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DEVELOPMENT OF VACUUM PRECISION VEGETABLE SEEDERFORCELL TRAYSNURSERY SEEDLING

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***Key words**: vegetable, seeding drum, vacuum seeder, cell trays, greenhouse seedlings,*

***Summary.** The seeding device includes a dibbling drum with dibblers on its surface and a seeding drum. Seeds can be sown in tray cells by means of a vacuum drum of the seeder which sucks the seeds from a hopper as the drum rotates, and then the seeds are carried along on the apertures made on its peripheral surface. At the bottom (lowest point) of the seeding drum is a scrapping plate that scrapes the seeds to drop into the cells of moving tray on a conveyor. The vacuum seeding device can suit different vegetable seeds by changing different drums which have different size and number of the apertures (openings). The seeder can accomplish the functions of compressing and dibbling substrate in the tray cells, sowing seeds, covering the seeds and firming the substrate with perlite or vermiculite against the seeds in each cell as well as watering the seeded seeds. Device seeding tests were carried out in agrokombinat "Zhdanovichi"Minsk. The seeding test showed labor costs reduction by 6.5 times as well as providing quality of seedlingas compared to manual labor. Single seeds of cabbage were seeded at 96.9% in the cells while double-seeds and missed seeding was only about 0.8% and 3.1% respectively per tray. Sowing depth was observed to be 13 mm which is within the allowable limit of 15 mm and there was no un-mulched seeds found during the test.This showed the feasibility of the vacuum seeder to meet the agriculture requirements for seedlings and other vegetable production.*

***Ключевые слова**: овощи, высевающий барабан, вакуумный высевающий аппарат, кассеты, теплица, рассады.*

***Аннотация.** Установка для высева состоит из барабанного лункоообразователя с пуансонами на его поверхности и высевающего барабана. При враще-*

нии барабана забор и вынос семян из бункера и последующий перенос их в ячейки кассеты осуществляется за счет присасывания семян к высевающим отверстиям вакуумного барабана. В нижней части высевающего барабана пластинчатый отделитель снимает семена с отверстий, которые падают в ячейки перемещающейся по конвейеру кассеты. Барабанно-вакуумный высевающий аппарат может использоваться для высева разных овощных культур при условии подбора соответствующих диаметров присасывающих отверстий. Установка может выполнять уплотнение субстрата, лункообразование в ячейках кассеты, высев семян, мульчирование высеянных семян перлитом или вермикулитом в каждой ячейке с последующим увлажнением. Проведены государственные приемочные испытания установки в УП «Агрокомбинат «Ждановичи» г. Минск. По результатам испытаний установлено снижение затрат труда в 6,5 раз с обеспечением высокого качества высева по сравнению с ручным трудом. Количество одноштучного высева семян капусты по ячейкам составило 96,9%, семян-двойников и пропусков (не засеянных ячеек) соответственно 0,8% и 3,1%. Глубина заделки была 13 мм, находилась в пределах допустимого предела 15 мм. Во время испытаний не наблюдалось количество не заделанных семенами ячеек. Результаты испытаний свидетельствуют о целесообразности применения барабанно-вакуумного высевающего аппарата для высева семян при производстве рассады и других овощных культур.

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INTRODUCTION. Presently, most vegetable growers in Belarus sow vegetable seeds in trays manually or directly on soil surface. These methods generally affect the pre-germination of seeds sown due to unsuitable condition for germination that negatively affect both the quantity and quality of produced seedlings which invariably affect harvested crop. The problems range from low germination rate, inconsistency of germinating seed on the ground as well as deviation of seed from the centre of the tray cell, and the problem of weed and pest control[1]. In order to solve and ease these problems, Belarusian State Agrarian Technical University (BSATU) in Minsk tried to suggest to vegetable growers another method of sowing vegetable seeds in order to increase the quality and efficiency of their vegetable seedlings. Therefore, seed sowing in cell trays is promoted to greenhouse vegetable growers. Generally, seeding in cell trays can be done in two ways. First, manual seeding – the seeds are seeded in cell tray by human hand which is normally practiced in small-scale greenhouses. This method requires a lot of time to drop seeds into each filled with substrate, preprepared and indented cell of the tray manually, but it is cost-effective to operate in this way. Second, machine seeding- seeds are seeded by means of semi-automatic or an automatic seeding machine that is meant for preparing cell trays in medium and/or big large-scale vegetable growers, in this, the cost of the seeder is higher couple with complexity and maintenance prob-

lems for ordinary growers[2]. Considering the above, BSATU in collaboration with a machine production company "Tehmash" decided to develop a mechanized seeder for cell trays in order to ease the seeding process for vegetable growers in the country.

MATERIALS AND METHOD

a. Types of seed to be used on the seeder

The development of the seeder was designed to seed the seeds that are practically seeded in cell trays which have spherical shape such as cabbage, tomato, ball pepper etc seeds. Initially before beginning the conceptual design of the seeder, physical and mechanical properties of some vegetable seeds were studied and investigated that might have effect on the seeding process in the BSATU laboratory. The properties include: average geometric size of the seeds, seeds repose angles, the coefficient of friction between seeds and material (stainless steel) used for designing seeding drum. These and other factors were considered for the design and development.

b. Design consideration for the cell tray seeder

Dimensions of the cell tray are very important in designing the seeder's size. The cell trays must be easily accessible to the vegetable growers. The developed seeder consists of the following major components:

- Seed metering unit comprising the seed hopper to hold the seeds, substrate surface indenting and compressing drum (controls the depth of the released seeds into the cell tray containing indented substrate), seed releasing mechanism to release seed into the cells of the tray.
- Slat conveyor belt with corrugated surface for the stable gripping it with cell trays during their movement during indentation, seeding, seed placement as well as moisturizing the substrate and seeded seeds in the cell tray.
- Conveyor roller to align the substrate in the cell tray.
- Chain and sprocket drives.
- Swirl single-stage blower to blow extra seeds.
- Vacuum pump that creates residual pressure in the drum of the seeding unit.
- Control panel to activate the vacuum pump and the conveyor belt speed control.

Advantageously, the study was undertaken to develop the cell tray seeder using indigenous available materials in Belarus.

c. Testing the efficiency of the cell tray seeder

The efficiency evaluation was carried out both in Agrocomplex "Zhdanovichi" Minsk region and in "Tehmash" factory inLida town using white cabbage (*valentina* cultivar) seeds. This was performed in order to evaluate the seeder's efficiency in terms of number of trays seeded as well

as time taken to seed the trays. Thus, the efficiency can be obtained by number seeds seeded in a tray as follows:

$$\text{The efficiency of seeded seeds (\%)} = \frac{\text{number of cells found with seeds in the tray}}{\text{total number of cells in a tray}} \text{ x}$$

The seeder operation time can also be calculated as follows:

$$\text{Seeder operation time (trays/time)} = \frac{\text{number of cell trays}}{\text{operating duratic}}$$

Production test results using 64 cells tray with 1mm diameter of drum aperture showed that single seeds were seeded at 96.9% in the cells while double-seeds seeding was only about 0.8% per cell of tray. However, sowing depth was observed to be 13 mm which is within the allowable limit of 15 mm and there was no un-mulched seeds found during the test [3].

- quantity of cells found with germinated seedlings – 98.0%;
- quantity of cells found without germinated seedlings – 2.0%;
- height of the seedlings – 14 mm;
- unevenness in plant height – 14.3%.

In comparison, this vacuum drum seeder was found to be 7.9 times faster than hand-made sowing in cell trays while seeding labour was minimized by almost 6 times [4].

RESULTS AND DISCUSSION. The table below represents the investigation results of physical and mechanical properties of some tested vegetable seeds. These seeds almost have spherical shape for easy picking through the apertures on the seeding drum. The samples were investigated for repose angle and angle of friction 6 and 3 times respectively and the obtained values were considered to develop the seeder.

Table – Physical and mechanical properties of some vegetable seeds

Seeds	Average geometric size, mm			Weight of TSW, g.	Rest angle, degree	Friction angle, degree	Average geometric diameter, mm
	Length	Width	Thick-ness				
Ball pepper	3,96	3,40	0,76	5,94	20,56	25,66	1,52
tomato	3,23	2,36	0,63	2,80	26,24	31,82	1,69
cabbage	2,10	1,97	1,85	4,67	21,22	14,05	1,97

From the table it can be seen the average seeds diameter obtained by the use of computer microscope – MICMED-6 (fig. 1) which is used to calculate the appropriate diameter of picking apertures on the drum as follows:

For seeding cabbage – 1.18 mm; tomato – 1.36 mm and for ball pepper – 1.56 mm.

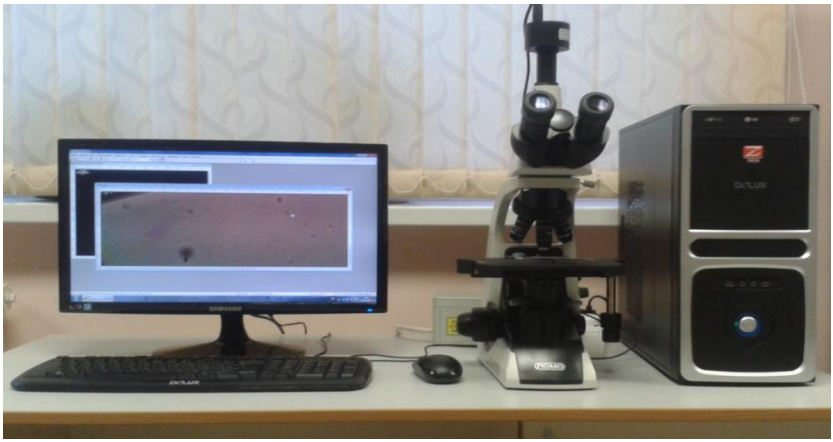

Figure 1 – Computer Microscope based on microscope MICMED-6

In Belarus, Belvtor factory manufactures special cell trays for seedlings. Two different trays were selected and considered in the seeder design calculations. These trays have following configurations:

- 64 cells and 25 m^3 by volume;
- 144 cells and 54 m^3 by volume.

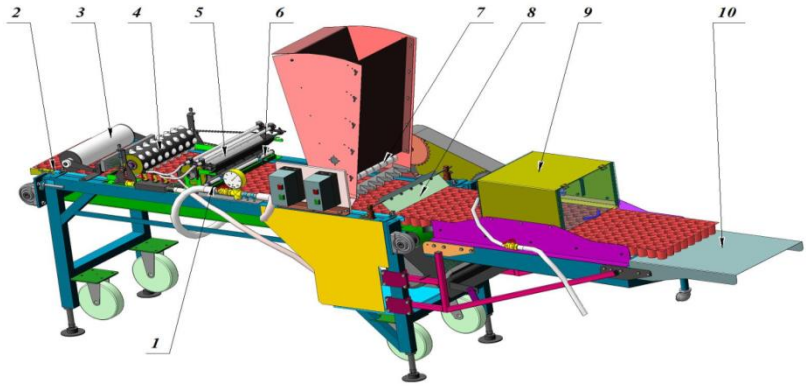

Figure 2 **–** Laboratory vacuum seeder for cell trays

1 – vacuum system; 2 – cell tray on the conveyor belt; 3 –compressing drum; 4 – dibbling drum; 5 – seeding drum; 6 – seed hopper; 7 – mulching mechanism; 8 – leveling brush; 9 – moisturizer; 10 – frame.

The operational sequence of the vacuum seeder (fig. 2) starts by placing cell trays on the conveyor belt while filling the seed hopper with seeds. After preparatory activities, the vacuum pump is turned on together with a single-stage vortex blower motor by means of a panel control which turns on the conveyor belt drive, then the of the conveyor speed is chosen. At this moment, a chain transmission drives theseeding drum while vacuum level adjustment is carried out in the seeding drum that provides seed sucking by all the cavities of the drum.

Then, by adjusting the pressure level which opens valve from the blower, the openings on the pipe are directed to the seeds on the surface of the drum, the air flow is regulated by providing blowing unnecessarily entrained seeds.As a result only a single seed is left on the cavity zone of the drum which is transported to the lower part of the seeding drum and then the seed separator separates the seeds from drum surface and fall into the cells of the tray.

After the aforementioned preparatory activities,substrate-filled trays are fed onto a conveyor belt and between a tray roller (compressing drum), which presses the tray to the conveyor.Then it is fed in a continuous cycle with substrate-filled trays. Whenthe tray approachesdibbling drum which dibbles the cell already filled with a substrate forms a dibble and at the same time is drivesseeding drum by a chain drive. Seeds sucked on the cavities arescrapped from the drum cavities and fall into the cells of the trays. It is necessary to establish the precise alignment of the cavities on the drum with the dibbled holes made in the tray cells. When the first substrate-filled tray leaves the seeding zone on the conveyor, it then moves to mulching zone where perlite will be dosed on the surface of the seeded seeds. Then the tray is sent to the moisturizer that moistened the mulched substrate with the seeded seeds.

CONCLUSION. Using the seeder in sowing vegetable seeds in the greenhouses of vegetable growing farms and complexes was aimed at improving performance in the production of seedlings. The developed seeder was tested in order to seed cabbage seeds in trays of 64 cells. The seeding test showed labor costs reduction by 6.5 times as well as increase in the quality of seedling in comparison with manual labor. However, single seeds were seeded at 96.9% in the cells while double-seeds seeding was only about 0.8% per cell and sowing depth was observed to be 13 mm which is within the allowable limit of 15 mm and there was no un-mulched seeds found during the test.

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