The Pharma Innovation Journal 2023; 12(9): 2125-2129

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(9): 2125-2129
© 2023 TPI
www.thepharmajournal.com
Received: 09-06-2023
Accepted: 13-07-2023

Vivek Gumasta
Ph.D. Scholar, Department of Horticulture, Mansarovar Global University, Bilkisganj, Sehore, Bhopal, Madhya Pradesh, India

KN Nagaich
Professor and Head (Retd.), Department of Horticulture, RVSKVV, Gwalior, Madhya Pradesh, India

Devesh Kumar Pandey
Dean, Faculty of Agriculture Science and Technology, Mansarovar Global University, Bilkisganj, Sehore, Madhya Pradesh, India

CK Saxena
Senior Scientist, Irrigation and Drainage Engineering Division, ICAR - Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Corresponding Author:
Vivek Gumasta
Ph.D. Scholar, Department of Horticulture, Mansarovar Global University, Bilkisganj, Sehore, Bhopal, Madhya Pradesh, India

Morphological traits of selected commercially cultivated varieties of tomato (*Solanum lycopersicum* L.) in Vindhya Plateau region of Madhya Pradesh

Vivek Gumasta, KN Nagaich, Devesh Kumar Pandey and CK Saxena

Abstract
Most tomato varieties are inbred, highlighting the necessity to describe and assess morphological diversity as a resource for genotype selection with desired attributes toward ecotypes. A variety development study was conducted at the University Farm, Bhopal of the Mansarovar Global University, Sehore, Madhya Pradesh, in which sixteen released and un-released ecotypes/varieties of tomato with two local checks were evaluated for selected morphological features utilizing developmental, vegetative and fruit traits etc. The experiment was laid out in the Randomized Block Design with three replications and conducted for two consecutive years in 2020 and 2021. A broad range of variation has been observed among varieties, observations were recorded for the inflorescence and multiparous inflorescence, immature fruit colour, flesh colour of pericarp, colour of shoulder trips and intensity of greenback shoulder also the width of pedical (narrow, medium and wide), colour of flesh (dark and, intermediate). Slight intensity, and intermediate greenback shoulder were observed in five and two ecotypes respectively while and no intensity was observed in the rest. Narrow, medium and wide width of pedicel scars were found in six, six and four ecotypes, whereas, dark and intermediate colour flesh was present six and eight ecotypes respectively. Overall, the tomato ecotype VNR (THT) 9/2020 was revealed to be highly influenced and superior in all morphological characteristics for both the years as well as in pooled data. Whereas, the minimum morphological, yield, quality and economic parameters for both the years as well as pooled data were observed in the check ecotype of Shree.

Keywords: Tomato, *Solanum lycopersicum* L, morphological, traits, ecotype, fruit, colour

Introduction
Tomatoes, which are members of the *Solanaceae* family, are among the most widely consumed vegetables in the world, with an annual production value of more than 90 billion USD (Anonymous, 2019) [1]. It is a self-pollinated annual crop in the Solanaceae family, with chromosome number 2n = 2x = 24 (Jenkins, 1948; Peralta *et al*., 2008 and Grandillo, 2008) [8, 15, 5]. Tomato is vulnerable to a variety of environmental challenges, particularly high temperatures, dryness, salinity, and a lack of moisture (Kalloo, 1993; Gumasta *et al*., 2023) [9, 6]. Although it is practiced in wide climatic conditions (Saxena *et al*. 2017; Waghaye *et al*. 2018 and Rao *et al*. 2022) [25, 28]. However, despite its broad adaptation, production is concentrated in limited areas. Globally, tomato annual productivity has increased by nearly 300% over the last four decades (Costa and Heuvelink, 2007) [3]. In many nations around the world, tomato ranks second after potato in terms of importance (Prajapati *et al*., 2014) [17]. The tomato yield can be improved through breeding and management techniques besides appropriate crop protection measures as suggested by many researchers (Kishore *et al*. 2016; Rao *et al*. 2018; Saxena *et al*. 2020; Kishore *et al*. 2022 and Saxena *et al*. 2022) [23, 10, 11, 24]. To meet the requirements of a successful hybrid, it is necessary to be familiar with the detailed genetic structure of the selected material to be used for hybrid breeding. The systematic approach for developing F_1 hybrids in any crop depends mainly on selecting desirable parents. Success and pace of breeding is primarily conditioned by the availability of desired genetic variability for the traits of interest. Knowledge of genetic correlations between various traits is equally important in plant breeding for indirect improvement of characters that are difficult to quantify, especially for those traits which exhibit low heritability. Therefore, it is essential to make a preliminary inspection of the complex characteristics of the lines to be used for the development of superior hybrids. All these factors help in the selection of better parents for the development of a successful commercial hybrid. Most tomato varieties are inbred, highlighting the necessity to describe and assess morphological diversity as a resource for genotype selection with desired attributes toward variety development.

At Mansarovar Global University in Sehore, Madhya Pradesh, 16 promising released and un-released tomato varieties were described for 12 morphological features utilizing developmental, vegetative, and fruit traits. Under all of the variety, a broad range of variation was observed. The presence of a stem scar (where the fruit was attached to the plant), Stem internode length, skin colour of ripe fruit and pericarp thickness are some of the morphological characteristics of tomato fruits which are studied during the research work (Rick, 1979; Foolad, 2007; Peralta *et al*., 2008) [21, 4, 15]. These characteristics vary between tomato varieties such as heirlooms, hybrids, and wild species.

Material and Method

The field trial was conducted with 14 un-released and released tomato varieties along with two local checks at the University Farm, Faculty of Agriculture Science and Technology, Mansarovar Global University, Sehore, Madhya Pradesh during *Rabi* seasons in 2020-21 and 2021-22. The material and methods of the present investigation are given as follows based on the pooled mean of two successive years. The observations on different aspects such as morphological, yield, quality and economic parameters were recorded and evaluated.

The seeds were treated with the antifungal Thiram, 2.5 gm/kg of seeds and with Pseudomonas fluorescens @ 10 gm/kg of seeds; nursery was raised in seedling trays @ 1 seed per cell. The trays filled with coco peat were kept stalked and covered with a polythene sheet till germination started for approximately 5 Days. After 6 days, the trays with germinated seeds were placed on the raised beds inside a shade. Watering was done regularly to the seedlings [Fig. 1]. Plants with good sturdy stem were transplanted between 28-30 days after the sowing of nursery.

Fig 1: Seed placement for nursery

Fig 2: View of the experimental field

The NPK fertilizers were applied @180:100:60 kg/ha. One fourth of Nitrogen and full doses of P and K were applied just before transplanting while the remaining doses of N were applied manually in three equal splits on 45, 60 and 75 DAT (Days after transplanting) (Rao *et al*. 2018) [19]. The tomato fruits were picked up from 65 DAT till final harvest on 135 DAT. Uniform plant protection measures were also followed in all the treatments. After transplanting, fungicide (Carbendazim 12%+ Mancozeb 63% @ 1.5 kg/ha and Neem oil (@ 4.0 L/ha) was sprayed as the plant protection on 12th and 15th day from the date of transplanting (DAT) respectively. Later on neem oil and other chemicals namely Imdachlorprid 17.8% SL @ 0.5 L/ha, Dichlorovous 76% EC @ 0.8 L/ha and Carbendazim 12% + Mancozeb 63% @ 1.5 kg/ha apart from Neem oil were applied (Rao *et al*. 2018 & 2022) [19-20]. Uniform cultural practices were adopted among the treatments during the experiments [Fig. 2].

Stem internode length was calculated by measuring five tagged plants randomly selected in each plot with the help of measuring tap in both years. For foliage density spread of plants from north to south, east to west and plant height expressed in m^3 in both years was recorded. The total number of leaves under first Inflorescence was recorded at the time of inducing the first inflorescence in the plant in both years. Leaf attitude was classified into three categories semi-erect, horizontal and drooping leaves and leaf types were classified into six categories dwarf, potato leaf type, standard, *peruvianum*, *Pimpinellifolium* and *Hirsutum*. Inflorescence types of tomato plants observe the 2nd and 3rd truss of at least five plants. It is two types generally uniparous, both (partly uniparous, partly multiparous) and generally multiparous. For recording the exterior colour of immature fruit it was done before the maturity of fruit and expressed in these categories greenish-white, light green, green, dark green and very dark green. The fleshcolour of the pericarp was recorded in different categories light, intermediate and dark. The presence of green shoulder trips on fruit was recorded as the upper part of the fruit, around the calyx - is green while the pistilar area of the fruit is red or absent (Uniform ripening). And intensity of the green back shoulder was recorded in three categories slight, intermediate and strong. while the width of the pedicel scar was recorded at the widest part on 10 randomly selected fruits from different plants in three categories narrow (Covered by the calyx), medium (slightly apparent around the calyx) and wide (very apparent around the calyx). The skin colour of ripe fruit was observed in the peeled fruit skin in two categories colourless and yellow and fruit colour intensity was recorded in different categories light, intermediate and dark. The above parameters were obtained using IPGRI 1996 techniques.

Results and Discussion

Stem internode length

Data with respect of stem internode length is presented in Table 1. Result indicates that the short stem internode length was found in tomato ecotypes VNR(THT)1/2020, VNR(THT)4/2020, VNR(THT)5/2020, VNR(THT)9/2020 and VNR(THT)13/2020, intermediate stem internode length was observed in tomato ecotypes VNR(THT)2/2020, VNR(THT)6/2020, VNR(THT)7/2020, VNR(THT)8/2020, VNR(THT)10/2020 and VNR(THT)14/2020, while the long stem internode length was observed in tomato ecotypes VNR(THT)3/2020, VNR(THT)11/2020, VNR(THT)12/2020,

Abhilash and Shree. Mehmet *et al*. (2015) [12] and Singh *et al.* (2014) [26] confirmed the findings.

Foliage density

The data pertaining to foliage density is presented in Table 1. The result revealed that the sparse foliage density was present in tomato ecotypes VNR(THT)2/2020, VNR(THT)3/2020, VNR(THT)7/2020 and VNR(THT)10/2020, intermediate foliage density was recorded in tomato ecotypes VNR(THT)1/2020, VNR(THT)4/2020, VNR(THT)9/2020, VNR(THT)11/2020, Abhilash and Shree, while dense foliage density was showed in tomato ecotypes VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)8/2020, VNR(THT)12/2020, VNR(THT)13/2020 and VNR(THT)14/2020. Ojo *et al.* (2013) [13] also conducted this type of tomato variety evaluation.

Number of leaves under first inflorescence

The mean data of the number of leaves under the first inflorescence is presented in Table 1. It was observed that few leaves under first inflorescence was recorded in tomato ecotypes VNR(THT)2/2020, VNR(THT)4/2020, VNR(THT)7/2020, VNR(THT)9/2020, VNR(THT)10/2020, VNR(THT)11/2020 and VNR(THT)14/2020, whereas the many leaves under first inflorescence VNR(THT)1/2020, VNR(THT)3/2020, VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)8/2020, VNR(THT)12/2020, VNR(THT)13/2020, Abhilash and Shree. Ojo *et al.* (2013) [13] also conducted this type of tomato variety evaluation.

Leaf attitude

The data gathered on leaf attitude is given in Table 1. A perusal of data indicates that the horizontal leaves were recorded in tomato ecotypes VNR(THT)1/2020, VNR(THT)5/2020 and VNR(THT)11/2020, semi erect leaves were observed in ecotypes VNR(THT)4/2020, VNR(THT)8/2020, VNR(THT)10/2020, VNR(THT)12/2020 and VNR(THT)14/2020, however, the drooping leaves were noted in ecotypes VNR(THT)2/2020, VNR(THT)3/2020, VNR(THT)6/2020, VNR(THT)7/2020, VNR(THT)9/2020, VNR(THT)13/2020, Abhilash and Shree. Mehmet *et al*. (2015) [12] and Singh *et al.* (2014) [26] have done similar work.

Leaf types

The mean data of leaf types is given in Table 1. It was evident from the data that the standard leaves were found in ecotypes VNR(THT)1/2020, VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)11/2020, Abhilash and Shree, the dwarf leaves were observed in ecotypes VNR(THT)2/2020, VNR(THT)3/2020, VNR(THT)7/2020, VNR(THT)8/2020 and VNR(THT)13/2020, the *peruvianum* leaves were recorded in treatment VNR(THT)4/2020 and VNR(THT)9/2020, the *Pimpinellifolium* leaves were found in ecotypes VNR(THT)12/2020 and VNR(THT)14/2020, while the *Hirsutum* was noted in ecotype VNR(THT)10/2020. These findings are in agreement with the findings of Rangnamei *et al*. (2018) [18] and Salim *et al*. (2018) [22].

Inflorescence type

The data gathered on inflorescence type is given in Table 1. It was recorded that the uniparous inflorescence were found in ecotypes VNR(THT)1/2020, VNR(THT)3/2020, VNR(THT)4/2020, VNR(THT)7/2020, VNR(THT)9/2020, VNR(THT)10/2020, VNR(THT)11/2020, VNR(THT)14/2020, Abhilash and Shree, whereas the multiparous inflorescence were recorded in ecotypes VNR(THT)2/2020, VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)8/2020, VNR(THT)12/2020 and VNR(THT)13/2020. The findings are in close harmony with the results of Rangnamei *et al*. (2018) [18] and Salim *et al*. (2018) [22].

Exterior colour of immature fruit

Glance of the data on exterior colour of immature fruit is given in Table 1. Result revealed that the green colour of immature fruit was present in ecotypes VNR(THT)1/2020, VNR(THT)2/2020, VNR(THT)9/2020, VNR(THT)11/2020, VNR(THT)12/2020 and Shree, the greenish white colour of immature fruit was recorded in ecotypes VNR(THT)3/2020, VNR(THT)4/2020, VNR(THT)7/2020, VNR(THT)13/2020 and Abhilash, while light green colour of immature fruit was observed in ecotypes VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)8/2020, VNR(THT)10/2020 and VNR(THT)14/2020. Colour depends on maturity and lycopene percent of tomato results confirmed by Mehmet *et al.* (2015) [12] and Singh *et al*. (2014) [26].

Flesh colour of pericarp

Data obtained on the flesh colour of pericarp is presented in Table 1. A perusal of data indicates that the red colour flesh of pericarp was present in ecotype VNR(THT)1/2020, VNR(THT)2/2020, VNR(THT)4/2020, VNR(THT)11/2020, Abhilash and Shree, pink colour flesh of pericarp was observed in VNR(THT)3/2020, VNR(THT)5/2020, VNR(THT)8/2020 and VNR(THT)12/2020, yellow colour flesh of pericarp was noted in ecotypes VNR(THT)6/2020 and VNR(THT)9/2020, while orange colour flesh of pericarp was recorded in ecotypes VNR(THT)7/2020, VNR(THT)10/2020, VNR(THT)13/2020 and VNR(THT)14/2020. The findings are in close harmony with the results of Rangnamei *et al*. (2018) [18] and Salim *et al*. (2018) [22].

Presence green shoulder trips on fruit

Data with respect of presence of green shoulder trips on fruit is presented in Table 1. Result indicates that the green shoulder trips on fruit was present in ecotypes VNR(THT)3/2020, VNR(THT)4/2020, VNR(THT)7/2020, VNR(THT)10/2020 and VNR(THT)14/2020, while green shoulder trips on fruit was absent in ecotypes VNR(THT)1/2020, VNR(THT)2/2020, VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)8/2020, VNR(THT)9/2020, VNR(THT)11/2020, VNR(THT)12/2020, VNR(THT)13/2020, Abhilash and Shree. These findings are in agreement with the findings of Rangnamei *et al*. (2018) [18] and Salim *et al*. (2018) [22].

Intensity of green back shoulder

The data pertaining to the intensity of greenback shoulder is presented in Table 1. The result revealed that the slight intensity of greenback shoulder was present in ecotypes VNR(THT)3/2020, VNR(THT)5/2020, VNR(THT)7/2020, VNR(THT)12/2020 and VNR(THT)14/2020, the intermediate intensity of greenback shoulder was noted in ecotypes VNR(THT)4/2020 and VNR(THT)10/2020, while other excepted ecotypes showed no intensity of greenback shoulder

of tomato fruit. The findings are in close harmony with the results of Yonas and Abajebel (2020) [29] and Tujuba *et al.* (2020) [27].

Width of pedicel scar

The mean data of the width of the pedicel scar is presented in Table 1. It was evident from the data that the narrow width of pedicel scar was present in ecotypes VNR(THT)2/2020, VNR(THT)3/2020, VNR(THT)9/2020, VNR(THT)10/2020, Abhilash and Shree, the medium width of pedicel scar was present in ecotypes VNR(THT)1/2020, VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)8/2020, VNR(THT)12/2020 and VNR(THT)14/2020, while wide width of pedicel scar was present in ecotypes VNR(THT)4/2020, VNR(THT)7/2020, VNR(THT)11/2020 and VNR(THT)13/2020. VNR(THT)12/2020 and VNR(THT)14/2020, These findings replicate the findings of Olaniyi *et al.* (2010) [14] and Chattopadhyay *et al*. (2013) [2].

Skin colour of ripe fruit

The mean data of skin colour of ripe fruit is given in Table 1. The result clearly shows that the yellow skin colour of ripe fruit was present in all tomato ecotypes in first year, second year and in pooled. The findings are in close harmony with the results of Rangnamei *et al*. (2018) [18] and Salim *et al*. (2018) [22].

Flesh colour intensity

Data with respect to flesh colour intensity is presented in Table 1. The investigation revealed that the dark colour flesh was present in tomato ecotypes VNR(THT)1/2020, VNR(THT)4/2020, VNR(THT)5/2020, VNR(THT)9/2020, VNR(THT)11/2020, VNR(THT)12/2020 and VNR(THT)14/2020, while the intermediate flesh colour intensity was present in ecotypes VNR(THT)2/2020, VNR(THT)3/2020, VNR(THT)6/2020, VNR(THT)7/2020, VNR(THT)8/2020, VNR(THT)10/2020, VNR(THT)13/2020, Abhilash and Shree the results are also supported by Singh *et al*. (2014) [26].

Table 1: Morphological characteristics of different cultivars of tomato (Pooled mean)

Treatments detail	Stem internode length	Foliage density	Number of leaves under first Inflorescence	Leaf attitude	Leaf types	Inflorescence type	Exterior colour of immature fruit	Flesh colour of pericarp	Presence green shoulder trips on fruit	Intensity of green back shoulder	Width of pedicel scar	Skin colour of ripe fruit
VNR(THT)1/2020	Short	Intermediate	Many	Horizontal	Standard	Uniparous	Green	Red	Absent	Absent	Medium	Yellow
VNR(THT)2/2020	Intermediate	Sparse	Few	Drooping	Dwarf	Multiparous	Green	Red	Absent	Absent	Narrow	Yellow
VNR(THT)3/2020	Long	Sparse	Many	Drooping	Dwarf	Uniparous	Greenish white	Pink	Present	Slight	Narrow	Yellow
VNR(THT)4/2020	Short	Intermediate	Few	Semi erect	*Peruvianum*	Uniparous	Greenish white	Red	Present	Intermediate	Wide	Yellow
VNR(THT)5/2020	Short	Dense	Many	Horizontal	Standard	Multiparous	Light green	Pink	Absent	Slight	Medium	Yellow
VNR(THT)6/2020	Intermediate	Dense	Many	Drooping	Standard	Multiparous	Light green	Yellow	Absent	Absent	Medium	Yellow
VNR(THT)7/2020	Intermediate	Sparse	Few	Drooping	Dwarf	Uniparous	Greenish white	Orange	Present	Slight	Wide	Yellow
VNR(THT)8/2020	Intermediate	Dense	Many	Semi erect	Dwarf	Multiparous	Light green	Pink	Absent	Absent	Medium	Yellow
VNR(THT)9/2020	Short	Intermediate	Few	Drooping	*Peruvianum*	Uniparous	Green	Yellow	Absent	Absent	Narrow	Yellow
VNR(THT)10/2020	Intermediate	Sparse	Few	Semi erect	*Hirsutum*	Uniparous	Light green	Orange	Present	Intermediate	Narrow	Yellow
VNR(THT)11/2020	Long	Intermediate	Few	Horizontal	Standard	Uniparous	Green	Red	Absent	Absent	Wide	Yellow
VNR(THT)12/2020	Long	Dense	Many	Semi erect	*Pimpinellifolium*	Multiparous	Green	Pink	Absent	Slight	Medium	Yellow
VNR(THT)13/2020	Short	Dense	Many	Drooping	Dwarf	Multiparous	Greenish white	Orange	Absent	Absent	Wide	Yellow
VNR(THT)14/2020	Intermediate	Dense	Few	Semi erect	*Pimpinellifolium*	Uniparous	Light green	Orange	Present	Slight	Medium	Yellow
Abhilash	Long	Intermediate	Many	Drooping	Standard	Uniparous	Greenish white	Red	Absent	Absent	Narrow	Yellow
Shree (Checks)	Long	Intermediate	Many	Drooping	Standard	Uniparous	Green	Red	Absent	Absent	Narrow	Yellow

Conclusion

The short stem internode length, sparse foliage density, few leaves under first inflorescence was found in tomato ecotypes VNR(THT)9/2020 and VNR(THT)13/2020, intermediate stem internode length was observed best in tomato ecotypes VNR(THT)10/2020 and VNR(THT)14/2020, the *peruvianum* leaves were recorded in treatment VNR(THT)4/2020 and VNR(THT)9/2020 and *Hirsutum* was noted in ecotype VNR(THT)10/2020. Inflorescence and multiparous inflorescence were also recorded. Immature fruit was observed on the basis of colour of ecotype like green colour (6 varieties), greenish white colour and light green colour (5-5 variety for each). Flesh colour of pericarp was recorded red in six ecotype, pink in four ecotype, yellow in two and while orange flesh of pericarp was recorded in the remaining ecotypes. Whereas in shoulder trips on fruits were present in five ecotypes which were green in colour. The green shoulder trips on fruit was present in ecotypes VNR(THT)3/2020, VNR(THT)4/2020, VNR(THT)7/2020, VNR(THT)10/2020 and VNR(THT)14/2020, while green shoulder trips on fruit was absent in ecotypes VNR(THT)1/2020, VNR(THT)2/2020, VNR(THT)5/2020, VNR(THT)6/2020, VNR(THT)8/2020, VNR(THT)9/2020, VNR(THT)11/2020, VNR(THT)12/2020, VNR(THT)13/2020, Abhilash and Shree. Slight intensity of green back shoulder in five, intermediate intensity in two ecotypes were recorded, while other excepted ecotypes shown no intensity of green back shoulder of tomato fruit. The narrow width of pedicel scar was present in six ecotypes, medium width in six ecotypes, and wide width was present in four ecotypes. The dark colour

flesh was present in six ecotypes of tomato, while the intermediate flesh colour intensity was present in eight ecotypes.

Reference

1. Anonymous. FAOSTAT. Food and Agriculture Organization of the United Nations; c2019.
2. Chattopadhyay AC, Wasim S. Characterization of determinate tomato hybrids: search for better processing qualities, J. Food Process Technol. 2013;4:4.
3. Costa M, Heuvelink E. Today's worldwide tomato production. Fruit and Veg Tech: International Magazine for Production, Marketing and Technology of Fruits and Vegetables Worldwide; c2007. p. 14-16
4. Foolad MR. Genome mapping and molecular breeding of tomato. International Journal of Plant Genomics; c2007.
5. Grandillo S, Ku HM. Genetic diversity of a tomato species-wide collection and its use for crop improvement. Proceedings of the National Academy of Sciences. 2008;106(20):8365-8370.
6. Gumasta V, Nagaich KN, Pandey DK, Saxena CK. Growth Performance Evaluation of Selected Commercially Cultivated Tomato (*Solanum lycopersicum* L.) Varieties Under the Semi-Arid Conditions of Madhya Pradesh, India. International Journal of Agriculture Sciences. 2023;15(5):12369-12371.
7. IPGRI. (Descriptors for tomato); c1996. https://cgspace.cgiar.org/handle/10568/73041
8. Jenkins JA. The origin of the cultivated tomato. Econ. Bot. 1948;2:379-392.
9. Kalloo G. Genetic Improvement of vegetable crops. In Tomato. Kallo G and Bergh, B.O. (eds). Pergamon Press, New York; c1993. p. 645-666.
10. Kishore, Gottam, Singh, Kumar R, Saxena CK, Rajwade, YA, *et al*. Magnetic treatment of irrigation water: Its effect on water properties and characteristics of eggplant (*Solanum melongena*). Emirates Journal of Food and Agriculture. 2022;34(9):784-791. DOI: 10.9755/ejfa.2022.v34.i9.2945
11. Kishore Ravi, Gahlot VK, Saxena CK. Pressure Compensated Micro Sprinklers: A Review. International Journal of Engineering Research and Technology. 2016;5(1):237-242. [e-ISSN: 2278-0181; DOI: 10.17577/IJERTV5IS010184]
12. Mehmet UK, Rezzan K. Post-harvest Uv-b treatments increased fructose content of tomato (*Solanum lycopersicon* l. cv. tayfun f1) harvested at different ripening stages. Food science and technology. Campinas. 2015;35(4):742-749.
13. Ojo GOS, Ekoja EE, Ukpoju OP. Evaluation of tomato (*Solanum lycopersicon* L.) for fruit yield and yield components in the southern Guinea Savanna ecology of Nigeria. International Journal of Agronomy and Agricultural Research. 2013;3(3):1-5.
14. Olaniyi JO, Akanbi WB, Adejumo TA, Akande OG. Growth fruit yield and nutritional quality of tomato varieties. African Journal of Food Science. 2010;4(6):398-402
15. Peralta IE, Spooner DM, Knapp S. Taxonomy of wild tomatoes and their relatives (*Solanum* sect. *lycopersicoides*, sect. Juglandi folia, sect. Lycopersicon; Solanaceae). Systematic Botany Monographs; c2008. p. 84
16. Peralta IE, Spooner DM, Knapp S. Taxonomy of wild tomatoes and their relatives (*Solanum* sect. *lycopersicoides*, sect. Juglandi folia, sect. Lycopersicon; Solanaceae). Am. Soc. Plant Taxonomists; c2008. p. 151-160
17. Prajapati HN, Panchal RK, Patel ST. Efficacy of bioagents and biological interaction of Alternaria solani with *phylloplane mycoflora* of tomato. J Mycopathol. 2014;52:81-86.
18. Rangnamei KL, Kumar M, Meena KL, Rajkhowa DJ. Evaluation of tomato varieties for higher productivity in the NEH region of India. Indian Journal of Hill Farming, 2018;30(2):256-258.
19. Rao KV, Gumasta R, Saxena V, Patel CK, Babu GP, Bhushan V. Performance of tomato (*Solanum lycopersicum* L.) under drip irrigation with peripheral insect proof net. Agricultural Engineering Today. 2018;42(1):1-5.
20. Rao KV, Saxena R, Singh CK, Soni Kumar CD, Suchi G. Water Productivity of *Capsicum* and Tomato under different Growing Environments. Indian Journal of Ecology. 2022;49(3):763-767. DOI: 10.55362/IJE/2022/3592.
21. Rick CM. Tomato breeding. In Handbook of Plant Cell Culture. CRC Press; c1979.p. 259-295.
22. Salim M, Rashid H, Hossain Md. Zakaria M. Morphological characterization of tomato (*Solanum lycopersicum* L.) genotypes. Journal of the Saudi Society of Agricultural Sciences. 2018;19(10):1016.
23. Saxena CK, Ambast SK, Gupta SK. Laser Land Levelling for Higher Water Productivity in Rice-Wheat System. International Journal of Innovative Technology and Exploring Engineering. 2020;9(8):374-379. [DOI: 10.35940/ijitee.H6482.069820]
24. Saxena CK, Kumar M, Singh RK. Zero Budget Natural Farming for Sustainable Agriculture: A Review. Bhartiya Krishi Anusandhan Patrika. 2022;37(2):105-113. DOI: 10.18805/BKAP482.
25. Saxena CK, Arpna B, Nayak AK, Pyasi SK, Ramadhar S, Gupta SK. Hydraulic performance of litchi and banana under drip irrigation. *In*: Goyal, Megh R., Panigrahi, Balram and Panda, S.N. (Eds.) Micro irrigation scheduling and practices, under the book series, Innovations and Challenges in Micro Irrigation-Apple Academic Press, Inc. Waretown, NJ 08758 USA. 2017;7:99-116. (ISBN 13: 978-1-77188-552-2).
26. Singh T, Singh N, Bahuguna A, Nautiyal M, Sharma VK. Performance of Tomato (*Solanum lycopersicum* L.) Hybrids for Growth, Yield and Quality Inside Polyhouse under Mid Hill Condition of Uttarakhand. American Journal of Drug Discovery and Development. 2014;4(2014):202-209.
27. Tujuba M, Ayana NG. Evaluation of released tomato (*Lycopersicon esculentum* Mill.) varieties for fruit yield and quality parameters in western Ethiopia. Agricultural and Biological Sciences Journal. 2020;6(2):100-113
28. Waghaye Abhishek M, Saxena CK, Satyendra K, Pathan A, Abhishek R. Multiple linear modelling of electrical conductivity at a subsurface drainage site in Haryana using EM technique. International Journal of Chemical Studies. 2018;6(2):1953-1960.
29. Yonas M, Abajebel N. Evaluation of Vegetative and Yield Performance of Tomato (*Lycopersicon esculentum* Mill.) Varieties at Abol District, Gambella Region. Asian Journal of Agricultural and Horticultural Research. 2020;6(1):28-33.