whereas for summer season nursery raising starts in June and transplanted in August. However, these seasons may vary due to rapidly changing climatic conditions (Hussain et al., 2020).

Despite having wide range of adaptability, its production affected by various factors included unavailability of quality seed, lack of particular variety for a specific area, pest and disease incidence, poor soil fertility, and high postharvest loss etc. (Sirba et al., 2022). Among these factors, climatic and environmental conditions of a growing location have a significant role in introduction or adaptability of new cultivar to an area. Moreover, genotypic factors are also influenced by environmental factors (Hassan et al., 2021; Tsagaye and Alemu, 2021). Besides that, nutritional properties of tomato fruit is significantly influenced by genotype, maturity and growing environment (Asensio et al., 2019). Performance of tomato cultivars varies from location to location due to varying environmental conditions. Consequently, yield potential of a specific cultivar doesn't remain same at different regions (Kanaujia and Phom, 2016). Thus, multi-locational trial of a cultivar helps breeder in measuring the influence of varying environment on the genes, aids in recommending cultivar to a specific location (Onyia et al., 2019). It is essential to evaluate different cultivars in order to improve their adaptability at a certain area or a microclimate (Ali et al., 2022).

Keeping in view the importance of tomato both in domestic market along with export level. It is necessary to increase its productivity by improving adaptability under varying environmental conditions. Thus the present research was conducted to evaluate agronomic performances and adaptability of different genotypes with an aim to identify potential genotype for Pothwar region.

MATERIALS AND METHODS

Plant Material and Experimental site

In present research, five determinate tomato varieties "Nadir, Nagina, Naqeeb, Rio grande and Roma" were evaluated on the basis of vegetative, reproductive and yield related parameters. Seeds of these varieties were collected from Vegetable Research Institute and study was carried out during March-June 2023 at vegetable section of Barani Agricultural Research Institute. This experimental site is located at 72° longitude and 32° latitude with an altitude of 575m. The climate of an area consists of arid to semi-arid having annual mean temperature of 22.3^{o}C with average annual rainfall up-to 519 mm (Hassan et al., 2022).

Methodology

Soil of the experimental area was prepared to a good tilth and farmyard manure (40 ton ha^{-1}) was applied. Nursery of tomato varieties was sown at the end of December 2022 in nursery trays. After 90 days nursery was transplanted with a dimensions of 1ft plant to plant distance on both side of raised beds prepared 3 ft wide and 14 ft long. First irrigation was applied just after nursery transplantation, while subsequent irrigations were applied as per crop requirement. Fertilizers (125:125:123 kg ha^{-1}) were applied using Urea in three splits as a nitrogen source, while Diammonium phosphate (DAP) and Sulphate of potash (SOP) before beds preparation as a source of phosphorous and potash, respectively.

Data collection

Data of phonological parameters i.e., plant height (cm), number of primary branches/plant, days taken to 50% flowering, days taken to first fruit picking, number of flower/clusters, Number of fruits/cluster, total cluster/plant, plant vigor were noted.

Plant vigor was recorded at 50% flowering stage using a scale (1-5) developed by Gotame et al. (2021)

Plant vigor scale rating is as follow:

1: Very weak= all plants were small, few leaves, week plants, very thin stems and light green color).
2: Week = (75% of the plants were small or all plants were shorter than normal plant height, plants have few leaves, thin stem and light green color).
3: Medium = intermediate or normal growth.
4: Vigorous = 75% of the plants were taller than normal, robust with foliage of dark green color, thick stems and leaves were well developed).
5: Very vigorous (all plants were taller than normal, ground completely covered by foliage, plants were robust, with a thick stem and abundant foliage of dark green color).
For yield related parameters: Fruit length, width (cm), weight (g), marketable yield (t/ha), non-marketable yield (t/ha) and total yield (t/ha) were recorded respectively.
Marketable and Non-marketable fruit Yield: fruits with cracks, diseased, insect and bird damage, sunburn and small sized fruits were considered as non-marketable fruits. While fruits free from above mentioned damage and above 50g are recognized as marketable fruits (Regassa et al., 2012; Max et al., 2016).

Experimental layout and statistical analysis

The experiment was executed as a single factor arranged in randomized complete block design (RCBD) with four replications (each replication comprised of 30 plants). Data were collected and analyzed statistically using analysis of variance (ANOVA) in Statistix 8.1 and difference among means were calculated by least significant difference (LSD) at 0.05 probability level (Steel et al., 1997). Correlation analysis was done in excel to study relationship between two variables.

RESULTS

Performance evaluation of different tomato varieties

Performance evaluation of different tomato varieties on the basis of phenological traits were found to be significantly different at 5% probability level (Table 1). According to analysis of variance, variety “Roma” under agro-climactic conditions of Pothowar, produce plants of maximum height (73.00 cm) and takes minimum days to 50% flowering (45.33 days), fruit formation (69.33 days) and days taken to fruit maturity (78.33 days) respectively. However, number of branches/plants were significantly higher in Nadir variety (7.64) as compared to Roma variety which produced only 3.33 branches/plant. Thus, on the basis of plant height, number of branches and plant spread, it was observed that ‘Nadir” variety had most vigorous plants with respect to other studied varieties.

Table 1. Performance evaluation of tomato varieties for phenological growth stages.

Variety	Plant height (cm)	Number of primary branches	Days taken to 50% flowering	Plant Vigor	Days taken to fruit formation	Days taken to fruit maturity
Nadir	58.67 ^{bc}	7.64 ^{a}	49.60 ^{d}	5.00 ^{a}	70.30 ^{c}	85.00 ^{b}
Nagina	54.70 ^{cd}	4.00 ^{c}	52.70 ^{c}	2.67 ^{c}	73.00 ^{b}	81.23 ^{c}
Naqeeb	50.33 ^{d}	4.33 ^{bc}	56.00 ^{b}	3.00 ^{c}	81.06 ^{a}	84.33 ^{b}
Rio grande	61.67 ^{b}	5.70 ^{b}	62.12 ^{a}	4.00 ^{b}	74.33 ^{b}	88.67 ^{a}
Roma	73.00 ^{a}	3.33 ^{c}	45.33 ^{e}	3.00 ^{c}	69.33 ^{c}	78.33 ^{d}
cv	4.46	10.70	2.50	9.49	2.32	3.60
LSD $_{(0.05)}$	5.00	1.66	2.25	0.64	1.83	2.51
Grand Mean	59.67	5.00	53.13	3.60	73.60	83.47
SEM ±	2.14	0.45	1.55	0.25	1.13	0.98

Mean values followed by different letter(s) are significantly different at $p \leq 0.05$ according to least significant different (LSD) test. Mean = 120 (30 plants × 4).

Statistical analysis of floral parameters showed that both ‘Rio-grande” and “Nadir” varieties had highest number of total clusters/plant (38.00 and 35.30), number of flowers/clusters (7.33 and 6.33) and number of fruits per clusters (4.00 and 4.67). Whereas for fruit related traits, variety ‘Nadir” performed better in terms of maximum fruit weight (50.30 g), fruit width (5.40 cm) and fruit length (7.03 cm) (Table 2).
Like fruit traits, yield marketable such as marketable yield, non-marketable yield and total yield depicted similar trend and “Nadir” variety had significant total yield (26.24 t/ha) and marketable yield (25.57 t/ha) with minimum non-marketable fruit yield (0.68 t/ha) respectively. On the other hand, “Nageena” and “Naqeeb” are least performing

varieties with highest non-marketable fruit yield (Figure 1).

Table 2. Performance evaluation of tomato varieties for floral and fruit parameters.

Variety	Floral traits			Fruit traits		
	Total cluster/Plant	No. of flowers/ Cluster	No. of fruits/ Cluster	Avg. fruit weight (g)	Avg. fruit width (cm)	Avg. fruit length (cm)
Nadir	35.30 ^{ab}	6.33 ^{a}	4.00 ^{ab}	50.3 ^{a}	5.4 ^{a}	7.03 ^{a}
Nagina	32.00 ^{bc}	3.70 ^{c}	2.33 ^{c}	32.3 ^{d}	4.5 ^{b}	4.3 ^{c}
Naqeeb	28.53 ^{cd}	4.34 ^{bc}	2.66 ^{c}	25.0 ^{e}	4.5 ^{b}	4.1 ^{d}
Rio grande	38.00 ^{a}	7.33 ^{a}	4.67 ^{a}	40.0 ^{b}	4.2 ^{b}	4.6 ^{cd}
Roma	25.33 ^{d}	5.00 ^{b}	3.33 ^{bc}	37.3 ^{c}	3.5 ^{c}	6 ^{b}
cv	8.44	10.55	18.21	3.70	4.33	4.73
LSD $_{(0.05)}$	5.05	1.05	1.06	2.57	0.36	0.46
Grand Mean	31.80	5.33	3.40	37.00	4.44	5.23
SEM ±	1.33	0.37	0.27	2.27	0.17	0.31

Mean values followed by different letter(s) are significantly different at $p \leq 0.05$ according to least significant different (LSD) test. Mean = 120 (30 plants × 4).

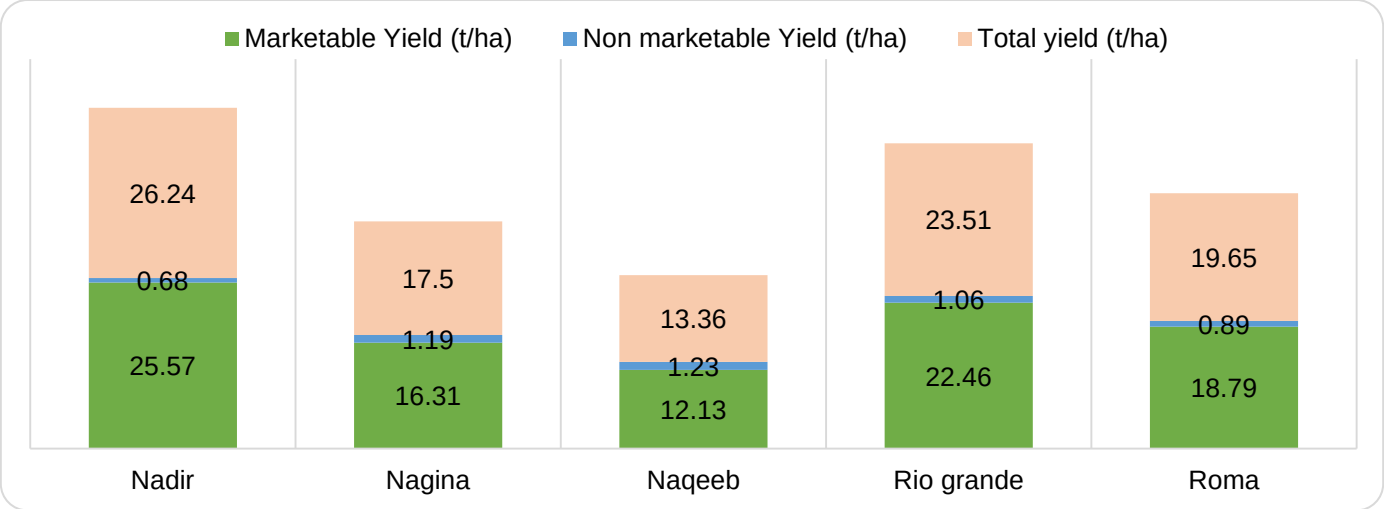

Figure 1. Yield related traits of different tomato varieties under Pothwar conditions.

Correlation analysis

Positive and negative correlation among different morphological (vegetative and reproductive) parameters were presented in figure 2. According to correlation matrix, green color depicts positive correlation between different traits while red color represents negative correlation. Analysis showed that total yield had very strong correlation with fruit weight (0.98), plant vigor (0.86), number of fruits/clusters (0.81) and number of flowers/clusters (0.81), while it was in strong association with number of primary branches (0.77) and total clusters/plant (0.65). Similarly fruit weight was also positively correlated with plant vigor (0.87), number of primary branches (0.77) and total flowers/cluster (0.70) respectively. For primary branches, positive association was found between plant vigor (0.96), fruit width (0.82), fruit weight (0.77), total yield (0.77) and total clusters/plant (0.76).

On the other hand, days to fruit formation was in strong negative correlation with fruit weight and fruit width (-0.75) and total yield (-0.69). Plant height is also negatively correlated with days to fruit formation (-0.75), fruit width (-0.63), days to flowering (-0.49) and days to fruit maturation (-0.42).

Economic Analysis

Economic data presented in Table 3 revealed that cost of production for an hectare was same for all evaluated tomato varieties (Rs. 553 thousand/-). However, on the basis of marketable yield and market price, Nadir variety had maximum gross return (Rs. 818.24 thousand/-) and benefit cost ratio (1.48) followed by Rio-grande having gross return of

Rs.718.72 thousand/- with 1.30 BCR value. But, other varieties Roma, Nagina and Naqeeb cultivation gives low net return owing to their low marketable yield with less market demand that causes reduction in their market price.

	PH	PB	DF	PV	DFF	DFM	TCP	FLC	FRC	FWT	FWD	FL	TY
PH	1.00												
PB	-0.21	1.00											
DF	-0.49	0.20	1.00										
PV	0.05	0.96	0.08	1.00									
DFF	-0.75	-0.17	0.62	-0.32	1.00								
DFM	-0.42	0.67	0.85	0.59	0.39	1.00							
TCP	-0.27	0.76	0.65	0.67	-0.04	0.85	1.00						
FLC	0.31	0.68	0.39	0.79	-0.25	0.71	0.70	1.00					
FRC	0.40	0.63	0.33	0.77	-0.32	0.64	0.65	1.00	1.00				
FWT	0.41	0.77	-0.23	0.87	-0.75	0.24	0.53	0.70	0.71	1.00			
FWD	-0.63	0.82	0.11	0.65	0.09	0.46	0.56	0.16	0.09	0.42	1.00		
FL	0.52	0.55	-0.65	0.69	-0.75	-0.17	0.04	0.39	0.43	0.85	0.30	1.00	
TY	0.41	0.77	-0.04	0.86	-0.69	0.37	0.65	0.81	0.82	0.98	0.36	0.73	1.00

Figure 2. Correlation analysis among growth and yield parameters of tomato varieties
(PH: Plant height; PB: Number of primary branches; DF: Days taken to 50% flowering; PV: Plant vigor; DFF: Days taken to fruit formation; DFM: Days taken to fruit maturity; TCP: Total clusters/plant; FLC: Flowers/cluster; FRC: Fruits/clusters; FWT: Fruit weight; FWD: Fruit width; FL: Fruit length; TY: Total Yield)

Table 3. Economic analysis and benefit cost ratio of evaluated tomato varieties.

	Input		Output		
Variety	Cultivation cost (000 Rs/-)	Marketable Yield (t/ha)	Market price (000 Rs/-)	Gross Return (000 Rs/-)	Benefit:Cost Ratio (BCR)
Nadir	553.685	25.57	32	818.24	1.48
Nagina	553.685	16.31	31	505.61	0.91
Naqeeb	553.685	12.13	31	376.03	0.68
Rio grande	553.685	22.46	32	718.72	1.30
Roma	553.685	18.79	30	563.7	1.02

DISCUSSION

Agronomic traits/parameters are effective characters in assessing plant growth and development in response to various environmental conditions (Ochar et al., 2019). In this study, significant variation were observed in different varieties performance that is usually due to genetic architecture, as there are inherent genetic variation related to photosynthetic abilities that are also influenced by environmental factors (Asare-Addo et al., 2022).

Phenological traits like days taken to 50% flowering, fruit formation and fruit maturity etc determines the earliness of a variety as early crop can leads to early harvest that can fetch higher price by avoiding market glut (Kumar et al., 2024). Early or late maturity trait is mainly influenced by plant genotype and less impacted by growing locations or environmental conditions (Spaldon and Hussain, 2017). Also earliness is considered as an important traits for off-season or rainy season tomato production (Jalloh et al., 2017). In present research, earliness trait in “Roma” variety was attributed due to its higher ability to utilize assimilates up to the plant apex quickly during growth phases of plants results in early flowering (Basumatary et al., 2022). However, it was observed that varieties with maximum days to 50% maturity are high yielder due to their effective resource/nutrient utilization ability, ensuring continuous fruit production as presently “Nadir” despite being late maturing variety, produced higher yield. Similar results were observed by Sirba et al. (2022), as among newly released varieties, “Gelilima” performed better even with late maturity trait.

Usually height is an indicator of vigor and productivity (Sharma et al., 2023) but trait like tallness or shortness are controlled and expressed by certain genes and less influenced by growing conditions (Fikre et al., 2022). Furthermore, an increase in plant height causes an increase in stem girth that prevents stem lodging and contribute

towards plant vigor (Asare-Addo et al., 2022). Moreover, number of primary branches indirectly affect plant yield as more number of branches produced more clusters/plant and fruits/plant thus improving yielding capacity of a plant (Sirba et al., 2022). Increase in primary branches increase yield of tomato under Plain conditions of India (Pamukuntla et al., 2023) and West Shoa zone of Ethopia (Bedassa et al., 2020).

Number of clusters per plant is a direct indicator of number of fruits per plant, subsequently plays part in plant yield and considered as a criteria for varietal selection (Bedassa et al., 2020). Maximum number of clusters per plant in "Nadir and Rio-grande" were due to better genetic makeup. Highest number of clusters per plant also produced maximum yield in variety Bishola (Fikre et al., 2022).

Average fruit weight and length are most important yield contributing parameters as farmers prefers varieties with heavier fruit to get more marketable yield (Mamta et al., 2022). Increase in total yield with an increase in fruit weight was observed by Jain et al. (2022) and Sureshkumara et al. (2017) in different tomato varieties. Since, it is genotypic related traits, thus variation in fruit weight among different genotypes were could be due to presence of multiple alleles associated with genes related to determination of fruit weight (Mulatu et al., 2019). Or because of higher ability of variety to transport photosynthetic products towards different organs and maximum stomatal conduction (Jalloh et al., 2017). In different performance evaluation studies, fruit weight of different varieties/cultivars/hybrids varied from variety to variety (Basumatary et al., 2022; Hassan et al., 2021; Pamukuntla et al., 2023).

Fruit yield, an important economic trait is significantly affected by genetic and environmental factors in terms of abiotic and biotic stresses and growing locations (rainfall, temperature etc) (Spaldon and Hussain, 2017). Also it determines the commercial viability of a variety (Mamta et al., 2022). Moreover, any breeding program pre-requisite is to maximize marketable yield (Chikkeri *et al*., 2023). Higher yield in "Nadir" variety was attributed due to plant health and vigor because of favourable agro-climatic conditions of Pothwar region that developed maximum number of branches and ultimately more number of fruit clusters/plant. Also differences in yield traits among different varieties were linked with genetic makeup of a plant as all varieties were grown in same environmental conditions (Ali et al., 2022). A research conducted by Gebremeskel et al. (2016), observed that Chali variety of tomato produced maximum marketable yield under both irrigation and rainfed conditions. Furthermore, two hybrids "Platinum F_1 and Mongal F_1" had maximum yield both in greenhouse and open field conditions of Ghana (Ochar et al., 2019).

Pearson correlation statistical analysis is used to study relationship between different traits of a varieties (Manzoor et al., 2021). As in current study, positive correlation were observed in between plant yield, number of branches, plant vigor, flowers per clusters and fruit weight. Similar positive association of marketable yield with primary branches and fruit width among different tomato varieties was observed by Ketema and Beyene (2021). In another study, number of flowers was also positively linked with number of primary branches and clusters per plant in newly introduced tomato varieties (Mrema et al., 2014).

Economic analysis depicted maximum benefit for cultivation of Nadir and Rio-grande in field. The higher net profit achieved from these two varieties were because of the oval fruit shape and thick pericarp that prevents fruit compression during transportation, preventing fruit rotting or other postharvest losses. Whereas, other varieties, due to their short shelf life along with high postharvest losses didn't fetch high market price thus contributes towards low consumer demand.

CONCLUSION

Success of tomato production in a particular area/location is mainly depend upon a selection of specific variety for that region through performance evaluation. Nadir variety proved to be high yielding under temperature conditions of Pothwar and therefore recommended for cultivation due to its ability to yield quality and firm fruits also suitable for *long* distance transportation. Moreover, it can generate income for farmer and improves commercialization by producing high marketable yield, an important factor involved in varietal selection.

ACKNOWLEDGEMENTS

The present article was supported and financed by the project number PARB: 18-554 (Development and transfer of the seed production technology of Vegetables (Tomato, Onion, Carrot and Okra) to farmers/private sector Funded by Punjab Agricultural Research Board.

AUTHOR CONTRIBUTIONS

Ayesha Manzoor: Conceptualization, original draft preparation and writing, Muhammad Saqib Naveed and Azhar Ali:

Executed experiment in field and collect data, Khuram Danial Shah: Statistical analysis, Muhammad Farooq Ahmed: Final review and editing of manuscript

COMPETING OF INTEREST

The authors declare no competing interests.

REFERENCES

Ali, T., Butt, S.J., Zia-Ul-Haq, I.N., Abbas, F., Ijaz, R., 2022. Characterization and performance evaluation of tomato genotypes grown under unheated greenhouse condition. Pure and Applied Biology 12, 326-341.

Asare-Addo, D.C., Amissah, J.N., Ofori, P.A., Owusu-Nketia, S., Opoku-Agyemang, F., Nkansah, G.O., 2022. Evaluation of agronomic performances and fruit quality of improved tomato (Solanum lycopersicum L.) lines under greenhouse conditions. Journal of Agriculture and Food Research 9, 100360.

Asensio, E., Sanvicente, I., Mallor, C., Menal-Puey, S., 2019. Spanish traditional tomato. Effects of genotype, location and agronomic conditions on the nutritional quality and evaluation of consumer preferences. Food Chemistry 270, 452-458.

Basumatary, P., Dutta, S., Bhuyan, M.K., Neog, M., 2022. Evaluation of tomato hybrids for yield and attributing traits under agroclimatic conditions of Kokrajhar District, Assam. Indian Journal of Hill Farming 35, 129-133.

Bedassa, C.B., Fufa, B.O., Aga, M.C., 2020. Yield Performance of Improved Tomato (Lycopersicon esculentum Mill.) Varieties at West Shoa Zone, Ethiopia. Advances in Bioscience and Bioengineering 8, 1.

Benti, G., Degefa, G., Biri, A., Tadesse, F., 2017. Performance evaluation of tomato (Lycopersicon esculentum Mill.) varieties under supplemental irrigation at Erer Valley, Babile District, Ethiopia. Journal of Plant Sciences 5, 1-5.

FAOSTAT, 2022. Tomato Yield and Production data. https://www.fao.org/faostat/en/#data/QCL.

Fikre, G., Mensa, A., Wodaje, A., 2022. Adaptability evaluation of improved Tomato (Lycopersicon esculentum Mill.) varieties for yield and other quantitative traits in Arba Minch, Southern Ethiopia. International Journal of Agricultural Research, Innovation and Technology 12, 79-83.

Gebremeskel, H., Abebe, H., Biratu, W., Jaleto, K., 2016. Study on agronomic evaluation of tomato (lycopersicon esculentum, mill.) varieties for phonological, growth and yield characters. Current Research in Agricultural Sciences 3, 22-30.

Gotame, T.P., Shrestha, S.L., Poudel, S., Shrestha, J., 2021. Growth and yield performance of different open pollinated tomato genotypes in Terai region of Nepal. Journal of Agriculture and Natural Resources 4, 256-264.

Hassan, M., Ashraf, T., Asim, M., Khan, B.A., Nadeem, M.A., Naseer, M.U., ADNAN, M., ASIF, M., ALI, A., NIJABAT, A., 2021. Evaluation of different varieties of tomato for growth and seed quality in district Sargodha climate. Plant Cell Biotechnology and Molecular Biology 22, 533-545.

Hassan, M.F., Javed, A., Aslam, M., Rabbani, G., Hussain, A., Ahmad, R., Iqbal, M., Hussain, T., Akhtar, J., Mahmood, K., 2022. Fakhar-e-Chakwal: a short duration, high yielding, pink seed coat colored peanut variety for the Punjab Barani tract. International Journal of Agriculture and Biology 28, 1-6.

Hussain, M., Ali, S., Wali, S., Hussain, A., Faiz, F., Hussain, S., 2020. Performance and quality attributes of tomato cultivars under agro climate of bagrote valley, Gilgit-Baltistan. Pakistan Journal of Botany 52, 1299-1303.

Jain, S., Trivedi, J., Sharma, D., Das, K., Jatra, H., 2022. Evaluation of different genotypes for growth, fruit yield and quality parameters of determinate tomato (Solanum lycopersicum L.). The Pharma Innovation Journal 11, 3119-3122.

Jalloh, S., Kanneh, S., Bah, A., 2017. Evaluation of tomato (Solanum lycopersicum L.) genotypes for adaptation and yield components on Njala Upland soil southern Sierra Leone. International Journal of Agriculture Innovations and Research 6, 391-395.

Kanaujia, S., Phom, M., 2016. Performance of various genotypes of tomato under foothill condition of Nagaland. Annals of Plant and Soil Research 18, 33-36.

Kaur, A., Singh, D., Kamboj, P., Singh, N., 2023. Evaluation of growth characters of various genotypes of tomato (Solanum lycopersicum L.) under different environment conditions. Current Journal of Applied Science and Technology 42, 222-233.

Ketema, W., Beyene, D., 2021. Adaptability study and evaluation of improved varieties of tomato (Lycopersicon esculentum L.) under irrigation for their yield and yield components in east Wollega, western Ethiopia. International Journal of Advanced Research in Biological Sciences 8, 118-125.

Kumar, M.N.a.M.K.R., 2021. Evaluation of tomato (Solanum lycopersicum L.) genotypes for yield and yield attributing characters in semiarid zone of Haryana (Hisar). The Pharma Innovation Journal 5, 1246-1249.

Kumar, V., Kumar, S., Kumar, R., Yadav, A., Luthra, S., Rajbhar, R., Tiwari, C.P., Prasad, L., 2024. Determination of Yield Parameters and Quality Traits of Tomato (Solanum lycopersicum L.) Genotypes. Journal of Advances in Biology & Biotechnology 27, 171-178.

Mamta, N.S.D., Sharma, A., Singh, H., 2022. Assessment of tomato (Solanum lycopersicum L.) hybrids for development and yield accredits under polyhouse condition in subtropical area. Innovation Journal 11.

Manzoor, A., Naveed, M.S., Ali, S.R., Ibrar, D., Syed, S., Ashraf, S., Rafiq, A., 2021. Standardization of seed production technology in radish (Raphanus sativus) Cv. mino using different stecklings size. Pakistan Journal of Agricultural Research 34, 725.

Mrema, E., Kagimbo, F., Lobulu, J., Bagarama, F., 2014. Yield and adaptability evaluation of newly introduced tomato (Solanum lycopersicum) varieties in Tabora Region. Tanzania Journal of Agricultural Sciences 13.

Mulatu, A., Zewde, A., Astatkie, T., 2019. Productivity of nationally released tomato (Lycopersicon esculentum Mill.) varieties in southern Ethiopia. Crop Research 54, 147-151.

Ochar, K., Blay, E., Asante, I., Nkansah, G., 2019. Evaluation of selected tomato (Solanum lycopersicum L.) cultivars in Ghana for superior fruit yield and yield component traits. Journal of Horticulture 6, 1-8.

Onyia, V., Chukwudi, U., Ogwudu, V., Atugwu, A., Eze, S., Ene, C., Umeh, S., 2019. Evaluation of Tomato Genotypes Growth, Yield, and Shelf Life Enhancement in Nigeria. Journal of Agricultural Science and Technology 21, 143-152.

Pamukuntla, M., Sharma, D., Vangapandu, T., Siwna, Y., Banjare, A., Barman, G.D., 2023. Mean performance of tomato (Solanum lycopersicum L.) genotypes under Chhattisgarh plains for fruit yield, quality and its components. Biological Forum- An International Journal 15, 592-596.

Sharma, A., Kerketta, A., Topno, S.E., Malik, V., Singh, K., 2023. Performance of Different Hybrids of Tomato (Solanum lycopersicum L.) for Growth and Yield under Prayagraj Agro-climatic Conditions. International Journal of Plant & Soil Science 35, 452-458.

Sirba, H.Y., Begna, T., Gojam, M., 2022. Evaluating performance of recently released tomato (Lycopersicon esculentum Mill.) varieties at highland areas of West Hararghe, Ethiopia. International journal of Research in Agronomy 5, 18-24.

Spaldon, S., Hussain, S., 2017. Performance of tomato (Solanum lycopersicum L.) genotypes for yield and quality traits under Jammu subtropical condition. International Journal of Agriculture Innovations and Research 6, 28-32.

Steel, R.G.D., Torrie, J.H., Dicky, D.A., 1997. Principles and Procedures of Statistics, A Biometrical Approach., 3rd ed. McGraw Hill, Inc. Book Co, New York.

Sureshkumara, B., Lingaiah, H., Shivapriya, M., Pavithra, H., 2017. Evaluation of tomato genotypes for growth, yield and quality attributes under eastern dry zone of Karnataka, India. International Journal of Current Microbiolgy and Applied Sciences 6, 1922-1930.

Tsagaye, D., Alemu, Y., 2021. Evaluation of Tomato (Solanum lycopersicum MILL.) Genotypes for Quantitative, Qualitative and Quality Traits at Mid-altitude and Central Rift Valley. International Journal of Research in Agricultural Sciences 8.