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Preliminary design, construction and evaluation of robot of tomato seed planting for the trays of greenhouse

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Introduction: From an economic viewpoint, tomato is considered as the second most valuable crop after potato. It is also preceded by the potato in terms of per capita consumption in the world. In 2008, the cultivation area used for the tomato as equal to 163,539 hectares in Iran and the production of it was equal to 5,887,715 tons with an average production of 117,887 tons in 4352 hectares in the provinces, respectively. Having high production volume and quality, costly hybrid seeds are currently used for the major planting areas of vegetable in Iran. Most of the used transplanted seedlings are 83%. Since the seeds are expensive, the percentage of seedlings and healthy and disease-free seeds should be used for maximized germination and be transferred to the fields of open space. Preparing seedlings in transplanting trays is a technology to respond to this need. Trays are covered with a layer of Peat and Miculite fertilizers. Then, one seed is manually placed in each cell after gauging and preparing a suitable field. However, manually placing seeds is time-consuming and requires hard labor. Sixteen working labors per hour are required for 15 × 7 cell in order to have 10200 seedlings grown in 100 trays. Due to lack of adequate labor, production capacity of greenhouses is reduced, especially in the farming season when finding labor for planting vegetable sprouts is laborious. Therefore, mechanizing tray seeding operations is essential to increase the capacity of the growing industry of greenhouses in Iran.

Materials and Methods: Initially, the tomato seeds were examined in the laboratory. The most important parameters of the study included size, shape, weight, the speed of getting out of the tank and the minimum carrying speed. Then, a vacuum-based single seed picking unit was prepared to investigate the factors influencing the design, so that a single tomato seed can be harvested from the masses. The most important factors considered in the design and construction included: cost, ease of performance, portability, use of local equipment, the planter's capacity as well as the style of picking single seeds (In Fig.1, the original scheme of the device is presented). The planter consists of several parts operating harmoniously to yield the desired results. These parts include a chassis and conveyor belt mechanism, primary and secondary fertilizer tanks, squashing unit, seed metering device and vibrating reservoir of the seed (The main text of modeling the device with SolidWorks software is shown in Fig.2). This device is designed in such a way that the position of the nozzle, the suction pressure, the height of removing seeds and the vibration frequency of the seeding tray are adjustable. Evaluation of the device was carried out by single seeding of tomato seeds in trays with 105 cells (7 × 15). Suction pressure and nozzle size were calculated for tomato seeds. Scaling distances were considered equal, based on the 30.5-mm intervals of the cells. Single seed picking efficiency of seeds was calculated by the system, as the single percentage of seeding and the total percentage of seeded cells. Seed consumption efficiency is the ratio of the total seeded cells to the total number of existing seeds in the cells. Seeding efficiency also refers to single, dual, and multiple harvested seeds. Furthermore, the device capacity is defined as the number of seeded tray cells per hour. In order to design and build a precise robot planter, an experiment including the designed planter and planting speed of workers in 10 repetitions was designed and implemented to estimate the seeding time and compare with automated and manual planting methods. Seedling trays with four replications were cultivated by the designed robot and the number of cultivated seeds per tray at each stage were correctly counted. After that, the spent planting time by a worker was determined with four replications.

Results and Discussion: The planting rate of tomato seeds is different when comparing mechanized and manual methods. As it is known, the time required for cultivation in the mechanized method is at least one-tenth of the time

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required for cultivation in the conventional and manual method, which causes the planting rate to increase, and this robot is one of the components of cultivation in the mechanized method in cultivation and production of tomatoes. By assessing planting time using the mechanized method it was revealed that an average of 26.3 seconds is needed to fill a 7 × 15 centimeter tray of tomato seeds with 105 cells. The same planting procedure in the manual method takes an average of 357 seconds which is indicative of the high rate of the designed device. The planter capacity experimented using a seedling tray with the size of 15×7 cells, was calculated to be 17750 cells per hour showing that the suction pressure increases by a reduction in seed size. Thus, while working with small-sized seeds, fluctuations of the suction pressure must be carefully considered to be minimized and the seed being dual was only affected by the opening diameter. Therefore, the opening diameter should become the same in size in order to minimize the dual seed instances. In case of the tomato, the opening diameter had a great influence on the seeds being bulky.

Conclusions: Manual planting takes a considerable time in comparison with the mechanized planting. Furthermore, using the designed device in addition to speeding up the planting process, caused regular and accurate cultivation of tomato seeds in order to produce seedlings. The results indicate that utilizing the device over time is highly economical for the major producers of tomatoes, and it is recommended to be used in agro-industry companies, and in the mechanized method of planting in large scales.

Keywords: Manual and mechanized cultivation, Planting, Robot, Seedling tray, Tomato seed, Worker