Environment and Ecology 40 (2A) : 476—481, April—June 2022
ISSN 0970-0420

Investigation of Physical Traits of Brinjal Seedlings Apropos to the Design of a Transplanter

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Received 4 February 2022, Accepted 9 March 2022, Published on 28 May 2022

ABSTRACT

Physical traits of 25, 32 and 40 days old plug-type brinjal seedlings relevant to the design of a mechanical transplanter were investigated in this study. The seedlings were grown in pro-trays with 104 and 98 square and round cell plugs, respectively. Seedling height, weight, stem diameter, spread diameter and plug compactness were all determined. During the study, it was observed that all selected traits of brinjal seedlings increased with age of seedlings for both type of cell. The seedling weight was higher than the seedling age in round cells pro-trays at 32 and 40 days, whereas seedling height, stem and spread diameter, plug compactness were found more in square cells in each selected seedling age. The maximum seedling height, stem diameter, spread diameter and plug compactness score was 153, 2.10, 88.67 mm and 9.10 corresponding to square cell and 40 days age of seedling. On the other hand, the maximum seedling weight was 13.70 g corresponding to round cell and 40 days age of seedling. These traits are important in the design and selection of various components of a mechanical brinjal transplanting machines.

Keywords Brinjal, Cell, Seedling age, Pro-tray, Physical.

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INTRODUCTION

Brinjal (*Solanum melongena* L.) is one of the most important vegetable crop grown and is rich in vitamin A and B. The brinjal, also known as "Guinea squash," belongs to the Nightshade family, which also includes the tomato, pepper and potato. Brinjal has nutritional values comparable to tomato, such as vitamin C, iron and fiber and can thus play an important role in combating malnutrition in undernourished areas (Singh *et al.* 2001). Brinjal is grown extensively in India, China, France, Italy, Spain, USA, Korea and Japan. China is the world's largest producer of brinjal, accounting for approximately 68.7 % of total production, while India ranks second with a 23.3 % share. Brinjal covers 8.14% of total vegetable area in India and produces 9% of total vegetable production (Soni 2021). However, brinjal productivity in India

is quite low (17.4 million tonnes) in comparison to other advanced countries, where productivity ranges from 17.8 to 35.9 million tonnes ha-1. In 2012-13, the area under brinjal in India was reported to be 7.22 lakh hectares, with a production of 13.0 million tonnes (Anonymous 2013).

To increase the acreage and production of the brinjal crop, new production technologies and machinery are critical in every step of the crop cultivation process. The most important input for the development/implementation of new technologies, particularly those related to the seedling transplanting process of brinjal production, is information on the physical traits of brinjal seedlings. With the use of mechanical or improved vegetable transplanters, the process of transplanting vegetable seedlings can be improved/accelerated. The growing importance of agricultural operations that use modern machinery for horticultural crop production necessitates a better understanding of their physical characteristics so that machines, processes and handling operations can be designed for maximum efficiency and end-product quality (Khadatkar *et al.* 2020). Having a precise estimate of the shape, size, weight, height and other physical properties that could be used as technical parameters in the development of a vegetable transplanter is critical (Khadatkar 2019). Gaikwad (2010) measured the physical properties of brinjal seedlings and found that 30 days old brinjal seedlings had an average total seedling weight and stalk height of 18.29 g and 36.90 mm, respectively and 45 days old brinjal seedlings had a critical canopy diameter of 48 mm. Given the importance of physical traits in the development of transplanting machinery, the current study was carried out to determine the physical traits of brinjal seedlings. As a result, the goal of this study was to determine the physical traits of brinjal seedlings that could be useful in the development of brinjal transplanters.

MATERIALS AND METHODS

The study was carried out to determine physical traits of plug-type brinjal seedling relevant to the development of a vegetable transplanter at Division of Agricultural Engineering, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-J), Jammu during 2020-21. The physical traits of plug seedlings govern the various parameters of vegetable transplanters such as seedling placement cups dimensions, which includes diameter and height of cups, transplanting dibber/dibblers size which includes the dimension of seedling catcher (hopper), connecting pipe, soil digging jaw. The easy collection and passage of plug seedlings through cups/chamber, hopper and connecting pipe without getting stuck and their subsequent vertical placement in the jaw are influenced by the physical traits of plug seedlings.

Plug-type nursery raising

The brinjal seedlings were grown in commercially available plastic pro-trays having the hole (s) in the bottom of the each cell for drainage of excess water. Pro-tray nursery benefits include the production of quality pest-free seedlings with independent area for each seed, improved seed germination, better root development, minimized seedling mortality and disease suppression, offering uniform, healthy and early ripeness, easy handling and cheaper transportation and good main field build-up and harvest status (Sharmila *et al*. 2014). The seedlings were grown using standard agricultural practices. A 3:1:1 volume ratio of coconut peat, vermiculite and perlite was used to grow seedlings in a soilless medium that was sterilized in an autoclave at 120 °C for half an hour. The square and round cells were filled with a soilless medium mixture. The brinjal plant seeds were sown at a shallow depth after the medium was carefully pressed into the plugs filled with soilless media with a finger. Because vermiculite absorbs water, a thick layer of it has been applied to the seeds to help them germinate. After that, the trays were placed in a poly house to achieve the ideal temperature for early and better germination. Each day, water was sprayed evenly over each pro-tray using fine sprinkler rods.

Type of cell

The growth of the seedlings from the plug is determined by the size and shape of the seedling shell cell. This is an important component as it determines the amount of nutrients the seedlings will have available for growth. The larger the cell size, the more media it contains, which gives the seedlings more nutrients to

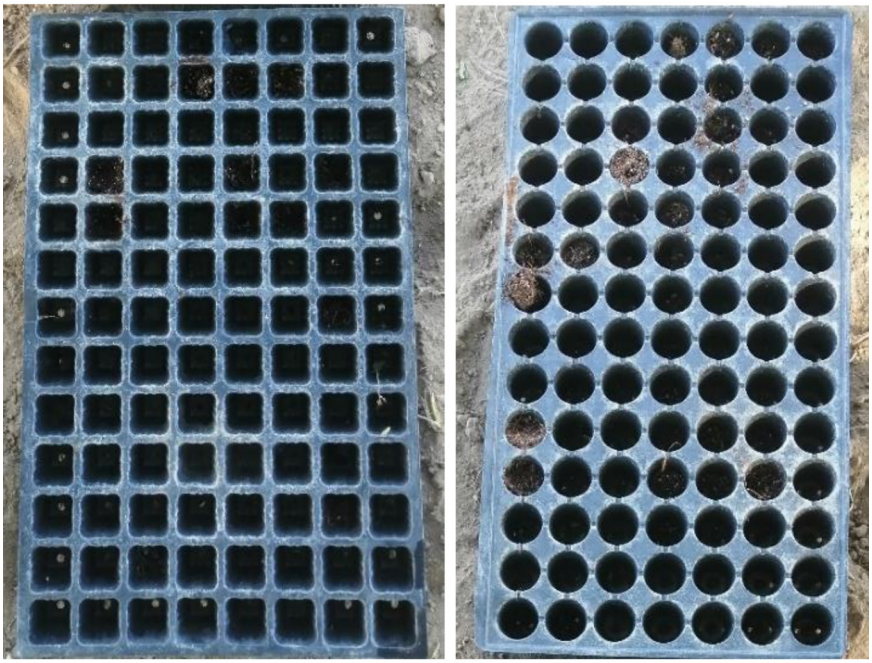

Fig. 1. Pro-trays having square (Ts) and round (Tr) cells.

grow. However, a large cell size requires more trays per unit of area to be transplanted, which not only affects the production costs of the nursery, but also the operating costs (Bhambota 2018). For the current study plastic pro-trays having square (T_s) and round (T_r) cell types with a cell count of 104 and 98 and cell volumes of 17 and 21 cm^3 were selected from the local market. The view of the pro-trays is shown in Fig. 1.

Age of seedling

Brinjal seedling transplanting is usually done when the seedlings are one month old. Two additional seedling ages, one week before and after the one month old seedling age, were choosen to investigate the effect of seedling age variation. Therefore, three brinjal seedlings ages 25, 32 and 40 days were choosen for the current study to assess the impact of different seedling ages on the physical traits of brinjal seedlings.

Measurement of physical traits

Height and weight

The seedlings were gently pulled from the plug to determine the average height and weight. The seedling height of each sample was measured using the ASNS (2014) method, which involved placing the seedlings on a table and measuring the distance from the tip of the seedling to the end of its root on a 300 mm scale with a 1 mm accuracy. The weight of the seedling, on the other hand, affects the ease with which seedlings flow in various components of the transplanting machine, as heavier seedlings drop better than lighter seedlings due to gravitational effect and was weighted

Fig. 2. Measurement of the height and weight of brinjal seedling.

with an electronic weighing balance with a minimum count of 1 g. The view of measurement of seedling height and weight is shown in Fig. 2.

Stem and spread diameter

Mohsenin (1986) proposed using a digital micrometer with a minimum count of 0.01 mm to measure the stem diameter of uprooted seedlings of various ages and cells. To ensure uniformity, the plant's stem diameter was measured at a height of 20 mm from the bottom end. On the other hand, the maximum diameter of the plant canopy was used as a spread diameter which was important for the size of holes in feeding and metering mechanisms as well as the size of the planting device, which guides seedlings to the soil for transplanting. The spread diameter of brinjal seedlings samples was measured using a ruler with a 1 mm accuracy and placed in the field in their natural state (ASNS 2014).

Plug compactness

If the plug seedling breaks or loses shape during transplanting, it will not be properly placed in the field (Bhambota 2018). Therefore, the seedling pluck rating was choosen as a criterion in this study. The plug damage was given a pluck rating of ten based on the qualitative evaluation. A rating of ten was given if the nursery seedlings were removed without damaging the plug. To test plug compactness, twenty nursery seedlings of various ages and cell types were uprooted at random.

A descriptive statistical analysis was performed using SPSS 26.0 to examine the effect of varying seedling age and cell shape on the physical traits of brinjal seedlings and the results were presented as mean and standard deviation values for various parameters.

RESULTS AND DISCUSSION

The physical traits of the brinjal seedling such as height (mm), weight (g), stem diameter (mm), spread diameter (mm) and plug compactness selected for the present study differs significantly under different seedling ages and increase with an increase in the age of seedling for each type of cell shape. This could be due to the maturation of brinjal seedlings with age.

Table 1. Physical traits of brinjal seedlings at different age and cell shape. All results are obtained from 20 samples.

Traits	Height (mm)		Weight (g)		Stem diameter (mm)		Spread diameter (mm)	
Type of cell	Ts	Tr	Ts	Tr	Ts	Tr	Ts	Tr
Seedling age				25days				
Minimum	70	70	8.0	6.9	1.28	1.19	45	42
Maximum	95	92	12.2	9.5	1.44	1.41	65	62
Average	82.50	80.67	10.12	8.72	1.35	1.31	55.50	52.17
SD	9.35	9.54	1.98	0.97	0.06	0.09	7.18	7.55
CV (%)	11.34	11.83	19.61	11.11	4.45	6.75	12.93	14.47
Seedling age				32 days				
Minimum	100	86	9.6	12.2	1.33	1.19	60	42
Maximum	132	105	12.5	14	1.81	1.46	78	65
Average	119.17	94.67	11.33	13.03	1.62	1.36	70.00	53.83
SD	12.40	6.92	1.06	0.68	0.17	0.10	6.60	8.59
CV (%)	10.41	7.31	9.33	5.22	10.43	7.23	9.43	15.95
Seedling age				40 days				
Minimum	128	105	7.5	12.0	1.81	1.63	75	55
Maximum	172	140	13.5	15.4	2.40	1.94	102	75
Average	153.00	122.17	11.47	13.70	2.10	1.76	88.67	64.67
SD	15.67	13.95	2.61	1.29	0.24	0.11	9.83	7.76
CV (%)	10.24	11.42	22.78	9.45	11.27	6.53	11.09	12.00

Table 2. Plug compactness score of brinjal seedling at selected age and cell shape.

Seedling age	25 days		32 days		40 days	
Cell shape	Ts	Tr	Ts	Tr	Ts	Tr
Minimum	5	5	6	5	7	6
Maximum	9	9	10	10	10	10
Average	6.8	6.4	8.1	7.5	9.1	8.7
SD	1.48	1.35	1.45	1.43	1.10	1.42
CV (%)	21.70	21.09	17.89	19.12	12.09	16.30

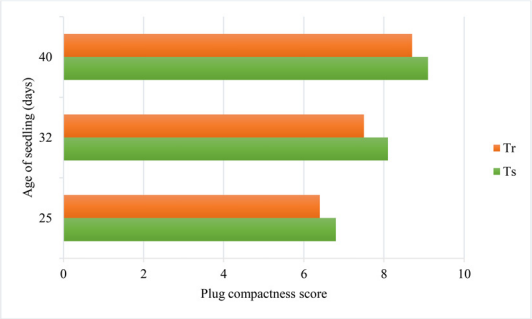

Fig. 4. Effect of age of seedling and type of cell on plug compactness.

The variation in physical traits due to change in cell shapes attributed to the seedlings' differing responses to varying amounts of cell medium as seedling age increased. The selected traits were measured and summarized in Tables 1, 2.

Height and weight

At 25 and 40 days of seedling age, the average minimum and maximum seedling heights and weights were 80.67 and 122.17 mm, 8.72 and 13.70 g, respectively. At 25 days age of seedling, cell T_s and T_r had average minimum seedling height and weight of 82.5 and 80.67 mm, 10.12 and 8.72 g, respectively. On the other hand, at 40 days of seedling age, the maximum average seedling height and weight were 153 and 122.17 mm, 11.47 and 13.70 g in cells T_s and T_r, respectively. The effect of seedling age and type of cell on height and weight of seedling is shown in Fig. 4. The effect of seedling age and type of cell on seedling height was significant at the 5% level of significance. However, the effect of seedling age on seedling weight was significant, but the effect of cell type on seedling weight was not. For both height and weight, the age of seedlings and the type of cell interaction were found to be significant.

Stem and spread diameter

At 25 and 40 days of seedling age, the average minimum and maximum stem and spread diameters were

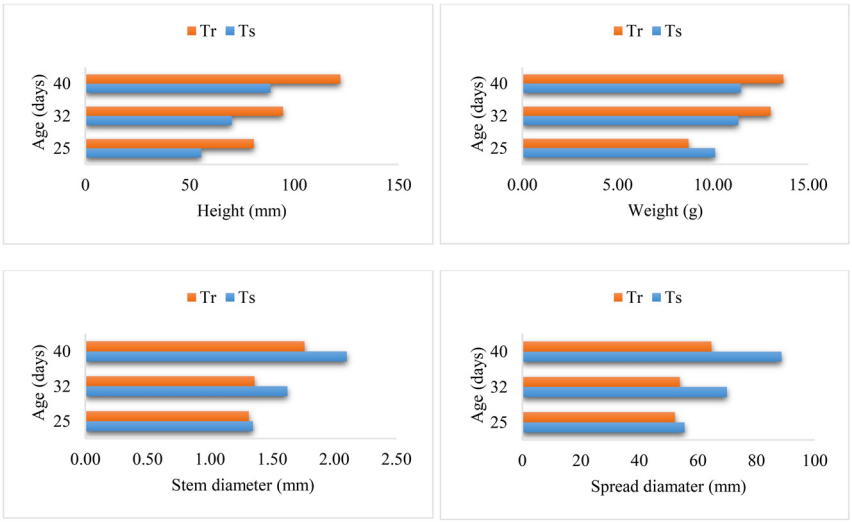

Fig. 3. Effect of age of seedling and type of cell on the height, weight, stem and spread diameter.

1.31 and 2.10 mm, 52.17 and 88.67 mm, respectively. At 25 days of seedling age, cell T_s and T_r had an average minimum stem and spread diameter of 1.35 and 1.31 mm, 55.50 and 52.17 mm, respectively. At 40 days age of seedling, cell T_s and T_r had an average maximum stem and spread diameters of 2.10 and 1.76 mm, 88.67 and 64.67 mm, respectively. Narang *et al.* (2011) measured the stem and spread diameter of two 49-day-old brinjal seedlings to be 1.94 and 2.75 mm, 79.21 and 80.50 mm. The effect of seedling age and type of cell on the stem and spread diameter of the seedling is shown in Fig. 3. The analysis of variance revealed that, at the 5% level of significance, the effect age of seedling and type of cell on the seedling stem and spread diameter was significant, as was their interaction.

Plug compactness

At 25 and 40 days of seedling age, the average minimum and maximum plug compactness score was 6.4 and 9.1, respectively. At 25 days age of seedling, the average minimum plug compactness score was 6.8 and 6.4 for cell T_s and T_r, respectively, while the average maximum plug compactness score was 9.1 and 8.7 for cell T_s and T_r at 40 days age of seedling. Narang *et al.* (2011) determined the plug compactness score of two 49-day-old brinjal seedlings to be 9.26 and 9.75. The effect of seedling age and type of cell on plug compactness score is shown in Fig. 4. According to the analysis of variance, the effect of seedling age on plug compactness score was significant at the 5% level of significance whereas the effect of cell type on plug compactness score was not statistically significant and the effect of interaction between these two was also not significant.

CONCLUSION

This study provides information on the physical traits such as seedling height, weight, stem diameter, spread diameter and plug compactness of brinjal seedlings that can be used to select and design seedling holding/placing cup/holes used in feeding and metering mechanism, connecting pipe, transplanting device and so on. The physical traits of 25, 32 and 40 days old plug type brinjal seedlings grown in pro-trays cells with the square and round shapes were investigated. The seedling weight was greater in the case of round cells pro-trays with 32 and 40 days age of seedling, whereas the seedling height, stem diameter, spread diameter and plug compactness were greater in the case of square cells pro-trays with each selected age of seedling. The maximum seedling height, stem diameter, spread diameter and plug compactness score was 153, 2.10, 88.67 mm and 9.10, respectively, corresponding to the square cell and a seedling age of 40 days. On the other hand, the maximum seedling weight was 13.70 g, corresponding to a round cell and 40 days age of seedling.

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