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PLUG SEEDLINGS CHARACTERISTICS

BY

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Abstract. The plug seedling behavior during the planting process determines the machine configuration. The precast plug is the element that provides dimensional uniformity for automating the transplanting seedling operation. The Dimensional and kinematic Jiffy plug characteristics study allows the optimization of the automatic transplanter.

Key words: plug; seedling.

1. Introduction

An automatic seedling planting technology designed for our country existing conditions should include a simple constructive machine, based on gravitational pull and transport and mechanical distribution of the plug seedlings, grown in rigid plastic trays.

The design, sizing and operation of the machine's parts are related to the used seedlings type and their mode of growth. The seedling tray is the seedlings automatic transplanting component technology that produces junction between plug and planting machine. The seedling is the one which dictates configuration of the machine and the whole process of planting.

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The parameters that characterize it are related to two elements: the plug and the biological component, the plant itself. Of these, the share decisive in behavior during extraction operations, transportation, delivery, insertion and fixation in soil is hold by the seedling plug (Huang & Ai, 1998).

In order to avoid complicated mixing and disinfection operations of soil mixtures, are widely used Jiffy type pressed peat plugs, with growth stimulators and retention and protection net (Fig. 1).

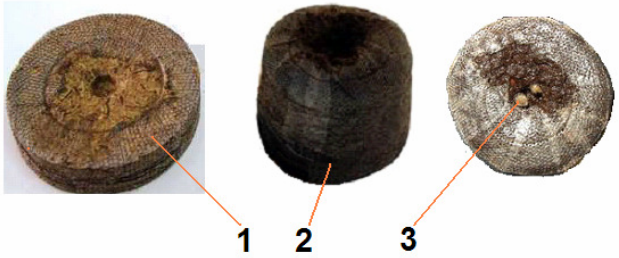


Fig. 1 − Jiffy plug: 1 − initial state; 2 − expanded form; 3 − seed.

The automatic machine planting process requires use of a large number of seedlings. To avoid the necessity of growing seedlings, it has been chosen the simulacra solution (Hallonborg, 1998), consisting of a real-type Jiffy plug with is inserted a plant imitation (Hallonborg, 1998).

Benefits of simulacra using are:

− avoid the damage and impossibility of re-use planting material;

− obtaining information about planting faults, not possible with real plants;

− the implementation well delimited groups, regarding seedlings height, number and position of leaves.

2. Seedling Simulacra Characteristics

2.1. Dimensional Characteristics

Simulacra used for experiments have the stem made of thin wire, which highlights any shocks during planting and leaves made of polythene, to withstand the repeated necessary watering to keep the plug moisture, mounted on a Jiffy pellet (Fig. 2). The top of pseudo-strain shows a ring for making traction measurements , in order to evaluate the degree of soil fixing.

2.1.1. *Plug Characteristics*

Jiffy type plug has in initial status the following dimensions: 36 mm diameter and 8 mm height. Pellets shall be submitted on a tray, where their

watering shall be carried out in two stages: the first part of the operation is carried out by water absorption through the bottom, and the second phase by spraying at the top. The process takes approximately 15 min and lead to full plug expanding.

Dimensional parameters values are measured for a 32 Jiffy expanded plug set, after several watering made in time to simulate a real seedling growth process. Jiffy pellets parameters: the height, the lower and the upper diameter are measured before and after wetting operation by means of a sliding caliper (Fig. 2); also, the plug substrate mass is measured with a precision weight scale. The measured values are shown in Table 1, and the determined values, processed by calculating standard deviation values, in Table 2.

Table 1

Measured Values of Jiffy Expanded Parameters Plugs

No.	Lower diameter d_{si} [mm]	Upper diameter d_{ss} [mm]	Height h_s [mm]	Weight m [g]		No.	Lower diameter d_{si} [mm]	Upper diameter d_{ss} [mm]	Height h_s [mm]	Weight m [g]	
				Dry	Wet					Dry	Wet
1.	40.1	39.8	39.2	5.8	41.6	17.	39.9	37.8	40.8	5.9	41.5
2.	40.4	39.6	41.1	6.2	44.9	18.	40.0	38.7	40.6	5.8	42.0
3.	39.9	38.5	41.4	6.0	44.7	19.	40.2	38.5	39.6	5.3	41.3
4.	40.5	39.7	40.1	6.1	44.2	20.	40.7	39.2	38.7	5.7	41.1
5.	40.2	38.6	40.9	5.7	44.6	21.	40.0	39.8	40.6	5.8	42.5
6.	40.3	39.2	41.8	6.7	46.0	22.	40.9	40.1	40.3	5.6	42.7
7.	39.9	38.7	40.7	5.9	41.1	23.	40.8	39.7	39.5	5.5	42.2
8.	39.9	39.2	42.0	5.8	41.4	24.	40.5	39.6	40.4	6.1	44.2
9.	39.8	37.8	39.9	5.2	39.0	25.	41.4	39.4	41.0	5.3	41.5
10.	39.7	39.5	39.3	5.9	40.1	26.	41.2	40.2	40.5	6.0	44.4
11.	38.5	37.9	39.8	5.3	38.2	27.	40.4	39.2	40.6	6.1	45.0
12.	39.1	38.8	39.5	5.8	40.1	28.	41.3	40.3	39.7	5.8	43.1
13.	40.1	39.4	39.9	5.8	42.4	29.	40.2	38.2	39.5	5.4	41.0
14.	40.4	40.1	40.2	5.6	43.6	30.	41.7	39.8	40.2	5.6	43.0
15.	39.9	38.7	41.1	6.0	42.5	31.	40.5	38.4	38.8	5.3	41.8
16.	39.3	38.6	40.5	6.0	41.4	32.	40.1	39.1	40.6	5.9	43.5

Fig. 2 − The measurement of the plug parameters: 1 − plug; 2 − caliper.

Table 2

The Determined Values of the Jiffy Expanded Parameters Plugs

Lower diameter d_{si} [mm]	Upper diameter d_{ss} [mm]	Height h_s [mm]	Plug weight [g]	
			Dry	Wet
40.24 ± 0.1154	39.13± 0.1254	40.28± 0.1411	5.578± 0.0565	41.25±1.175

It is to be noted that:

− lower diameter of substrates is greater by 2-4 mm than the upper diameter, due to it's weight and to repeated tray handling;

− height of substrate is relatively constant, which is explainable by the restrictive action of the biodegradable fabric protection;

− weight substrates in expanded status shows reduced varies, explainable as not uniform water absorbed quantity by each unit.

2.1.2. *Simulacra Characteristics*

By analysing the seedlings dimensional characteristics, imposed by the quality standards (Mănescu & Ştefan, 2003): minimum and maximum height of the seedlings stem, number and arrangement of leaves, the thickness to stem base may, the seedling simulacra used in the process of planting can be described (Fig. 3). The diameter of substrate is considered the upper limit of the measurement. For a better approximation of the real situation, shall be carried out in variations within limits of 20%, excepting for plug, where uniformity is approximately 5% (Table 3).

Simulacrum mass is about 45 grams; having in mind that the plug weight represents 90% of the seedlings total mass and during transportation, it

is in vertical direction, it can be considered that the center of gravity is not shifted significantly in the case of simulacra and it can be good substitute for the true seedlings during the transplanter research project.

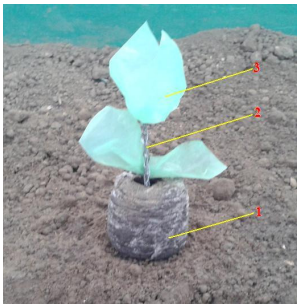


Fig. 3 − Plug seedling simulacra:
1 − plug; 2 − stem; 3 − leaves.

Table 3
Seedling Simulacra Dimensions

Total seedling height h_t [mm]	Stem height h_p [mm]	Plug height h_s [mm]	Plug average diameter d_s [mm]	Foliage diameter d_c [mm]	Number of leaves [pcs.]	Weight m_r [g]
120-160	64-96	38-42	38-43	48-72	2-4	42-47

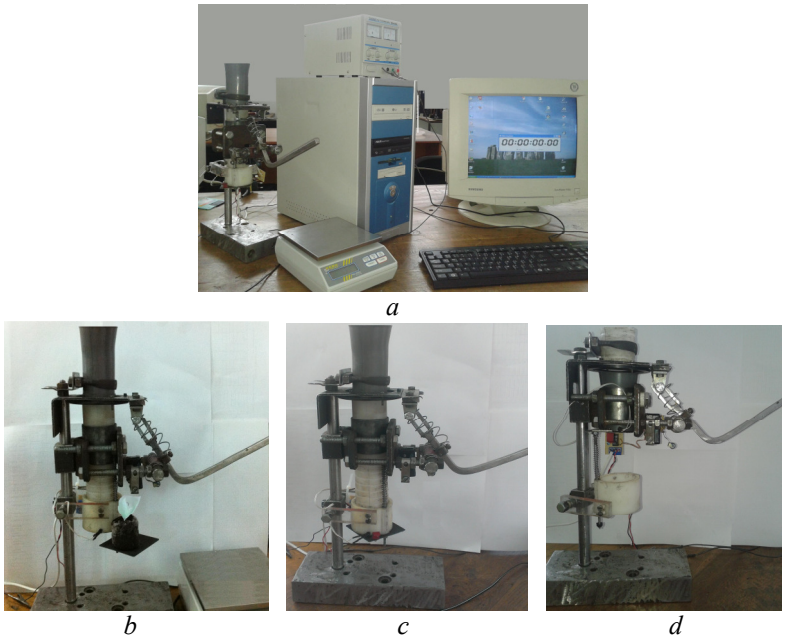
2.2. Simulacra Dynamics

The objective is to obtain experimental data for sizing transport pipe and to determine seedlings time planting.

Measurement of the plug residual deformation is determined by simulating the impact of gravitational transport used during the three stages process: download seedlings from one tray's row of planting with the timing in the distribution device, one plug seedling in the planting device and its transfer in the planting hole. At the same time, it shall be also measured the drop times for each transport sequence.

The test (Fig. 4) shall be carried out at the real systems appropriate heights, according to the configuration of the machine, in the transplanter working process order, using a variant of the experimental stand for every stage of transport. Stand operation shall include the following aspects:

− the hatch, at the time of the seedling issue, operates a micro-contact, which triggers the computer timer;



a *b* *c* *d*

Fig. 4 − System for determining plug seedling deformation and fall time: *a*) general structure; *b*) droping installation adjusted to 185 mm height (with the plug seedling on the falling surface); *c*) installation adjusted to 228 mm height; *d*) installation adjusted to 80 mm height.

Table 4

Dimensional and Impact Parameters of the Plug Seedling After Gravitational Transports

No.	Initial lower diameter	Initial Height	Transport I h_1 = 185 mm			Transport II h_2 = 228 mm			Transport III h_3 = 80 mm		
			Lower diameter	Plug height	Drop time	Lower diameter	Plug height	Drop time	Lower diameter	Plug height	Drop time
	d_i [mm]	h_i [mm]	d_{1r} [mm]	h_1 [mm]	t_1 [s]	d_{2r} [mm]	h_2 [mm]	t_2 [s]	d_{3r} [mm]	h_3 [mm]	t_3 [s]
1.	40.1	39.2	41.6	39.1	0.20	42.1	37.2	0.21	42.4	36.9	0.09
2.	40.4	41.1	41.4	38.4	0.17	42.3	36.6	0.29	42.9	36.1	0.11
3.	39.9	41.4	41.5	39.9	0.18	42.2	39.0	0.26	43.0	37.7	0.09
4.	40.5	40.1	42.2	38.7	0.18	42.7	38.1	0.25	43.1	37.0	0.11
5.	40.2	40.9	41.0	40.2	0.20	41.6	36.5	0.25	42.2	36.2	0.10
6.	40.3	41.8	41.2	40.9	0.18	41.6	39.1	0.26	41.9	38.0	0.09
7.	39.9	40.7	41.1	39.0	0.22	41.7	38.0	0.24	41.6	36.3	0.09
8.	39.9	42.0	41.2	39.8	0.18	41.5	37.8	0.27	42.1	38.0	0.11
9.	39.8	39.9	41.3	38.5	0.20	41.7	38.2	0.22	42.4	37.5	0.11
10.	39.7	39.3	40.4	38.8	0.18	41.2	37.8	0.21	42.5	37.2	0.10
11.	38.5	39.8	40.0	39.2	0.24	40.7	37.7	0.27	41.1	37.4	0.10
12.	39.1	39.5	40.3	40.2	0.23	41.5	38.8	0.26	42.3	36.7	0.11

Table 4
Continuation

No.	Initial lower diameter	Initial Height	Transport I h_1 = 185 mm			Transport II h_2 = 228 mm			Transport III h_3 = 80 mm		
			Lower diameter	Plug height	Drop time	Lower diameter	Plug height	Drop time	Lower diameter	Plug height	Drop time
	d_i [mm]	h_i [mm]	d_{1r} [mm]	h_1 [mm]	t_1 [s]	d_{2r} [mm]	h_2 [mm]	t_2 [s]	d_{3r} [mm]	h_3 [mm]	t_3 [s]
13.	40.1	39.9	41.5	38.3	0.18	42.3	37.2	0.31	43.1	37.4	0.10
14.	40.4	40.2	41.5	38.7	0.17	42.3	37.4	0.27	42.7	36.9	0.11
15.	39.9	41.1	41.0	38.8	0.18	42.3	37.2	0.26	42.6	35.3	0.09
16.	39.3	40.5	41.2	38.3	0.18	42.2	37.9	0.30	43.3	37.2	0.13
17.	39.9	40.8	41.1	39.7	0.22	42.4	37.3	0.23	42.8	35.3	0.11
18.	40.0	40.6	41.8	39.2	0.18	42.6	38.2	0.28	43.4	37.1	0.11
19.	40.2	39.6	42.0	39.5	0.18	42.6	38.8	0.28	43.2	37.2	0.10
20.	40.7	38.7	41.8	38.4	0.18	42.7	38.1	0.26	42.5	37.3	0.10
21.	40.0	40.6	41.0	39.8	0.20	42.9	38.2	0.28	43.5	38.6	0.10
22.	40.9	40.3	42.1	39.2	0.20	42.8	38.4	0.22	43.4	38.0	0.13
23.	40.8	39.5	41.9	38.8	0.19	42.7	38.0	0.24	43.0	37.2	0.08
24.	40.5	40.4	42.1	38.9	0.18	43.2	37.8	0.21	43.6	37.1	0.08
25.	41.4	41.0	42.5	40.0	0.18	42.9	39.1	0.26	43.2	37.2	0.10
26.	41.2	40.5	42.2	39.8	0.29	43.2	37.8	0.27	43.1	37.2	0.15
27.	40.4	40.6	41.7	40.1	0.21	43.3	39.2	0.22	43.7	38.2	0.11
28.	41.3	39.7	42.9	38.3	0.25	43.2	37.8	0.21	43.2	38.4	0.17
29.	40.2	39.5	42.4	38.5	0.17	42.6	37.7	0.31	42.8	35.7	0.09
30.	41.7	40.2	42.0	40.1	0.24	42.7	38.9	0.27	43.1	37.1	0.10
31.	40.5	38.8	41.6	37.9	0.23	42.3	37.3	0.21	42.9	37.8	0.09
32.	40.1	40.6	41.7	39.6	0.18	42.6	38.4	0.25	43.1	36.2	0.14

− substrate, at the transport end, in contact with the impact surface, interrupt the light beam produced by the LED with infra-red emission toward to infrared light sensitive phototransistor, and in this way ordering interruption of the computer timer Xnote Stopwatch Timer program (http://www.stopwatch-timer.com/xntimer.exe);

− the data acquisition board transmits the signal to the timer data cable with 9-pin serial port;

− the result is displayed in the program window and allows direct reading of the falling time, in hundredths of a second, the results being listed in Table 4;

− after lowering the impact area the plug, without being repositioned, not to alter determination, it is measured using a sliding caliper on two diameters at right angles, and the mean value is in the Table 4.

The determined values of dimensional and temporal parameters presented above in Table 4, are statistically analyzed by calculating the mean square error of the arithmetic mean value, and the results are summarized in Tables 5 and 6.

Table 5

Values of the Dimensional and Impact Parameters of the Seedlings Plug

Initial lower diameter d_{si} [mm]	Transport I h_1 = 185 mm		Transport II h_2 = 228 mm		Transport III h_3 = 80 mm	
	Lower diameter D_{1r} [mm]	Height h_{1r} [mm]	Lower diameter D_{2r} [mm]	Height h_{2r} [mm]	Lower diameter D_{3r} [mm]	Height h_{3r} [mm]
40.24±0.1154	41.54±0.1129	39.21±0.1298	42.33±0.1108	37.98±0.1240	42.8±0.104	37.11±0.1449

Table 6

Gravitational Drop Time Values

Transport I h_1 = 185 mm	Transport II h_2 = 228 mm	Transport III h_3 = 80 mm
t_1 [s]	t_2 [s]	t_3 [s]
0.1984±0.005	0.2541±0.005	0.1068±0.003

3. Conclusions

1. The seedling plug characteristics values allow for sizing the tray cells:

− the cell diameter must exceed by 3-5 mm the size of maximum measured lower diameter (41.7 mm), for bottom extraction and an air-pruning effect on the roots system, so the adopted value is 48 mm;

− cell height must exceed the maximum height of substrate (41.8 mm), so that it does not distort over sides, making impossible the extraction, so the value is set to 45 mm;

− the relatively high plug mass, is ensuring the necessary extracting weight force from the cell and keep the water reserve after planting.

2. The values of the plug residual deformation after gravitational transport establish the following dimensions:

− the value of extreme lower diameter (43.7 mm) allows the choice of 48 mm diameter for transport pipe, within the limits of a calculated interval previously determined;

− final maximum plug height (38.6 mm) indicates the required height for the wheel spigots, the value being 45 mm.

3. Measured drop times permit the establishment of the time of planting seedling and the maximum working speed of the transplanter.

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CARACTERISTICILE SUBSTRATURILOR NUTRITIVE

(Rezumat)

Un sistem integrat de plantare şi producere a răsadurilor cuprinde o maşină automată de plantat şi răsadurile cu substrat nutritiv. Alegerea soluțiilor tehnice şi dimensionarea componentelor maşinii sunt legate de caracteristicile răsadurilor.

În timpul desfăşurării experimentelor pentru determinarea indicilor procesului de lucru al maşinii, se utilizează simulacre de răsaduri, cu caracteristici similare celor reale. Parametrii determinați ai simulacrelor de răsaduri, în urma unor experimente ce simulează procesele de alimentare, transport şi plantare, servesc la dimensionarea unor parametri constructivi şi funcționali ai prototipului maşinii de plantare.