

Design, development and evaluation of an automatic metering system for bare root seedlings of onion

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Introduction

In recent years due to lack of water resources in our country, planting of bare root seedlings of onion has been welcomed by farmers. Considering the desired high dense planting of Iranian farmers, lack of proper transplanting machine has appeared as the main problem. To overcome this problem, some researchers tested a few methods, but none of them reached to complete successfully. As the one of last efforts, Taki and Asadi (2012) developed a semi-automatic transplanting machine with 9 planting units. This machine requires to 9 men to separate and single out a bunch of seedlings. Usage of this machine is very time-consuming and labor intensive. In Iran, transplanting of bare root seedlings is practically performed by hand with a density of 700-800 thousand plants at hectare. The main purpose of this study was designed, manufacture, and evaluation of an automatic metering device that with the separation and singulars of bare root seedlings of onion could get a high density planting.

Materials and Methods

Fig. 1 shows the main employed idea of this research for separation and single out a bunch of seedlings.

As shown in Fig. 1, the metering device consisted of two carrying and separating belts with different teeth forms. Placing seedling bunches between the two belts, the belts move at different speeds in opposite directions and separate seedlings from their bunch.

For proper design of metering device system, measurement of some physical properties were necessary. The obtained information was used to select two belts form. A belt with flexible plastic teethes with a height of 6 mm and the distance of 4mm was selected as separator while for carrier, two types of belts were selected: the first was the same as a separator and the second was made of metal teethes.

Based on the average thickness of seedling bunch and some pre-tests, the horizontal angle of separator belt determined as ≈ 20 degrees. Theoretical calculations were done to computating of the needed force of the system. In this section, seedlings were modeled as some solid cylinders with a length of 200 and a diameter of 10 mm. In the mentioned system, it was necessary that the speed of separator belt is more than the speed of carrier

$$\left. \right\} = \frac{V_{\text{Separator}}}{V_{\text{Carrier}}}$$

belt. Thus, ratio of two linear velocities () of 1.67 and 2.32 were considered for evaluation of the system. For evaluation of manufactured metering device, the effects of three factors, i.e., carrier belt type, ratio of linear velocities of the belts, and number of seedlings in a bunch ($n=30$ and $n=60$), on qualitative planting parameters were studied in a factorial experiment based on completely randomized design with three replications. The studied qualitative planting parameters were miss index, consumed seedlings, miss length, quality of feed index, multiple index, mean, and damaged seedlings.

Results and Discussion

The results of analysis of variance showed that, except of belt type, effects of the two studied factors and all interactions are statistically non-significant on consumed seedlings and miss length indexes. The results indicated significant differences between miss index ($P<0.01$), multiple index ($P<0.05$), and mean ($P<0.05$) as affected by belt type. None of the studied variable had a significant effect on damaged seedlings. Interactions of

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belt type and ratio of linear velocities significantly affected the quality of feed index ($P < 0.01$). An increase in ratio of linear velocities in plastic toothed belt lead to decrease of mean and miss indexes, whereas in case of metal toothed belt there is no significant effect on this two indexes. The results also showed that increase of linear velocities for the two types of carrier belt lead to increase of consumed seedlings and decrease of miss length. At the two ratios of linear velocities, miss length in metal toothed is less than plastic toothed belt.

Conclusions

Commercial transplanting machines are not suitable for dense planting of onion. In this research an automatic metering device for separation and singularize of bare root seedlings of onion was manufactured and evaluated. The results indicated that the carrier belt with long and rigid teeth, having an angle of attack, could separate seedlings more efficiently. The results also showed a 80 percent increased in uniformity of plant seedlings distances is reachable using the metering system.

Keywords: Bare root seedlings, Metering device, Onion, Transplanter