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Development of manually operated pull type paperpot transplanter for onion

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Abstract
India is the second largest producer of vegetables in the world next to China with a production of 169.47 million tons from an area of 9.54 million hectors. Vegetables are an important part of human diet and provide vitamins, proteins, minerals, carbohydrates and roughages. Onion is a major vegetable used in many different ways in daily diet. The demand for onions is worldwide. Onion growers are facing lot of problems in transplanting of onion seedlings with the shortage of farm labours during transplanting seasons. This transplanter was designed on the basis of ergonomical consideration for transplanting one row at a time. The main part of vegetable treansplanter is paperpot conveyer. For seedling rising papepot sheet is used. It decomposes in the soil during the season. The underside of the body has a furrow opener that creates a furrow, in which the seedlings are funneled into. Sweep and pressure wheel cover seedlings with plant. The theoretical field capacity in manual transplanting ranged from 0.002 ha/h against 0.0599 ha/h in mechanical transplanting. The effective field capacity of paperpot transplanter during experiment was 0.0246 ha/h whereas average field efficiency was 41.04 per cent. Traditional method, average manual transplanting rate was in the range of 8.57 to 10.59 seedlings-min^{-1}-person^{-1} and the labor requirement was 400 man-h/ha. Whereas, in mechanical transplanting, the transplanting rate of paperpot transplanter 81.37 seedlings-min^{-1}-person^{-1}which leading to decrease in labor requirement.

Keywords: Paperpot, transplanter, seedlings, onion

Introduction
India is the second largest producer of vegetables in the world next to China with a production of 169.47 million tons from an area of 9.54 million hectors. Agriculture in simple words may be defined as a large-scale process of cultivating land or raising stock for producing food, feed, fiber and other desired products. Agriculture has remained traditionally the most important economic activity in our country, that a majority of the rural households are directly or indirectly dependent on agriculture. The topography of India, soil types, rainfall availability of water for irrigation are the factors that determine the crops and livestock pattern. Many operations in agriculture are now being performed by machines. This reduces the labor requirements which have been the principal motivating force in mechanization. There are some areas, like vegetable transplanting and harvesting, where mechanization has progressed very slowly. Onion growers are facing lot of problems in transplanting of onion seedlings with the shortage of farm labours during transplanting seasons (Turbatmath *et al.*, 2011) [5]. The manual transplanting operation requires considerable hard labour pulling of the plants and setting them in the field that entails considerable time labour expenditure and extremely tiring. For these reason manual transplanting of seedlings can only be practiced on small size farms. The results of manual transplanting are not always satisfactory in that the stands may suffer high morality or non uniform growth (Nikhade, 2001) [4].

Mechanization of transplanting means the reduction demand for labour in cultivating operation in which the minimum damage to seedling and the maximum efficiency of cultivating is being provided. However, this requirement happens when the labour income is less than the revenue provided by machines replacement. This need increases by rising cultivating of crops that can be cultivated in transplanted form, and in contrast, it should design and build new equipment and devices for mechanization of this kind of cultures (Zamani, 2014) [6]. The paperpot transplanter is a simple machine; operate by single person to transplant seedlings in less time. It is a system especially suited for the production of onions which becomes labour intensive at a greater scale.

Materials and Methods

Determination of Agronomical Requirement for Vegetable Seedlings

Time and spacing required for transplanting

Generally vegetable crop like Tomato, Onion, Chilli, Brinjal, Cauliflower, Cabbage etc. are transplanted (Choudhury *et al.*, 2001) [2]. Onion is selected for the study purpose. Table 1 shows the time of transplanting and agronomically recommended spacing for the crop under study.

Table 1: Transplanting time and spacing requirement for onion

Crop	Season	Time of seed sowing	Time of transplanting	Spacing (cm × cm)
Onion	Early Kharif	Feb. - Mar.	April - May	10 × 10 and 10 × 15
	Kharif	May - June	July - Aug.	
	Late Kharif	Aug. - Sept.	Oct. - Nov.	
	Rabi	Oct. - Nov.	Dec. - Jan.	

Determination of relevant biometric properties of onion seedlings

Studies were conducted on GJRO-11 variety developed at Vegetable Research Centre of Junagadh Agriculture University, Junagadh, Gujarat. Fresh onion (*Allium cepa* L.) seedlings were procured from green house of CAET, JAU and also grown with the standard agronomic practice of nursery raising under the direction of onion breeder scientist.

Age of seedlings

Conventionally, the farmers practice transplanting of 30 days old plug seedling. But it was planned to test 40 and 50 days old plug seedlings, since the seedlings would be easier to eject if the root mass formed is solid by age.

Height of seedlings

Seedlings were gently pulled from the nursery bed as well as from paperpots and height of seedling was measured through longest dimension with the help of digital vernier scale as suggested by Mohsenin (1986) [3].

Weight of seedlings

Onion seedlings were generally de-topped at 10-12 cm height before manual transplanting. Thus, twenty randomly selected seedlings were weighed without de-topping of electronic weighing balance with least count of 0.001 g.

Moisture content of seedlings

The moisture content of onion seedlings was determined at transplanting stage. The standard method given by Association of Official Agricultural Chemists (AOAC) to determine the moisture content of seedlings was used for the purpose.

Bulb diameter of seedlings

The bulb diameter of onion seedlings were measured at the centre of bulb using vernier caliper with least count of 0.1 mm (Plate 3.4) as suggested by Mohsenin (1986) [3].

Development of Paperpot Transplanter

A successful onion seedling transplanting system should have mechanism to i) open the soil in form of narrow furrow, ii) placing of onion seedlings vertically upright in it and iii) closing and compacting soil around the bulb without damaging it. Such type of transplanting mechanisms include furrow opener to open the soil for placement of onion seedlings in it and press wheels and sweeps for closing and compacting the soil around the onion bulb. Use of furrow opener to open soil, then placement of seedlings at desired depth in it and subsequent furrow closing using a press wheel and sweeps is possible using simple mechanisms.

Paperpot Seedling Trays

The foundation of the paperpot system was trays. These trays were slightly larger than the traditional tray commonly found anywhere. Size of tray is 60×30×3 cm (l×w×h). Made of aluminium, the trays have a long lifespan and can be reused for many seasons.

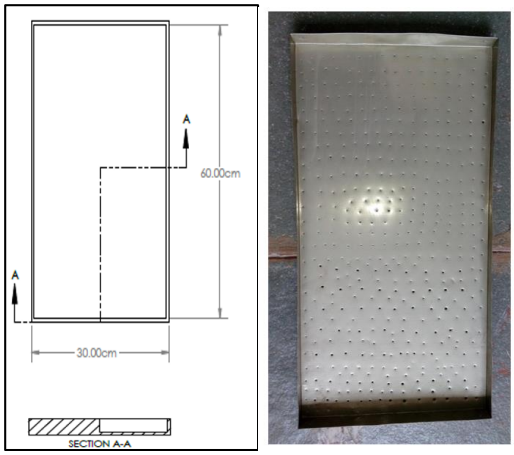


Fig 1: Paperpot seedling tray

Paper chain pots

As the name indicates it was made from paper material. The paper chains were home mad. So there were not ideal as readymade paperpot available in the international markets. There were come in a compressed form, and offered in 10 cm spacing for onion crop. Each cell was bottom less and linearly connected. Each has 264 cells and was placed into the seedling trays. But the homemade paperpot were having spacing of 6 cm and 10 cm.

Fig 2: Compressed paperpot

Fig 3: Paper chain pots placed in a tray

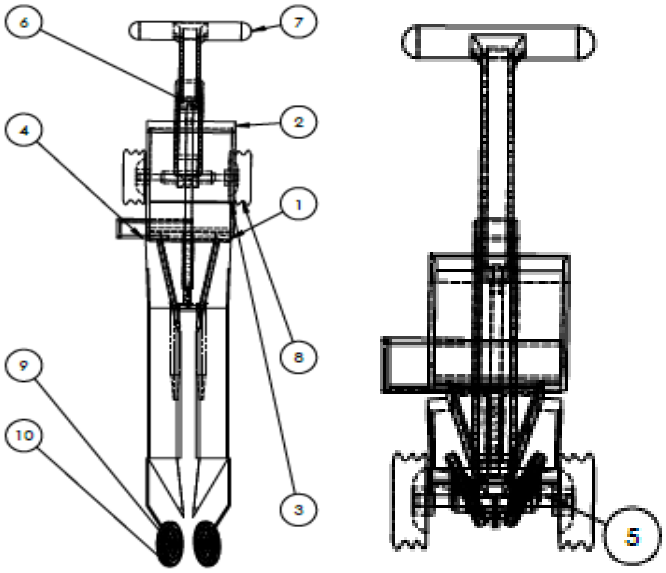
Design of paperpot transplanter

The design criteria for the functional components were kept as lowest, simple design and highly economical in nature. The line diagram and conceptual design of machine is shown in Figure 4. The main components of designed machine are pull handle, tray, tray holder, paperpot conveyer, furrow opener, sweep, ramp and pressure wheels.

Field Testing

Field operation of paperpot transplanter

Adjust the height of handle as per requirements of labour. Then adjust the require depth favorable to crop with the help of depth adjustment given in transplanter. First of all take ramp and place it on back side of the seedling tray by pushing the paperpot. Than fixe the tray on paperpot conveyer. The transplanter opens a narrow furrow, the paper chain goes down into the furrow, and then the plants were covered by a set of metal sweeps. At the start of a row, the lead cell of a flat of paperchain pots was pulled down into the furrow, staked to hold it in place, and then pull the transplanter forward. The transplants all follow each other into the ground. Packing or pressure wheels firm the soil around the transplants.



(a) Top view **(b) Rear view**

Fig 4: Line diagram of paperpot transplanter

1. Paperpot conveyer (main body), 2. Tray holder, 3. Ramp, 4. Carry handle, 5. Wheel rode, 6. Depth adjustment, 7. Pull handle, 8. Pressure wheel, 9. Wheel holder, 10. Front wheel

Fig 5: Developed paperpot transplanter

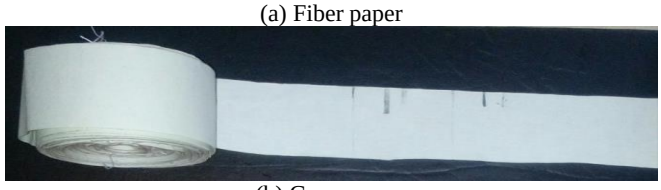
Fig 6: Field operation of paperpot transplanter

Fig 7: Field operation of paperpot transplanter

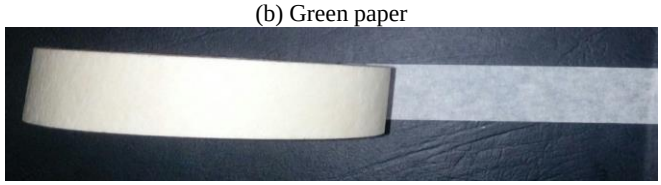
Testing the quality of paper pot material

Paperpot were made from thin paper sheet, which are decomposing in soil in a month (Anon., 2011). I developed paper chain pots from different paper material and its strength and decomposition time was tested. Paper material was used for the experiment purpose are fiber paper having thickness of 2 mm (having less water effect), green paper having thickness of 1.5 mm, paper used for bag having thickness of 1 mm and combination of fiber paper and paper bag material. The material best suitable for seedling growth, transplanting with less breakage of paper chain was combination of wall paper and paper bag material.

(a) Fiber paper



(b) Green paper



(c) Paper bag material

Fig 8: Paperpot materials

Results and Discussion

Variation in height, weight, moisture content and bulb diameter of onion seedling in both the cases are given in Table 2. Which indicates that as the numbers of days are increases height and weight is also increased but in case of seedlings raised in paperpot the height is decreases with increase in numbers of days. Moisture content is decreased and bulk diameter is increased in both the condition.

Table 2: Biometric properties of onion seedlings

Sr. No.	Properties	Raised in nursery bed		Raised in paperpot	
		40 days	50 days	40 days	50 days
1	Height of onion seedlings (mm)	244.34	259.22	157.64	151.05
2	Weight of seedlings (g)	0.57	1.89	0.56	1.49
3	Moisture content (%)	91.63	84.89	91.63	84.89
4	Bulb diameter of seedlings (mm)	2.65	4.03	3.66	4.39

Testing the quality of paperpot material

Chain pot was made from paper only, so it supplies air and water equally to root. Theses help to raise healthy seedlings. At the time of transplanting, seedling put in to field with paperpot. It means that does not need to remove paper. Paper material pretect a root and it also help in initial growing, specially for non healthy seedling and young seedlings Paper materials used for preparing paperpot sheet were from the stationary shop.

Table 3: Life of paper day after sowing

Sr. No.	Paperpot material	Life of paper DAS
1	Fiber paper	30
2	Green paper	40
3	Paper bag material	45
4	Combination of fiber and paper bag material	50

The problem associated with paperpot system was the decomposition starts after 3 to 4 weeks after transplanting in fiber paper and green paper. At the time of transplanting paper chain breaks after numbers of transplanting which takes more time for transplanting. But remaining two sheets having less breakage during transplanting the reason of it was the constructional elements of paper.

Field performance results

After the completion of both manual and mechanical transplanting operations in the selected area, different performance parameters were recorded. The average row spacing at different locations was 50 cm for selected onion verity. The width of operation of the machine was 20 cm. The plant spacing for developed transplanter was 6 cm and 10 cm against recommended plant spacing of 10 cm. whereas in manual transplanting it was 10±3. The average planting depth for GJRO-11 was 2.5 cm with mechanical transplanting and 1.5 cm with manual transplanting. The depth of transplanting was adequate for sustenance and establishment of seedlings in field. The percent miss transplanting in mechanical transplanting was 2.99 percent which was closer to recommended acceptable limit of 4 percent. The percent seedling mortality increased respectively from 2.93 to 4.17 percent in mechanical transplanting and 1.28 to 4.25 percent in manual transplanting for 10 to 30 days after transplanting. The small increment in percent seedling mortality in mechanical transplanting was due to increase in damage to the seedlings in comparison to manual transplanting. The damage was attributed to mechanical damage as well as damage and missing caused by birds. The theoretical field capacity in manual transplanting ranged from 0.002 ha/h against 0.0599 ha/h in mechanical transplanting indicating the satisfactory performance of onion seedling transplanter. The effective field capacity during experiment 0.0246 ha/h. Whereas, average field efficiency was 41.04 per cent. The draft required to pull transplanter in field ranged from 8.19 kgf.

Conclusion

Paper material used in the experiment among them paper bag material and combination of paperpbag and fiber paper is more suitable for experiment purpose because it is having long life as compared with other two. During the transplanting breakage of paperpot chain is less in both (paperbag material and combination of paperpbag and fiber paper) of the material. There were small bits of paper left in the field which takes a while to decompose. For onion seedlings, plant mortality was 2.93%, 3.38% and 4.71% after 10, 20 and 30 day respectively for 40 and 50 days old seedlings. Theoretical field capacity was found as 0.0599 ha/h, Effective field capacity was found as 0.0246 ha/h, labour requirement was found 40.44 man- h/ha and minimum cost of operation was found as 11464.00 Rs./ha seedlings. Field efficiency was found as 41.04%

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