DETERMINATION OF WORK INDICES FOR INSTALLATION FOR SIMULTANEOUSLY FILLING POTS WITH NUTRITIVE MIXTURES AND SOWING

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Abstract. Producing seedlings in forms, with or without pressing the nutritional mixture (the seedlings are replanted with the nutritive substrate, in which they developed) makes this method particularly useful for cultivation technologies in greenhouses and solariums. Seedlings produced in pots or cubs are obtained by directly sowing plants in pots or cubes, in order to replant them in the definitive place along with the soil they grew in, so that the roots are affected as little as possible. Thus, the shock caused by replanting is reduced, the setting occurs more rapidly and plants continue to grow without any stagnation in vegetation, obtaining earlier and larger productions. Potting soil ensures better nutrition conditions, water and nutrient reserves, which ensure that seedlings set even in draught conditions. In the paper experimental researches are presented conducted in the laboratory to determine functional and qualitative work indices of an installation for simultaneously filling pots with nutritive mixtures and sowing. This installation operates in stationary conditions in multiplication greenhouses, having the role of simultaneously filling plastic material pots (6, 8, 10 and 12 cm square and 6-12 cm high) with nutritive material and sowing. The installation can also be used to fill pot sets, made from 2, 3, 4 and 5 cm hexagonal (honeycomb shaped) paper. Functional work indices determined were: linear speed of the conveyor from the filling machine, flow rate of the distribution device from the filling machine, the depression in the distribution head. Qualitative work indices determined were: compaction degree, sowing precision as the number of seeds in pots, lateral seed displacement compared to the centre of the pot, the depth of burying the seeds.

Keywords: pots, nutritive mixture, sowing, greenhouses, solariums, seedling.

Introduction

The increase of fresh fruit consumption throughout the entire year has determined the development of new cultivation methods, in spaces protected from cold and bad weather [1]. The large quantity of seedlings necessary for crops situated in protected areas has imposed the necessity to mechanize works in the technology of producing seedlings [2; 3]. Nutritive pots for seedlings are made by pressing nutritive mixes or by filling cups made from various materials (plastic, paper, etc.) with nutritive substances [4].

A good seedling for planting needs to fulfil de following conditions: to be young (the optimum age being 40-60 days for tomatoes, eggplants and bell peppers, 40-45 days for cabbage and 60 days for cucumber), to be vigorous but not elongated, with dark green leaves, well developed and whole roots [5]. The planting mechanism is a key component of the machine for planting seedlings in pots [6]. The purpose is to plant seedlings in a stable manner at high speed and to rise rapidly without removing seedlings from the pots. Through experimental researches an analysis of the ideal movement for seedlings and for the planting mechanism during the process of fast planting was achieved, proposing a planting mechanism with seven bars, also establishing a 3D simulation model for the mechanism [7]. In order to achieve unbroken test for pepper plug seedlings, a calculating model based on leaf area image parameters showed that the determination coefficient of pepper leaf area and plant dry weight was 0.9312, which reached a significant level of correlation [8]. Through experimental researches, different proportions were evaluated of termite mound substrate in the emergence and early development of tomato seedlings, were emergence, emergence speed index, shoot height, number of leaves, shoot dry mass, root length and root dry mass of tomato seedling development were evaluated after 25 days [9].

Materials and methods

The installation for filling pots with nutritive mix and simultaneously planting, used for conducting experimental researches, is formed of the following equipment: roller conveyor for feeding the installation with pot crates; roller conveyor for transporting pot crates to the planting machine; sowing machine, machine for covering seeds with nutritive material; roller transporter; buffer bunker; inclined conveyor with scrapers for feeding the bunker of the filling machine with material from the buffer bunker; short inclined conveyor for transporting the excess nutritive mix from the filling machine to the buffer bunker.

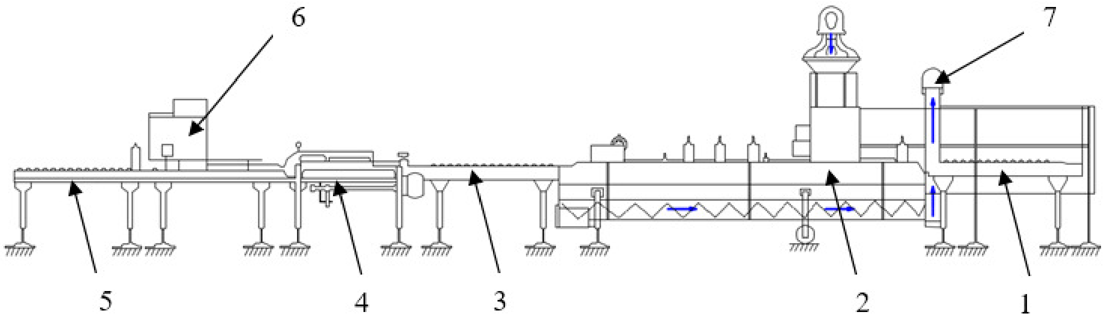

Fig. 1. **Overview of installation for filling pots with nutritive mix and simultaneous sowing:** 1, 3, 5 – roller conveyor; 2 – installation with pot crates; 4 – planting machine; 6 – buffer bunker; 7 – inclined conveyor with scrapers

The installation for filling pots with nutritive mix and simultaneous sowing, used for conducting experimental researches, is destined to work stationary in multiplier greenhouses for feeding plastic pots (square section with 6, 8, 10 and 12 cm sides and heights between 6-12 cm) with nutritive material and simultaneous sowing. The installation can also be used for filling sets of paper (honeycomb shaped) pots with 2, 3, 4 and 5 cm sides.

Laboratory experiments were conducted in the purpose of determining functional and qualitative working indices. The functional indices determined were: linear speed of the conveyor from the filling machine; the flow rate of the distribution apparatus of the filling machine; the depression in the distribution head pipes. The qualitative working indices determined were: compaction degree; sowing precision as number of seeds in one pot; lateral seed deviation compared to the center of the pot; depth of burying the seeds; installation working capacity; energetic indices. Experiments in laboratory conditions were conducted stationary, using various nutritive material mixes, seeds and pot sizes. The materials used for laboratory tests are shown in Table 1.

Table 1

Material used for laboratory experiments

Crop name	**Name of omponents in the mix**	**Percentage value, %**
Tomatoes	garden soil	63.6
	peat	18.2
	sawdust	13.7
	sand	4.5
Bell pepper	garden soil	47.6
	peat	47.6
	sand	4.8

Characteristics of seeds used for experimental researches are shown in Table 2.

Table 2

Characteristics of seeds used for experimental researches

Crop name	**Germination, %**	**Dimensions, mm**			**The mass of a thousand seeds, g**
		L	**l**	**g**	
Tomatoes	70-85	3.65	2.70	1.02	3.44
Bell pepper	85-90	4.15	3.75	1.08	6.68

Determination of the linear speed for the machine conveyor belt was performed in three repetitions for two speeds, by counting the time, in which a point on the conveyor belt passed the length of two meters. The results obtained are shown in Table 3.

Table 3

Determination of linear speed for the machine conveyor belt

Speed gear	Area covered, m	Average time, s	Average travel speed of conveyor belt, $m \cdot s^{-1}$
I	2.0	71.9	0.0278
II		36.0	0.055

Determination of the distribution apparatus of the machine for filling pots was performed in the following conditions: at a 2 mm distance between the corrugated cylinders; at two speeds of revolution of the corrugated cylinders; at a 360 mm active length of the corrugated cylinders, equal to the biggest length of boxes, where pots are placed; at an opening of the damper from the filling machine between 0 and 25 mm. The results obtained from experiments are presented in Table 4.

Table 4

Determination of the flow rate for the distribution device of the pot filling machine

Number of rotations of the corrugated cylinders, rpm	Damper opening, mm	Time, s	Mass of nutritive material distributed, kg	Distribution devices flow rate, $kg \cdot s^{-1}$
30	0	60	0	0
	2.0		18.9	0.316
	5.0		26.3	0.403
	8.0		43.9	0.733
	11.0		56.0	0.935
	14.0		67.2	1.120
	17.0		78.1	1.303
	25.0		103.2	1.720
60	0		0	0
	2.0		26.7	0.495
	5.0		53.9	0.898
	8.0		70.3	1.171
	11.0		104.8	1.746
	14.0		112.4	1.873
	17.0		122.7	2.044
	25.0		166.3	2.755

Determination of the depression index in the distribution head pipes was achieved by measuring the depression created by the aspirator in the distribution head pipes and in the pipe connecting the distribution head and the aspirator. In the distribution head pipes, measurements were performed for nozzles with the orifice calibrated at 0.5, 0.75 and 1.0 mm. Measurements were conducted using a vacuum meter in three repetitions, the result being shown in Table 5.

Table 5

Determination of the depression in the distribution head pipes

Distribution head with	Depression in the pipe connecting the aspirator and distribution head pipe, mm col H_2O	Depression value at nozzle diameter, mm col H_2O		
		Ø 0.5 mm	Ø 0.75 mm	Ø 1.0 mm
96 nozzles	1300	1000	980	900
48 nozzles		1100	1085	1075
27 nozzles		1180	1170	1150
24 nozzles		1200	1190	1180

Determination of the compaction degree was performed by weighing an established volume of nutritive material fallen from the distribution device of the machine in the pots, without any vibration and compaction, and by weighing this volume of material in the pots after the vibration operation and after the vibration and compaction operation performed simultaneously. The compaction degree was determined using the following relation [10], the results being presented in Table 6:

$$G_t = \frac{G_f - G_i}{G_f} \cdot 100, \qquad (1)$$

where G_t – compaction degree, %;
G_i – weight of nutritive material fallen in the pots after filling them using the distribution device, g;
G_f – weight of the same material volume after vibration and vibration + compaction, g.

Table 6

Determination of the compaction degree

Moisture, %	Compaction degree after vibration, %	Compaction degree after vibration and compaction, %
14.3	6.2	10.1
19.6	9.1	14.6

In Figure 1 the sowing precision is presented as the number of seeds in pots, namely, the percentage of pots with a number of seeds equal to the adjusted one, respectively one seed.

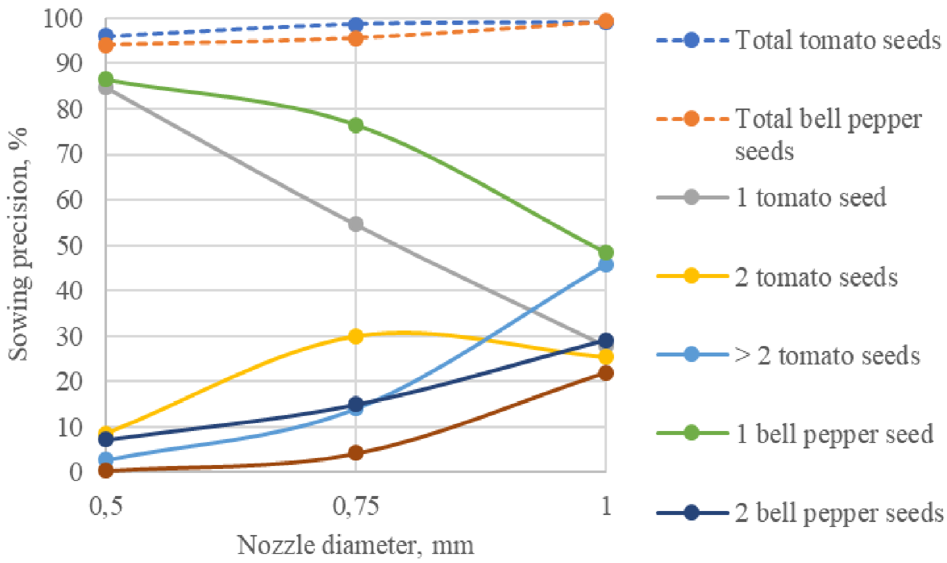

Fig. 2. **Seeding precision for tomato and bell pepper crops**

Determination of lateral seed deviation compared to the center of the pot was performed in the purpose of establishing, at what extent the sowing machine places the seed in the center of the pot in order to create conditions as good as possible for the radicular system to develop and to obtain straight rows, when planting the pots. After measurements, pockets were grouped on the following distance categories: 0-0.5 cm; 0.5-1 cm; 1-2 cm and over 2 cm. The data obtained following the measurements are presented in Table 7.

Table 7

Determination of lateral seed deviation compared to the center of the pot

Crop name	No. of pockets with distance categories, %			
	0-0.5 cm	0.5-1 cm	1-2 cm	>2 cm
Tomatoes	96.5	3.1	0.4	-
Bell pepper	97.6	2.0	0.4	-

Determination of the depth of burying the seeds was performed according to the "in green" method, by measuring the distance from the seed to the surface of the soil on a number of fifty pots for three previously adjusted depths of: 10 mm, 15 and 25 mm. The results of measurements are presented in Table 8. The degree of working depth unevenness was calculated using the relation [10]:

$$N = \frac{\sum_{i}^{n} |h_m - h_i|}{h_m \cdot n} \cdot 100, \tag{2}$$

where N – degree of seed depth unevenness, %;
h_m – average depth calculated for all measured pots, mm;
h_i – adjusted working depth, mm;
n – number of pots for which measurements were performed

Table 8

Determination of the depth of burying the seeds

Crop name	Adjusted working speed, mm	Average seeding depth achieved, mm	Degree of unevenness, %
Tomatoes	10	8.5	3.8
	15	13.2	4.1
	20	18.1	5.0
Bell pepper	10	8.7	3.7
	15	13.1	4.2
	20	18.3	4.9

Results and discussion

Analysing the data obtained from the measurements it was found that:

- The linear speed of the filling machine's conveyor is 0.0278 $m \cdot s^{-1}$ on average in gear I, and in gear II is 0.055 $m \cdot s^{-1}$ on average (double compared to the speed that can be obtained in stage I);
- The range of flows for the distribution device of the machine for filling pots ensures the filling of the entire range of pots (with sides of 6, 8, 10 and 12 cm) for both speed gears of the conveyor (0.0278 and 0.055 $m \cdot s^{-1}$), because for pots with 6 cm it is necessary to have a flow ranging from 0.6 and 1.15 $kg \cdot s^{-1}$, respectively 0.8-1.35 $kg \cdot s^{-1}$ for pots with 12 cm sides;
- A depression of 900 mm H2O col in the nozzles can attract the seeds used in experimental researches;
- The degree of compacting the nutritive material at the same moisture shows much higher values for the combined compaction and vibration operation compared to the case, when only the vibration operation is used;
- Along with increasing the nozzle orifice, the percentage of pots without seeds decreases, but, in turn, the number of pots with two or more seeds increases. Therefore, the number of pots with two seeds increases from 5.56 % for the 0.5 mm nozzle to 30 % for the 0.75 mm nozzle, and the number of pots with more than two seeds increases from 2.27 % for 0.5 mm nozzles to 45.83 % for the 1 mm nozzle;
- The highest seeding precision of 86.54 % as the number of seeds in pots was obtained, when the 0.75 mm nozzles were used for the bell pepper crop;
- The percentage of the pots, for which the distance from where the seed is placed fits in the 0-0.5 cm category, is of 96.53 % for tomatoes and 97.58 % for bell peppers, because bell pepper seeds have higher weight and during their free fall towards the pot they describe a trajectory with a smaller deviation from the center of the pot;
- At the same sowing depth, the degree of unevenness for each crop has similar values.

Conclusions

1. The use of the installation for filling pots with nutritive material represents a viable alternative for the emergence and early development of tomato and bell pepper seedlings.
2. It is recommended to use 0.5 mm nozzles for sowing tomatoes, because the percentage of seedless pots is 2.08 %, and the sowing precision is 89.59 %.
3. For sowing bell pepper, it is recommended to use 0.75 mm nozzles, thus obtaining a sowing precision as the number of seeds in the pots of 86.54 % and a percentage of pots without seeds of only 1.39 %.

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