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Development, Performance & Evaluation of Automatic Vegetable Transplanting Mechanism for Protray Seedlings

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Abstract: **Most of the vegetables like tomato (Solanum lycopersicum), chilli (capsicum annuum l.) and eggplant (solanum melongena) are first sown in nursery beds and later transplanted manually either on ridges or on a well-prepared seedbed. Moreover, there are several activities involved in the vegetable transplanting operation. Particularly transplanting of vegetable seedlings are labour intensive. In India, labour requirement for manual transplanting of vegetables varies from 240 to 320 man-h ha-1. Keeping the above facts in view, the research was conducted on development and performance evaluation of an automatic gripping type transplanting mechanism for plug type vegetable seedlings. Tomato, chilli and brinjal seedlings were considered as the transplanting object which is local and major plug type protray vegetable seedlings of Tamil Nadu. 40 and 25 days old chilli, brinjal and tomato seedlings were used for the study. Well decomposed coco-pith was used as media for raising the vegetable seedlings. Moisture content of the growth media was found that 68.46%. The tray contains 98 cells in which the arrangement of cells is 14 x 7. The growth characteristics of vegetable plug type protray seedlings were recorded. Development of an automatic transplanting mechanism consisted of pneumatic actuated gripper for grasping and releasing the plug type seedling, pneumatic cylinder for remove the seedling from the protray cell and linear rail used for transplant the seedlings in linear motion which moves on linear guide way. The entire operations of transplanting mechanism were programmed in microcontroller which is controlled by Programmable Logic Controller (PLC) unit. Pneumatic air was supplied from compressor to the pneumatic actuated gripper and cylinder through Filter Regulator Lubricator (FRL) unit. The transplanting rate of developed mechanism was set as 20 - 25 seedlings per minute. The success ratios of automatic transplanting of seedlings were 87.22%, 91.72% and 89.85% for 25 days old tomato seedlings, 40 days old chilli and brinjal seedlings respectively. In terms of success ratio of transplanting, the average for the three kinds of seedlings was 89.59%. The pick-up device satisfactorily grasped and removed each seedling from the protray, and transported the seedling to the place where they would be precisely transplanted into the ground.**

***Keywords*: Protray seedlings, gripping mechanism, pneumatic gripper and success ratio.**

I. INTRODUCTION

India is the second largest producer of vegetables after China. Production of vegetables in India stands at 14 per cent of the world production in 2014 - 15. The area under vegetable in India is about 8.50 million ha with a production of 146.55 million tonne (Anonymous, 2015). Each field worker is only able to set 400 plants h-1 (Suggs et al., 1989), so a considerable labour force is demanded. Most of the vegetables like tomato (Solanum lycopersicum), chilli (capsicum annuum l.) and eggplant (solanum melongena) are first sown in nursery beds and later transplanted manually either on ridges or on a well-prepared seedbed (Patil, 2015). Moreover, there are several activities involved in the vegetable transplanting operation which include preparing the field for placing the seedling in addition transporting the seedling from the nursery to the field, planting at appropriate spacing and depth. Particularly transplanting of vegetable seedlings are labour intensive. In India, labour requirement for manual transplanting of vegetables varies from 240 to 320 man-h ha-1(Kumar and Raheman, 2012).

1.1. Existing automatic vegetable transplanting mechanism for plug type seedlings

At present, the research of vegetable automatic transplanter in India is still primary stage. Many studies had been done on seedling pick-up mechanisms. A pneumatic-type manipulator of seedling picking was prepared (Zhang et al. 2015). It was mainly composed by a level cylinder, a lifting cylinder, a substructure, a clamping cylinder and an end-effector. During working process, travel swatches of PLC could reach up the accurate location of the manipulator for the tray, then, under the action of the clamping cylinder, the movement of gripping and loosening was done by the manipulator's end-effectors.

Ye and Yu, 2011 developed a planetary-gear system seedling pick-up mechanism. In the planetary gear system, a pair of seedling pick-up arms which were respectively fixed in planetary noncircular gear, on the one hand, rotated around central axis with planet carrier, on the other hand,

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made intermittent rotating with non-uniform speed relatively to planet carrier. Because of combined action of the two motions, the seedling pick-up arm cusp had a movement curve which required. Through was determining suitable structure parameters of the mechanism, the trajectory of seedling pick-up arms which meet the requirements of automatic seedling picking would be obtained.

Hongsong et al. 2008 manufactured man drill-type seedling pick-up mechanism: Its working principle was that push rods of seedling pushing mechanism entered the bottom of trays from the hole and push the vegetable potted seedling against the rods, which transfer the seedlings to the required position. This study could be used for avoiding the injury of seedling stem.

1.2. Limiting factors of existing vegetable transplanting method

Although there are lot of transplanting mechanisms are developed for plug type seedling in India, the existing system of vegetable cultivation is to transplant the seedling manually with the help of women labours (Zhou et al., 2009). The vegetable seedling needs to be transplanted within a short period of 25 to 30 days. Now a day labour is not available for doing this job due to drudgery involved in this operation. Keeping the above facts in view, the research was conducted on development and performance evaluation of an automatic gripping type transplanting mechanism for plug type vegetable seedlings.

II. MATERIALS AND METHODS

2.1. Nursery management system

Well decomposed coco-pith was used as media for raising the vegetable seedlings. Tomato, chilli and brinjal seedlings were considered as the transplanting object. 40 and 25 days old chilli, brinjal and tomato seedlings were used for the study. The growth characteristics of vegetable seedlings were recorded (Fig. 1). Moisture content of the growth media was also recorded by using hot air oven method and it was found that 68.46%. The tray contains 98 cells in which the arrangement of cells is14 x 7.

Fig. 1 Measurement of growth characteristics of plug type vegetable seedlings

2.2. Conceptual design of plug type seedling gripping, picking and transplanting mechanism

Development of an automatic transplanting mechanism for vegetable seedlings raised in protray, two important mechanisms viz. movement of seedling gripping and picking mechanism from cell to cell in a row and movement of protray conveyor mechanisms were considered. An end effector / gripper, which works like a robotic arm was selected for gripping and picking the seedlings from the portray. The concept of development of automatic picking and dropping mechanisms is given in the Fig.2.

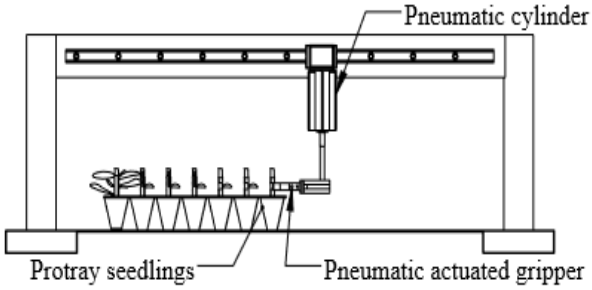

Fig. 2 Conceptual design automatic gripping, picking and transplanting mechanism

2.3. Development of an experimental set up for an automatic transplanting mechanism

Development of an experimental set up for an automatic transplanting mechanism was consisting of main frame, aluminum extrusion, linear rail, linear guide way, stepper motor pulleys, stepper motor belt, M.S plates, pneumatic cylinder, pneumatic gripper, gripper arm, pneumatic hose, conveyor belt, wiper motor, solenoid value, limit switches, electrical panel box and compressor. All the components of aluminum extrusion, electrical panel box and belt conveyer were welded with frame made of mild steel. Pneumatic actuated gripper for grasping and releasing the plug type seedling. Gripper would open and close at regular intervals. The maximum opening of pneumatic actuated gripper was 10 mm. Based on the stem thickness of vegetable seedlings the pneumatic gripper was selected. pneumatic cylinder for remove the seedling from the protray cell. Pneumatic cylinder was clamped with linear rail which moves on linear guide way. Linear guide way which is used for the forward and reverse movement of the gripper in the horizontal direction. A vertical stroke of the pneumatic cylinder for the movement of the pneumatic gripper in the vertical direction which results in lifting the seedlings from the protray cell. A belt conveyer was used for the automatic movement of protray at a regular interval.(Fig. 3).

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Fig. 3 Development of an experimental set up for an automatic transplanting mechanism

2.4. Performance test

The function of the seedling gripping and pick-up device are to automatically extract seedlings from growing trays, transfer them, and release them directly into the ground.Taking tomato, chilli and brinjal seedlings as a transplanting object, the performance test was conducted to evaluate practicality and adaptability of the pick-up device. In the test trails, the seedlings from 98 cell protrays were transplanted. Each test was repeated three times. The transplanting rate of developed mechanism was set as 20 - 25 seedlings per minute.The corresponding results were recorded and data analysis were conducted. The success ratio (%) of picking or failure, transferring, missing and damage of plug seedlings were recorded with three different vegetable seedlingsfor each replication it was determined as followed:

$$\text{Success ratio (SR)} = \frac{NFS - NMS - NEF - NSD}{NFS - NMS} \times 100\ \%$$

Where,

NFS - No. of Seedling Fed
NMS - No. of Missing Seedling
NFF - No. of Extraction Failure
NLD - No. of Seedling Damage

III. RESULT AND DISCUSSION

3.1.Growth characteristics of plug type vegetable seedling used in performance test

Development of an automatic gripping mechanism was mainly influenced by the growth characteristics of plug type vegetable seedling. After 25th day the growth parameters viz., number of leaves, shoot length (mm), root length (mm) and stem diameter (mm) were measured for tomato seedlings whereas 40th day for chilli and brinjal. The seedlings were removed manually from the protray cells and the shoot and root length of the seedlings was recorded with a steel rule with least count of 0.5 mm. The stem diameter was measured using a digital vernier calliper with least count of 0.02 mm. Pulling force of plug seedlings was measured by force gauge meter which can be measured up to 50 N. Coir pith was used as a growth media for growing of vegetable seedlings. Measured growth characteristics of vegetable seedlings are shown in Table 1.

Table 1 Measured growth characteristics of vegetable seedlings

Sl.No.	Seedlings	No. of days	No. of leaf	Stem dia. (mm)	Shoot length (mm)	Root length (mm)	Pulling Force (N)
1	Tomato	25	3-4	1.46	75.3	52.8	1.15
2	Chilli	40	6-7	1.35	125.3	66.0	1.25
3	Brinjal	40	4-5	1.40	129.8	68.2	1.29

3.2.Performance evaluation of an automatic pick-up device

The result of performance test is shown in Table 2. Seedlings in 98 cell trays were extracted with pneumatic actuated gripper to further evaluate the performance of the pick-up device in the practical production. The success ratios of automatic transplanting of seedlingswere87.22%,91.72%and 89.85% for 25 days old tomato seedlings, 40 days old chilli and brinjal seedlings respectively. Obviously, the success ratios for tomato seedlings were the lowest among the three crops. Comparing the number of seedling missed to the successful seedling extractions, it was found that some seedlings not grew in picking up position. It resulted in 20 tomato seedlings, 16 chilli seedlings and 18 brinjal seedlings were missed at the time of transplanting operation. To reduce seedlings missing, it is recommended that the seedlings should be grow in the centre of the respective tray cells as much as possible (Shaw Lawrance, 1993).

Tomato seedling damages were recorded as more as compared to the other two crops. It was found that the seedling stems were torn by the gripper, because tomato seedling stems are quite brittle and may easily break as the pick-up device gripping the stems during the process of picking up seedlings. Hence the agronomic improvement above is particularly important for tomato seedling automatic transplanting mechanism (Mao et al. 2014).In terms of success ratio of transplanting, the average for the three kinds of seedlings was 89.59%. The pick-up device satisfactorily grasped and removed each seedling from the protray, and transported the seedling to the place where they would be precisely transplanted into the ground.

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Table 2 performance test for an automatic plug type seedling pick-up device

Sl.No.	Seedlings	No. of seedling fed	No. of missing seedling	No. of extraction failure	No. of seedling damage	Success ratios (%)
1	Tomato	294	20	17	18	87.22
2	Chilli	294	16	10	13	91.72
3	Brinjal	294	18	13	15	89.85

IV. CONCLUSION

An automatic transplanting mechanism was developed for plug type vegetable seedlings. The device consisted of pneumatic actuated gripper for grasping and releasing the plug type seedling, pneumatic cylinder for remove the seedling from the protray cell and linear rail used for transplant the seedlings in linear motion which moves on linear guide way. The performance test was conducted to evaluate practicality and adaptability of the pick-up device. The transplanting rate of developed mechanism was set as 20 - 25 seedlings per minute. The success ratios of automatic transplanting of seedlings were 87.22%, 91.72% and 89.85% for 25 days old tomato seedlings, 40 days old chilli and brinjal seedlings respectively. In terms of success ratio of transplanting, the average for the three kinds of seedlings was 89.59%. The pick-up device satisfactorily grasped and removed each seedling from the protray, and transported the seedling to the place where they would be precisely transplanted into the ground.

REFERENCE

1. Anonymous. 2015. Horticulture Data Base. National Horticulture Board, Department of Agriculture & Cooperation, Ministry of Agriculture, Govt. of Ind

2. B. l.Ye, and G.H. Yu.2011.Kinematics modeling and parameters optimization of seedling pick-up mechanism of planetary gear train with eccentric gear and non-circular gear. Transactions of the CSAE. 27(5):7-12.

3. Hongsong Yu,Tiezhong Zhang,Li Yang. 2008.The research status and development prospect of the automatic transplanting machine for the plugged seedling. Agricultural machinery.20：44－45.

4. Kumar, G.V.P., and H. Raheman. 2012. Development of a walk-behind type hand tractor powered vegetable transplanter for paper pot seedlings. Bio systems engineering.110:189 - 197.

5. Mao, H., Han, L., Hu, J., & Kumi, F. 2014. Development of a pincette-type pick-up device for automatic transplanting of greenhouse seedlings. Applied engineering in agriculture, 30(4), 547-556.

6. Patil, A. S., Davane, S. S., & Malunjkar, S. V. 2015. Design, Development and Testing of Hand Held Vegetable Transplanter. International Journal, 3(1), 247-253.

7. Shaw, L. N. 1993. Changes needed to facilitate automatic field transplanting. HortTechnology, 3(4), 418-420.

8. Suggs, C.W., D.L. Eddington, H.B. Peel., and T.R.Seaboch. 1989. Self –feeding transplanters. Proc.11th CIGR Congress on Agri. Engr., 3:1715-1722, Dublin, Ireland.

9. Zhang Wei, Zhaojun, N., Lianhao, L., & Yongrui, H. 2015. Design and optimization of seedling-feeding device for automatic maize transplanter with maize straw seedling-sprouting tray. International Journal of Agricultural and Biological Engineering, 8(6), 1.

10. Zhou, T., Wanh, X., Wang, C., Zheng, L., Li, X., Qiao, X., and Wang, C. 2009. Design and simulation analysis of transplanter for potted tray seedlings in greenhouse (In Chinese with English abstract). Machine Design Res, 25(2), 121-124.