Indian Journal of Ecology (2023) 50(2): 503-507
DOI: https://doi.org/10.55362/IJE/2023/3926

Manuscript Number: 3926
NAAS Rating: 5.79

Study of Biometric Attributes of Plug Type Tomato Seedlings Pertinent to Transplanter Design

Ankit Sharma, Sanjay Khar[1], Divakar Chaudhary[1] and Prerna Thakur[2]

Farm Machinery & Power Engineering, Punjab Agricultural University, Ludhiana-141 004, India
[1]Division of Agricultural Engineering, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-Jammu), Jammu-180 009, India
[2]Krishi Vigyan Kendra, Moga-142 001, India
E-mail: ankitsharma@pau.edu

Abstract: The biometric attributes such as seedling length, weight, plug compactness, stem and spread diameter of 25-, 32-, and 40-days old tomato plug seedlings relevant to the design and selection of various components of vegetable transplanter were investigated. The seedlings were grown in pro-trays having truncated square pyramid (104 cells) and right circular cone (98 cells) shape cells. The seedling length and plug compactness were more in truncated square pyramid cells pro-tray whereas seedlings' weight, stem diameter, and spread diameter were more in truncated right circular cone cells pro-tray. The maximum seedling length and plug compactness score were 208 mm and 8.8 corresponding to truncated square pyramid cells and 40 days seedling age on the other hand maximum seedlings weight, stem diameter, and spread diameter was 10.57 g, 3.02, and 136 mm corresponding to truncated right circular cone and 40 days seedling age. With the increase in seedling age all of the selected attributes of tomato seedlings increased for both types of cells.

Keywords: Attributes, Biometric, Cell, Pro-tray, Tomato

In India, more than 70 different types of vegetables are grown, but only a few are grown in portrays. Sowing, planting, and transplanting methods are used to propagate vegetable crops such as tomato, chilli, onion, cauliflower, brinjal, and cabbage. These crops are grown in a nursery (Khadatkar et al 2020). Among this tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops grown for their fleshy fruits and is a significant commercial and dietary vegetable crop. Tomato area, production, and productivity in India were approximately 814 thousand hectares, 20515 thousand MT, and 25.20 MT·ha^{-1}, respectively, in 2018-19 (Gaikwad et al 2020). The growing importance of agricultural operations utilising modern machinery for horticultural crop production necessitates a better understanding of their engineering properties so that machines, processes, and handling operations can be designed for maximum efficiency and end-product quality (Khadatkar et al 2020). Physical properties such as shape, size, height, weight, stem diameter, etc are important parameters to consider when designing a transplanter for vegetable seedlings (Gaikwad 2010, Turbathmath 2010, Pandirwar et al 2015). It is critical to have an accurate estimate of the shape, size, weight, height, and other physical and mechanical properties that may be used as engineering parameters for product development. Furthermore, mechanical damage to seedlings during handling and transplanting can have a serious impact on viability, germination, damage, growth, and crop yield (Gaikwad 2010, Pandirwar et al 2015, Khadatkar 2019).

Some researchers investigated the engineering and biometric properties of the onion crop concerning crop-based machine design (Khura et al 2010, Turbathmath 2010, Pandirwar et al 2015). Some research has also been conducted on the engineering properties of garlic to design crop production and processing equipment such as planting, handling, storing, aeration, drying, bulb breaking, and peeling (Masoumi et al 2006, Manjunatha et al 2008, Rathinakumari et al 2015, Bakhtiari and Ahmed 2015). Abubakar et al (2020) determined the physical and mechanical properties of four-week-old tomato seedlings such as stem thickness, height, weight, spread diameter, angle of friction, frictional coefficient, impact, compressive and tensile properties for the design of a mechanical tomato transplanter. Khadatkar et al (2020) investigated biometric properties such as weight, stem diameter, height, critical canopy diameter, drop shatter height, compressive strength, and coefficient of static friction that were relevant to the design of a vegetable transplanter for 30, 45, and 60-day old tomato and chilli plug seedlings. Xifeng et al (2015) investigated the physical and mechanical features of a 23-day tomato seedling pot that were directly related to the design of autonomous transplanting machine key components such as the seedling picking and transplanting mechanism. Therefore, keeping in view the importance of biometric attributes relevant to the development of transplanting machinery, the present study was conducted to determine the biometric attributes of tomato vegetable seedlings, which could be useful in designing and development tomato transplanters.

MATERIAL AND METHODS

Nursery raising in pro-trays: Standard agronomic practises were used to grow the seedlings. The soilless growing medium, which is made by combining coco peat, vermiculite, and perlite in a 3:1:1 ratio, was placed in the two different type of pro-trays having the square and round cells. Per cell, one seed was sown. For seed sowing, small depressions were made in the centre of the plugs with fingertips or mechanical tools. Depending on the season or the optimum temperature required for early and better germination, the tomato trays were then placed in a polyhouse or shade. Every day, water was sprayed evenly across each tray using a fine sprinkler boom.

Seedling age: The seedling age of 32 days is recommended for tomato crop seedling transplanting. In addition to the recommended seedling transplanting age, two additional seedling ages (one week before and after the recommended seedling age) were chosen to investigate the effect of seedling age variation. The tomato variety Himsona seedlings at ages 25, 32, and 40 days were chosen for the current study to assess the impact of different seedling ages on the developed transplanter.

Cells type: Two trays with cell numbers 104 and 98 and morphologies of truncated square pyramid (C_s) and truncated right circular cone (C_r) were chosen from the local market, with measurements displayed in Figure 1. The volume of truncated square pyramid cell was 16.99 cm^3 whereas truncated right circular cone cell had volume of 20.49 cm^3. Figure 2 depicts a dimensional image of a truncated square and right circular cone shape cell.

Measurement of Biometric Properties

Seedling weight (S_w): Thirty seedlings were randomly selected and weighted using an electronic weighing balance with a minimum count of 1 g.

Seedling length (S_l): To determine the average length, the seedlings were gently pulled from the plug and 30 observations were made in each case. The seedling length of each sample was measured using the ASNS (2014) method, in which the seedlings were laid on a table, and the distance from the tip of the seedling to the end of its root was measured using a 300 mm scale with an accuracy of 1 mm.

Seedling stem diameter (S_s): The stem diameter of thirty uprooted seedlings of various ages and cells was measured using a digital micrometre with a minimum count of 0.01 mm. To maintain uniformity, the plant's stem diameter was measured at a height of 20 mm from the bottom end (Mohsenin 1986).

Seedling spread diameter (S_d): The 30 randomly selected tomato seedlings samples were placed in the field in their natural state, and the spread diameter was measured using a ruler with a 1 mm accuracy (ASNS 2014).

Seedling plug compactness (S_c): Based on the qualitative evaluation, a plucking rating of 10 was assigned based on the damage to the plug. It received a 10 if the nursery seedlings were removed without damaging the plug. At random, plugs were taken from thirty plants of varying ages and cell types.

Statistical analysis: Descriptive statistical analysis was performed using SPSS (version 26) to investigate the effect of different seedling ages and cell type/shape on the biometric properties of tomato seedlings.

RESULTS AND DISCUSSION

Seedling length (S_l): At 25 days and 40 days of seedling

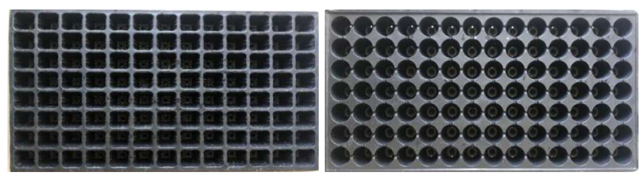

Fig. 1. Truncated square pyramid (C_s) and right circular cone (C_r) cell shape pro-trays

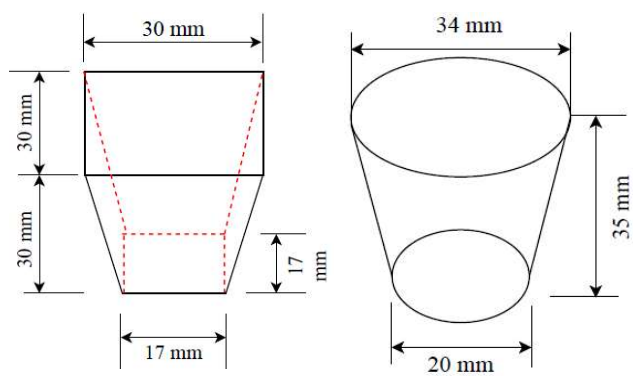

Fig. 2. Square and round cell

Fig. 3. Measurement of the seedling stem diameter and length

age, the average minimum and maximum seedling lengths were 118.67 mm and 208 mm, respectively. At 25 days seedling age, cell C_s and C_r had average minimum seedling lengths of 118.67 mm and 144.33 mm, respectively. At 40 days of age, the cell C_s and C_r had the longest average seedling lengths of 208 mm and 195.5 mm, respectively (Table 1). The effect of seedling age on seedling length was significant whereas the effect of cell type on seedling length was not. The interaction between seedling age and cell effect was also significant.

Seedling weight (S_w): The average minimum and maximum seedling weight of 8.73 g and 10.79 g was at 25 days and 40 days seedling age respectively. The average minimum seedling weight of 8.73 g and 9.25 g was observed in the case of cell C_s and C_r at 25 days seedling age. The average maximum seedling weight of 9.87 g and 10.79 g was in cell C_s and C_r at 40 days seedling age respectively (Table 1). The effect of seedling age on seedling weight was non-significant while the effect of cell type was significant. The seedlings age and the cell type interaction was insignificant.

Seedling stem diameter (S_s): The average minimum stem diameter of 1.82 mm and 2.40 mm was observed in cell C_s and C_r at 25 days seedling age. The average maximum stem diameter of 2.95 mm and 3.02 mm was in cell C_s and C_r at 40 days seedling age respectively (Table 1). The effect of seedling age and cell type on stem diameter was significant. The seedling age and cell type interaction was also significant.

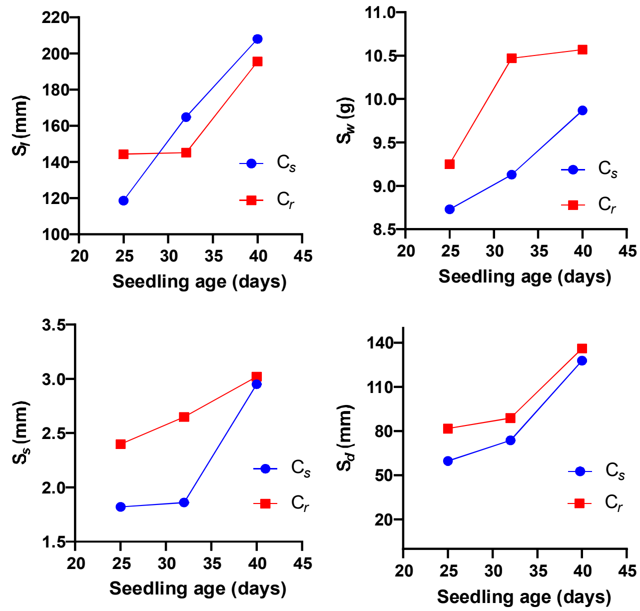

Fig. 4. Effect of the seedling age and cell type on the S_l, S_w, S_s and S_d

Table 1. Biometric attributes of tomato seedling at different age and cell type

Attributes	S_l (mm)		S_w (g)		S_s (mm)		S_d (mm)	
Cell shape	C_s	C_r	C_s	C_r	C_s	C_r	C_s	C_r
				Seedling age				
				25 days				
Maximum	140	172	11.6	11.60	2.00	2.57	72	120
Minimum	95	125	6.50	8.10	1.50	2.25	45	55
Average	118.67	144.33	8.73	9.25	1.82	2.40	59.67	81.67
SD	16.15	17.44	1.83	1.24	0.176	0.13	10.13	22.54
CV (%)	13.61	12.09	20.96	13.45	9.674	5.39	16.98	27.61
				32 days				
Maximum	185	165	10.0	11.80	2.30	3.27	90	102
Minimum	130	116	8.0	8.50	1.60	2.40	40	78
Average	164.83	171.17	9.13	10.47	1.86	2.65	73.67	88.83
SD	19.26	18.93	0.70	1.23	0.24	0.35	18.67	10.09
CV (%)	11.68	13.04	7.64	11.71	13.06	13.27	25.35	11.36
				40 days				
Maximum	245	236	11.0	12.20	3.15	3.50	154	175
Minimum	182	148	8.70	7.50	2.77	2.78	100	109
Average	208.00	195.50	9.87	10.79	2.95	3.02	127.83	136.00
SD	25.67	34.75	0.87	1.94	0.14	0.25	17.74	25.78
CV (%)	12.34	17.78	8.85	18.35	4.85	8.37	13.87	18.96

Table 2. Plug compactness score of tomato seedling at selected age and cell type

Seedling age	25 days		32 days		40 days	
Cell type	C_s	C_r	C_s	C_r	C_s	C_r
Maximum	9	9	10	10	9	10
Minimum	4	4	6	5	5	5
Average	6.7	6.4	7.9	7.3	8.8	8.4
SD	1.64	1.51	1.66	1.64	1.40	1.71
CV (%)	24.42	23.52	21.05	22.42	15.89	20.39

Seedling spread diameter (S_d): The average minimum and maximum seedling spread diameter of 59.67 mm and 136.00 mm was at 25 days and 40 days seedling age respectively. The average minimum seedling spread diameter of 59.67 mm and 81.67 mm was in cell C_s and C_r was observed at 25 days seedling age. The average maximum seedling spread diameter of 127.83 mm and 136.00 mm was in cell C_s and C_r at 40 days seedling age respectively (Table 1). The effect of seedling age and cell type on seedling spread diameter was significant whereas their interaction was found to be insignificant.

Plug compactness (S_c): The average minimum and maximum plug compactness score of 6.4 and 8.8 was at 25 days and 40 days seedling age respectively. The average minimum plug compactness score of 6.7 and 6.4 was in cell C_s and C_r at 25 days seedling age whereas the average maximum plug compactness score of 8.8 and 8.4 was in cell C_s and C_r respectively (Table 2). The influence of cell type on plug compactness score was not statistically significant. Effect of seedling age was significant and interaction between cell type and seedling age was insignificant.

The tomato seedling attributes such as seedling length (mm), weight (g), stem diameter (mm), spread diameter (mm) and plug compactness selected for the present study differs significantly under different seedling ages and increased with an increase in the seedling age for each type of cell shape. This could be due to the maturation of tomato seedlings with age. The variation in physical attributes caused by changes in cell shapes was attributable to the seedlings' differing responses to varying amounts of cell medium as seedling age increased. Bhambota et al (2019) observed that seedling age, medium, and cell size had a significant influence on plant height, stem diameter, and spread diameter (seedling growth parameters) in tomato, brinjal, and chilli crops. They also stated that seedling growth characteristics increased with seedling age.

CONCLUSIONS

For both kinds of cells, all of the specified attributes of tomato seedlings were observed to increase with seedling age. The seedling length and plug compactness score of truncated square pyramid cells were larger, but the seedling weight, stem diameter, and spread diameter of truncated right circular cone cells were greater. The maximum seedling length and plug compactness score were 208 mm and 8.8, respectively, corresponding to truncated square pyramid cells and 40 days seedling age. The maximum seedling weight, stem diameter, and spread diameter, respectively, were 10.57 g, 3.02 mm, and 136 days seedling age. These characteristics of vegetable seedlings are significant for designing and selecting various components of a vegetable transplanter.

REFERENCES

Abubakar AJ, Iya SA, Aliyu B and Tashiwa YI 2020. Determination of physico-mechanical properties of tomato seedlings for design of a tomato transplanter. *Journal of Agricultural Engineering and Technology* **25**(1): 106-122.

American Standard for Nursery Stock (ASNS) 2014. *American Horticultural Industry Association d/b/a American Hort an ANSI-accredited Standard Developing Organization 2130 Stella Court, Columbus, OH 43215*. Retrieved from www.AmericanHort.org on 21 March, 2016.

Bakhtiari MR and Ahmad D 2015. Determining physical and aerodynamic properties of garlic to design and develop of a pneumatic garlic clove metering system. *Agricultural Engineering: CIGR Journal* **17**(1): 59-67.

Bhambota S, Dixit AK, Dhatt AS, Manes GS and Mahal AK 2019. Optimization of plug size for mechanical transplanting of solanaceous vegetables. *Agricultural Research Journal* **56**(6): 308-316.

Gaikwad BB 2010. *Design and development of plug seedling transplanter for vegetable crops*. Ph.D. Dissertation, IARI, New Delhi, India.

Gaikwad LD, Nagargoje SR, Pathrikar DT and Pariskar GR 2020. Economic analysis of *Kharif* tomato production in Nashik district of Maharashtra State. *International Journal of Current Microbiology and Applied Sciences* **11**(Special Issue): 2288-2292.

Khadatkar A 2019. *Development of a tractor operated vegetable transplanter for plug-type seedlings*. Ph.D. Dissertation, CTAE, MPUAT, Udaipur, India.

Khadatkar A, Mathur SM, Gaikwad BB, Pandirwar A and Shrinivas DJ 2020. Biometric properties of plug vegetable seedlings relevant to the design of vegetable transplanter. *Journal of Agricultural Engineering* **57**(1): 16-24.

Khura TK, Mani I and Srivastava AP 2010. Some engineering properties of onion crop relevant to design of onion digger. *Journal of Agricultural Engineering* **47**(1): 1-8.

Manjunatha M, Samuel DVK and Jha SK 2008. Some engineering properties of garlic (*Allium sativum* L). *Journal of Agricultural Engineering* **45**(2): 18-23.

Masoumi AA, Rajabipoor A, Tabil LG and Akram AA 2006. Physical attributes of garlic (*Allium sativuml*.). *Journal of Agricultural Science and Technology* **8**:15-23.

Mohsenin NN 1986. *Physical properties of plant and animal material*. Gordon and Breach, New York, USA.

Pandirwar A, Kumar A, Mani I and Islam S 2015. Biometric properties of onion seedlings relevant to the development of onion seedling transplanter. *Journal of Applied and Natural Science* **7**(2): 768-773.

Received 15 November, 2022; Accepted 18 February, 2023

Rathinakumari AC, Channabasamma BB and Kumaran GS 2015. Physical and mechanical properties of garlic bulbs and cloves (*Allium sativum* L.) relevant to development of garlic bulb breaker. *International Journal of Tropical Agriculture* **33**(2): 1881-1887.

Turbathmath PA 2010. *Design and development of onion seedling transplanter*. Unpublished Ph.D. thesis, MPUAT, Udaipur, Rajasthan.

Xifeng L, Yangyang C and Yongwei W 2015. Experiment on physical and mechanical properties of tomato seedling pot for automatic vegetable transplanter. Journal of *Zhejiang University (Agric & Life Sci)* **41**(5): 616-622.