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Optimization of Bulk Density and Moisture Content in Different Stages of Plantation for the Single Row Manually Operated Vegetable Transplanter for Brinjal and Chilli

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Abstract

The machine used in the experiment was designed for suitability to the pot-type seedlings. In pot-type seedlings, soil in the form of soil block, keeps the roots of the seedling enact and therefore ensures minimum mortality and maximum survival of the seedlings. The compactness and seedling settlement time, before its removal from cage for planting, guides the soil block strength against breakage. The minimum damage of soil block in pot for Chilli (3.35%) and Brinjal (1.65%) was at bulk density 1.44 g/cm^3 and moisture content between 10% to 16%. Upon decrease in value of bulk density from 1.44 g/cm^3 to the range between 1.30 g/cm^3 to 1.27 g/cm^3 the damage of pot was 5.0% in Chilli and 5.0% to 6.65% in Brinjal respectively. The variation in pot damage at 1.27 g/cm^3 bulk density and above 10.0% moisture level was with value 5% in Chilli and 6.65%. The minimum mortality of seedlings was 1.65% in Chilli at moisture level above 10% and below 16% in the soil block having bulk density between 1.30–1.27 g/cm$^{3.}$ For the same range of soil density and soil moisture mortality of Brinjal seedling was ranging between 6.65% to 8.35%. Maximum seedling mortality was observed at 1.44 g/cm^3 bulk density and below 6% moisture level with value 15.0% in Chilli and 18.35% Brinjal respectively.

Keywords: Plantation, brinjal, chilli, seedling, bulk density

INTRODUCTION

Main aspects to achieve more yield of the crop as well as greater transplanting efficiency of the any transplanting machine are seedling. Compositions of the seedling for achieving high yield and quality in vegetable transplantation requires efficiency. In many agricultural locations, chilli and brinjal India are important crops, and there might be significant benefits to be gained from streamlining their plantation process. This study uses a manually controlled single-row vegetable transplanter to examine the effects of bulk density and moisture content on the transplanting process. Efficient transplantation methods are critical for the development of healthy seedlings, which has a direct impact on plant growth and output. The bulk density and moisture content of soil play important roles in seedling establishment, root development, and general plant health. Bulk density influences soil aeration, water infiltration, and root penetration, whereas moisture content is critical for seedling survival and growth in the early phases of transplantation.

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To increase total transplantation efficiency and ensuing crop growth, the ideal conditions for these characteristics must be found. This study seeks to determine the appropriate bulk density and moisture content necessary at various stages of brinjal and chilli plantation to maximize the efficiency and effectiveness of a single row manually operated vegetable transplanter. Understanding and optimizing these aspects allows us to improve transplanting success rates, increase crop production, and encourage sustainable agriculture practices. According to Bhambota et al. [1] the optimal opening time is when the planting mouth is 10 mm above its lowest position. They observed that 85% seedling efficiency from the 100 plants/(min·row), and 450 mm plant spacing. This method was confirmed to be suitable for big spacing planting of vegetable pot-seedlings (By Copyright 2015, Chinese Society of Agricultural Machinery. All rights reserved). Khadatkar et al. [2] developed the vegetable transplanter could transport 180 pots at a time. The transplanter's average field capacity for transplanting chili seedlings at 600 mm × 450 mm spacing was found to be 0.111 ha/h at a forward speed of 2 km/h, resulting in a saving of 87.14% and 87.5% labor; 87.71% and 87.20% of operating time over the conventional method of manual transplanting of pot and bare root seedlings, respectively. Kumar et al. [3] developed the transplanter's planting rate was determined to be 32 pot seedlings per min, with 4% missed planting and 5% skewed planting. The designed vegetable transplanter had a soil coverage efficiency of around 81%, and the transplanting quality was satisfactory. Magar et al. [4] design and developed the 3-DOF serial robotic arm and an autonomous feeding conveyor. The robotic arm was designed to pick up and drop tomato seedlings grown in biodegradable paper containers. Each pot had a volume of 50 cm^3 (3.5 cm diameter and 5.2 cm height) and a maximum weight of 47 g, including the pot mix and seedling. Nandede et al. [5] presented the design, development, and testing of a manual single-row vegetable transplanter for brinjal, chilli, and tomato seedlings. They concentrated on analysing the transplanter's performance compared to traditional procedures, highlighting labour savings and efficiency benefits. Paradkar et al. [6] conduct the experiment and observed the moisture content of tomato, brinjal, and cabbage seedlings was 84.3 (±3.6), 86.7 (±4.5), and 84.57 (±3.7) % w.b., respectively. The seedlings' average heights were 162.44 (±19.80), 129.4 (±16.96), and 114.13 (±19.98) mm, with canopy major dimensions of 110 ± 15.62, 79.3 ± 16.08, and 91.93 ± 14.44 mm, respectively. Yu et al. [7] evaluated that average weight of chilli seedlings was 13.1, 15.2, and 15.9 g at 30-, 45-, and 60-days old, respectively; for tomato seedlings, it was 13.4, 14.1, and 14.5 g at 30-, 45-, and 60-days old. For both seedlings, the optimal drop shatter height with the least amount of plug media breaking was 400mm. The critical canopy diameter for tomato and chilli seedlings was 70.4 mm and 68.2 mm, respectively. The mean coefficient of static friction for canvas belt, mild steel, aluminium, and galvanized iron ranged from 0.63 to 0.89 [8].

MATERIALS AND METHODS

The survival of pot type seedlings depends upon two factors viz. the moisture content of soil is intact with the roots of seedlings and the force with which the soil is intact with the roots to form a soil block. This force is generated by compaction and is expressed in terms of the bulk density of soil in the cage.

The former does not cause the plant mortality unless the soil is too dry to facilitate the water availability to the plants. Whereas the second may cause the soil block to collapse upon removal of seedling out of the cage, and thereby may lead to plant mortality, due to exposure of its root with the dry air of the environment. In fact, the excessive moisture in soil block weakens the binding force of soil surrounding the roots of the seedling and may lead to its mortality or retarded growth upon exposure of root from the soil. Thus, for optimization of the moisture content and compactness of soil block of pot type seedling, different quantity of soil was put and pressed inside the iron cage for holding the seedlings. In different replications of variable soil bulk density, a known quantity of water was poured in each cage and left to dry for 24, 36 & 48 hours. After drying the soil block of different density for different duration, they were taken out of the cage. The numbers of live plants and number of broken soil pots both were counted and seedling mortality as well as soil pot survival percentage was calculated by using formula given below:

Seedling / plant mortality (%) = $(1 - \frac{\text{No. of Survived Seedlings}}{\text{Total No. of Seedlings}}) \times 100$

Soil-pot survival (%) = $(1 - \frac{\text{No. of Broken Pots}}{\text{Total No. of Pots}}) \times 100$

The soil density and soil moisture at which the plant mortality was minimum and soil pot survival was maximum, were selected as the optimum soil moisture and optimum soil density for preparation of pot type seedling in local sandy loam soil of Pusa for mechanical transplanting of seedlings of chilli and brinjal [9]. As shown in Figure 1, the seedling tray is presented for observation, Figure 2 illustrates the pot in the seedling tray with varying bulk density. Figure 3 demonstrates the process of removing the soil pot from the seedling tray at different bulk densities.

Figure 1. View of seedling tray.

Figure 2. Pot in seedling tray at different bulk density.

Figure 3. Removing of soil pot from seedling tray at different bulk density.

RESULTS AND DISCUSSIONS

The data on, damage of soil pot and seedling mortality arranged for different level of bulk density and moisture content as placed in Table 1, indicates that the stability of soil block of pot-type seedling against damage, upon removal from the cage increases with increase in value of bulks density of the soil block.

The minimum damage of soil block in pot for Chilli (3.35%) and Brinjal (1.65%) was at bulk density 1.44 g/cm^3 and moisture content between 10 to 16 %. Upon decrease in value of bulk density from 1.44 to the range between 1.30 g/cm^3 to 1.27 g/cm^3 the damage of pot was 5.0% in Chilli and 5.0 to 6.65% in Brinjal respectively. However, in general as the moisture content was decreasing damage of pot was also going to decrease, irrespective of the value of bulk density. The variation in pot damage at 1.27g/cm^3.

Table 1. Optimization of bulk density and moisture content different stages of plantation.

S.N.	**Bulk Density (g/cm^3)**	**Moisture Range of Soil Seedling Pot (%)**	**Percentage Damage Soil Block of Seedlings (%)**		**Percentage Seedling Mortality (%)**	
			Chilli	***Brinjal***	***Chilli***	***Brinjal***
1.	1.27	>10% & <16%	5.0	6.65	1.65	6.65
		>6% & <10%	5.0	3.35	6.65	8.35
		<6% & >0%	0.0	1.65	15.0	11.65
2.	1.30	>10% & <16%	5.0	5.0	1.65	8.35
		>6% & <10%	1.65	3.35	8.30	10.0
		<6% & >0%	1.65	1.65	13.30	13.35
3.	1.44	>10% & <16%	3.35	1.65	5.0	11.65
		>6% & <10%	1.65	1.65	11.65	13.35
		<6% & >0%	1.65	1.65	15.0	18.35

Bulk density and above 10.0% moisture level was with value 5% in Chilli and 6.65%. In Brinjal this may because the matured seedlings of chilli might have its root better bounded with the soil block of the pot type seedlings. The seedlings of brinjal were tender and short with under-developed roots and may therefore have loose binding with soil, leading to lower value of bulk density, accountable higher pot damage percentage and this probably had shown increasing trend of plant mortality upon decrease in moisture content of soil in the pot.

The minimum mortality of seedlings was 1.65% in Chilli at moisture level above 10% and below 16% in the soil block having bulk density between 1.30–1.27 g/cm$^{3.}$ For the same range of soil density and soil moisture mortality of Brinjal seedling was ranging between 6.65% to 8.35%. However, there was direct bearing of soil moisture on seedling mortality and the mortality was increasing with decrease in moisture content of soil in pot. Maximum seedling mortality was observed at 1.44 g/cm^3 bulk density and below 6% moisture level with value 15.0% in Chilli and 18.35% Brinjal respectively.

CONCLUSIONS

For growing pot-type seedling, bulk density of soil block was found optimum between 1.27 g/cm^3 and 1.30 g/cm^3 with corresponding moisture content in the range of 10% to 16% within the above range of bulk density and soil moisture, soil block damage was 5.0% and 6.65%, respectively. The plant damage in Chilli was 1.65% but the same was in the range of 6.65% to 8.35% in Brinjal.

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