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Development of a seedling ejection mechanism for pro-tray seedling

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ABSTRACT : A novel seedling pick - up mechanism was developed and its performance was evaluated at the laboratory. The pick - up mechanism extracts seedlings from a 98 cell pro - tray and transfer them to place into the soil. The pick - up mechanism consisted of a coupler extension (claw), driven link, driving crank, and coupler. The pick - up mechanism is a four bar mechanism modified according to our requirement. The coupler joins the driving link and driven link. When the crank rotates, the claw enters into the pro - tray cell from the top and tease out a seedling from its cell. The coupler path was so designed to do this job without damaging the root ball and the plant. The pick - up mechanism was tested with different medium and depth of penetration. When tried on 20 days old seedlings, The seedling pick - up mechanism extracted 15 to 20 seedlings per minute and the success ratio was 80 per cent.

KEY WORDS : Pro-tray, Tray holder, Pick - up claw, Four bar mechanism

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One of the important components of the vegetable transplanter is the seedling extraction mechanism, which extracts the plug seedling from the pro - tray cell and transfers them to the transplanting device, which places them into the soil. Yanmar Agricultural Equipment Co. and Kubota Cooperation, leading agricultural machinery manufacturers in Japan, have developed two of the most common seedling pick - up devices for the vegetable transplanters widely used in Korea and Japan. The Yanmar - type moves the pick- up pins toward the lower part of the cell surface and extracts the seedling from the cell while moving along a path in an open, counter - clockwise loop. The Kubota - type generates a crossed path when picking up seedlings by using a more sophisticated mechanism comprising of a slider, cam, and links. Although these two pick - up devices perform well, their structural complexity have made them difficult to use for various types of vegetable transplanters. In addition, these pick - up devices are not economically feasible for indigenously made vegetable transplanters because of their high manufacturing costs (Choi *et al.*, 2000).

The demand for mechanization of vegetable production in India has increased every year, so attempts are being made to develop an automatic transplanter for vegetables. Seedling pick - up mechanisms that are simple, accurate and economically feasible are to be developed for vegetable transplanters in India. This study was one of these attempts. The articles authored by Brewer (1994), Choi *et al.* (2001) and Choi *et al.* (2002) were reviewed to develop a concept of seedling ejection device that will satisfy our requirement. Not much of literature is available in this context. The objective of this study was to develop a seedling pick - up mechanism for vegetable transplanters suitable to Indian conditions and evaluate its work performance in a laboratory.

METHODOLOGY

Development of seedling ejection mechanism:

To obtain the best performance of the pick - up mechanism, it needs to satisfy the following requirements.

The pick - up claw enters into the pro tray cell with the depth of penetration not to be more than half the depth of the pro - tray cell.

The pick - up claw should release the seedling immediately after coming out from the tray cell.

The mechanism should be simple and easy to fabricate.

Extracting and discharging of seedling should be done at predetermined points on the locus of the claw.

The stem and leaves of the seedling should not be

damaged.

The root ball of the seedling should not be damaged during extraction of the plug.

Experiments on seedling ejection by clawing out from the top of the pro - tray cell:

The developed pick - up mechanism claws out the seedling plug from the top of the tray using an appropriate mechanism. It was felt that the four bar mechanism would be appropriate to try this method by parking the seedling trays on its side and the mechanism opposite to the cell. A four mechanism was designed to extract the seedling from the tray cell and release it to fall free to the ground. The tip of the claw as an extension of the coupler bar was supposed to extract the plug seedling entering into the top of the pro - tray cell and tease it out, by moving in a predefined path. But care should be taken not to hit the seedling stem when it is done. A freeware by the name "four bar" was used to synthesise the coupler curve of the designed mechanism. A path was first assumed to do the job and the coupler curve analysis using the freeware was done to optimize the dimensions of the four bar mechanism appropriately to generate the required path of the claw. Fig. A shows the coupler curve finalized for the mechanism.

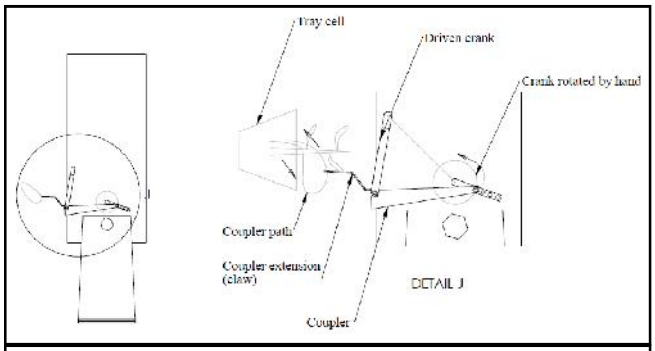

Fig. A : The finalized coupler curve of the mechanism

Experimental setup for assessing extraction performance of finalized mechanism:

A tray holder was (Fig. B) developed wherein the pro - tray with seedling could be placed horizontally. Three pair of six mm rod with height of 30 cm was mounted on the holder platform vertically at equal distance with 2 mm gap between the rods for inserting the pro - tray from above. The tray holder was made to slide horizontally on a rectangular bar and the whole assembly was fixed on a flat wooden plank. A handle was fitted at end of the tray holder for moving the pro- tray forward or rearward so that the pro - tray could be moved. The pro - tray along with the seedlings could hence be moved and positioned against the ejecting mechanism, so that ejection performance could be assessed against each seedling

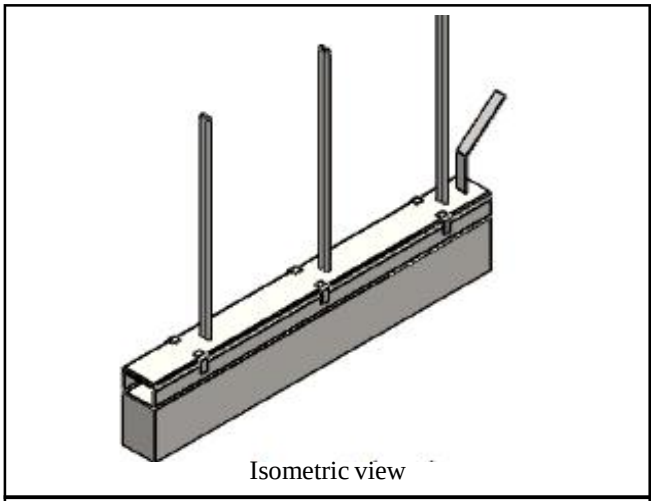

Fig. B : Tray holder

in a row. For assessing the bottom or top row, the holder platform was raised up on a set of wooden blocks to the required height. The four bar mechanism was mounted on a vertical stand with a handle provided for hand cranking (Fig. C). The handle when rotated in the appropriate direction made the pick - up pin of the claw enter the top side of the pro - tray to a depth of 3 cm, teased and ejected out the seedling. The pick - up claw was expected not to break up the root ball during the removal. In order to avoid root ball damage, the tips of the claw were flattened and the pro - tray seedlings removal was successful.

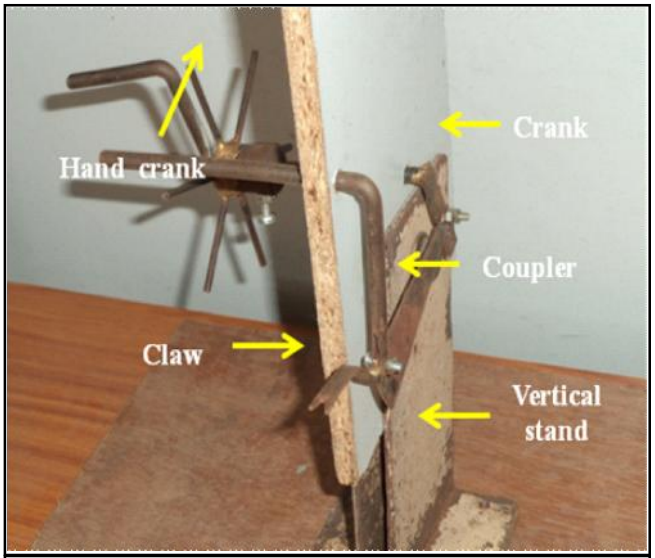

Fig. C : 3 Seedling pick - up mechanism

RESULTS AND DISCUSSION

The 98 cell pro tray with plug seedlings was mounted

vertically and the seedling pick - up mechanism was installed in front of the tray holder. The distance between the seedling tray and pick up mechanism was manually adjusted. Fig. 1 shows the pick - up claws extracting the seedling one by one from the tray. The vegetable seedlings used for evaluation were 20 days old seedlings as grown in three media namely coir pith alone (M1), coir pith + vermin compost 4:1 (M2) and coir pith + soil 1:1 (M3) (by volume).

The seedlings were watered a day before conducting the performance test in the laboratory. The performance test was conducted under 4 sets of operational conditions such as depth of operation, age of seedling, speed of rotation and growth medium. From the Fig. 2 it is observed that the pick - up claw penetrated into the root media to a depth of 35 mm, which was found satisfactory with the success ratio of 82 per cent.

When the crank was rotated by hand at appropriate speeds of 25 and 50 rpm, the success of seedling extraction was 67 and 81 per cent, respectively, because the higher the rotational speed it had caused slippage of the seedling in the tray (Fig. 3). Most of the successful extractions were made on 20 days old seedlings, while using the 30 and 40 days old seedlings the leaves get on tangled, which prevents free falling of the seedling (Fig. 4). The growth medium does not affect the performance of the seedling (Fig. 5).

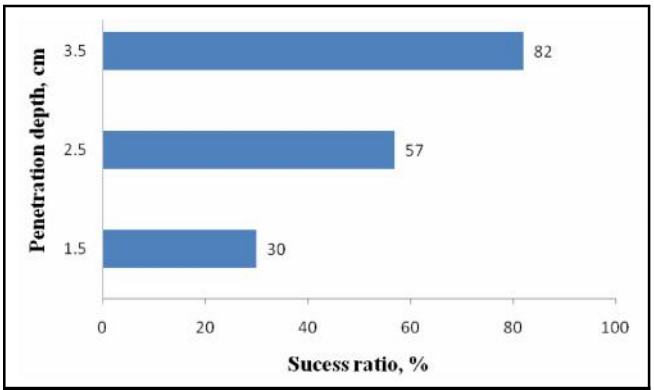

Fig. 1 : Success ratio by penetration depth of claw

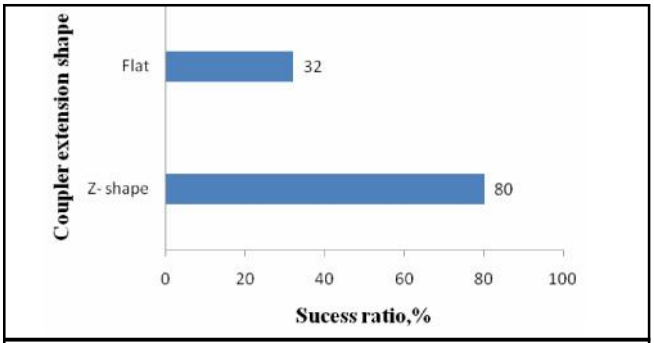

Fig. 2 : Success ratio by claw shape

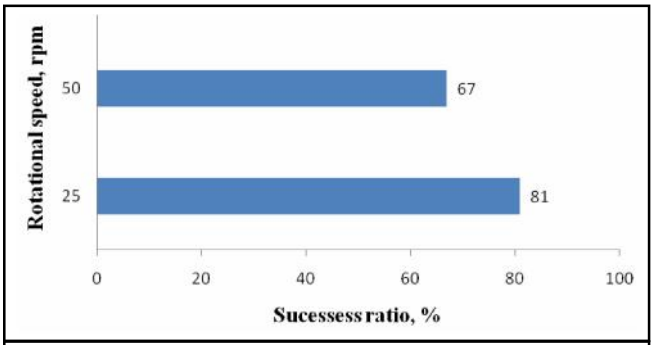

Fig. 3 : Success ratio by rotation speed

Conclusion:

A seedling ejection mechanism for extracting the plugs out of the pro - tray was developed and evaluated in a laboratory. The pick - up claw extracts the seedling from the tray cell. This is a four bar mechanism comprising of a driven link, driving link and pick up claws. This mechanism was tested under various operational conditions such as seedling age, penetration depth, growth medium and speed of rotation. The pick - up device extracted 15 to 20 seedlings per minute

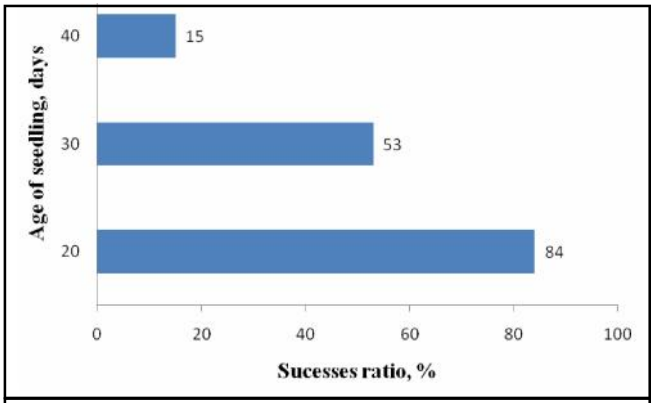

Fig. 4 : Success ratio by age of seedling

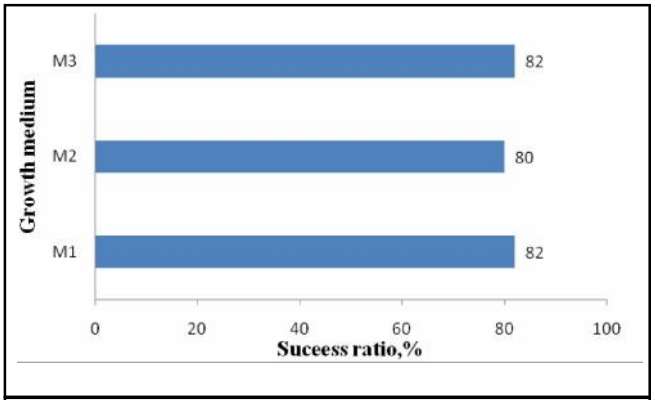

Fig. 5 : Success ratio by growth medium

and the success ratio was 80 per cent, while tested on 20 days old seedling. The seedling removal was successful but the root ball being fragile often broke up. In future, adding some binding material with growth medium could be used to improve the root ball integration.

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