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RESEARCH REGARDING THE ACHIEVEMENT OF THE QUALITATIVE PARAMETERS OF WORK ON SEEDLING PLANTING MACHINES

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Abstract

This paper presents some research on the achievement of qualitative parameters of work by seedling planting machines, especially the position of the seedling from the vertical, the degree of plant damage and planting mistakes, defining parameters for evaluating the planting work. The mechanized planting work is done, in overwhelming proportion, with semi-automatic machines or with automatic machines to a lesser extent. Depending on the constructive and functional solutions and the planting conditions (type and condition of the soil, working speed, and skill of the operator) different degrees of fulfillment of the qualitative working parameters mentioned above are obtained. It turned out that the solution with a planting machine with rotary bucket distributors meets a higher percentage of qualitative working parameters, especially the vertical position at planting and the degree of damage. These types are also found in two constructive variants, namely: with articulated bucket dispenser, which places the seedling in a gutter, opened by a coulter, and with non-articulated bucket dispenser, which places the seedling directly in the soil.

Key words*: planted seedlings, quality parameters, efficiency.*

INTRODUCTION

The experience gained in agriculture and other economic sectors with an advanced degree of mechanization, shows that mechanization is a form of activity that ensures the reduction of labor, increases the quality of work, increases productivity, all leading to lower production costs. Seedling planting machines are designed for mechanizing the work of installing crops through seedlings in well-prepared soil, loose and free of weeds.

When mechanized planting, the intervals between rows as well as the distances between plants per row, must comply with the cultivation scheme prescribed by the working technology. The rows planted should be straight and parallel to allow mechanization of subsequent work.

The planting machine must fix the plant in an upright position as recommended in the technical prescriptions, be covered with soil, without being damaged by planting equipment.

In general, a planting equipment should perform the following three functions: open the gutter in the soil; place the seedling upright in the gutter or directly in the soil; close the gutter and compact the soil around the seedling without damaging it. Mechanized planting of vegetable seedlings is widespread worldwide with a wide variety of seedling planting machines and the offer of machines in the field of vegetable planting is particularly rich (Vlahidis.V., 2018; Yonetani, 1999).

Also, the literature is very rich in articles on the topic addressed in this thesis (Han, 2018; Mitrache, 2019; Zhipeng, 2020) and other sites in the bibliography, these being just some of the multiple references.

The planting operation is one of the most important works in seedling cultivation technology, the correctness of this operation influencing the subsequent maintenance and harvesting of the crop, all having a final impact on the size of production per unit area (Nabu, 1992; Vlahidis, 2018).

Depending on how the seedling is placed in the planting machine and put it into the gutter, seedling planting machines can be classified into:

- machines without a planting apparatus, in which the seedling is placed directly in the gutter by the operator;
- machines with the manual taking over and introduction of the seedling in the planting apparatus followed by the mechanical introduction of the seedling in the gutter, these being generically called, semi-automatic machines;

- machines pick-up, automatic introduction of the seedling into the planting apparatus and mechanical introduction of the seedling into the gutter, these being generically called automatic machines.

The working performance of vegetable seedling machines depends on the frequency of alimentation the seed taking over system (for automatic machines), the frequency of the seedling unit, the distance between seedlings per row, the distance between rows and the optimum operating speed (to minimize damage and planting mistakes), work capacity, type of crop and other operating parameters.

Most researchers and manufacturers reported data on planting frequency and working speed and less on machine performance. Central Institute of Agricultural Engineering - CIAE, India, 2004 reported a working speed of 0.9 km h^{-1} and a working capacity of 0.1 ha h^{-1}, for planting tomatoes, at a distance between rows of 60 cm and 45 cm between plants per row, using a semi-automatic planting machine pulled by the tractor, in two rows, with planting system with pocket type organs.

The field performance of a two-row semi-automatic planting machine with pocket-type planting system, reported by the University of Agriculture in Punjab - PAU, India in 2004, is shown in Table 1 (Prasanna, 2014). The adequate operating speed to obtain a minimum of planting errors proved to be from 0.9 to 1.1 km h^{-1} for various crops. With the increase of the working speed, the percentage of mistakes also increases, thus being necessary two workers who servind one row, in order to keep the percentage of mistakes within acceptable limits. The planting machine, models 1500, FWD from Holland Transplater Co. 1500, and 1600, and Mechanical Transplanter models 1000, 1000B-3, 1000 2, 1980, 2000 and 22C, provided two operators for a single row (Prasanna, 2014).

Marr (Marr, 1994) stated that the planting machine must work at a speed that allows the operator to place the seedling correctly in the planting organ and also to observe the operation of the machine in general.

That is why a semi-automatic planting machine with a rotary bucket distributor, (in which the seedling is placed by simple hand release), allows a higher working speed than one equipped with a pocket-type planting organ at which the placement of the seedling is more difficult.

Tamil Nadu Agricultural University-TNAU, Coimbatore India, 2004, reported a working capacity of 0.14 ha h^{-1} for planting tomatoes, cauliflower, hot peppers and eggplants, using a semi-automatic planting machine with rotary bucket distributor, on three rows, at an average working speed of 1.4 km h^{-1} (Abhijit, 2018)

MATERIALS AND METHODS

The Bureau of Indian Standard (BIS) has not yet formulated test codes for performance testing of vegetable planters. However, based on the available literature, the limiting values for performance of vegetable planters can be classified as very good, good, satisfactory and inadequate, Table 2 (Abhijit, 2018).

Table 1. Field performance of two-row semi-automatic transplanted developed by PAU (2004)

Parameter	Vegetable			
	Tomato	Chile Pepper	Cabbage	Cauliflower
Row spacing, cm	67	67	67	67
Plant spacing, cm	25-30	50-54	25-30	25-30
Working speed, km h^{-1}	0,90	1.10	0.95	0.90
Working capacity, ha h^{-1}	0.082	0.090	0.092	0.084
Plant mortality, %	5.0-7.0	5.0-7.0	1.0	7.0
Percentage missed plantings, %	3.0-8.0			
Labor requirement per row	One person			

Table 2. Performance criteria for mechanical vegetable planters

Classification	Field efficiency, (%)	Planting efficiency (%)	Miss planting, (%)	Multiple planting (%)
Very good	>75	>90	<5	<5
Good	65–75	80–90	5–10	5–10
Satisfactory	55–65	70–80	10–15	10–15
Inadequate	<55	<70	>15	>15

In Romania, several agro-technical and technological recommendations have been identified that must be met and implemented by the technical equipment for planting seedlings, as follows:

- rows planted to be straight, deviations from permitted row axis are max. 5% within ± 20 mm;
- the row spacing is adjustable, preferably continuous, starting at min. 300 mm, to allow maintenance and harvesting operations to be mechanized;
- the distance between the plants in turn can be adjusted, either continuously or in steps of 50 mm, within 100-1200 mm;
- the planting depth can be achieved within 30-150 mm;
- the position of the planting seedlings is as close as possible to the vertical;
- the percentage of seedlings improperly planted (inclined more than 30^0 to the vertical, ground covered, left on the ground or damaged) is less than 5% (Popescu, 2006).

The field experiments, for determining the qualitative working parameters, were carried out with a semi-automatic seedling plant in a row, symbolized MPA (INMA, 2018) in the unit with the 45 hp tractor, New Holland TCE50 and were carried out in the experimental polygon of INMA Bucharest.

The MPA machine, Figure 1, consists of the following main assemblies: frame (1), planting device (2), type with vertical rotary distributor and buckets, transmission (3), rear support wheels (4), compaction wheels (5), rack or crate support (6), trace marker (7).

The experiments were performed in two functional variants, as follows:

- with the machine that places the seedling in a gutter made by a coulter, followed by its covering with earth, by two fins and the additional fixing it of two compaction wheels, named Variant I;
- with a machine that places the seedling directly in the soil, followed by an additional fixing it of two compaction wheels, named Variant II.

Constructively, the Variant II missing the coulter, a component part of the planting device.

The experiments were performed with the planting device equipped with three and four buckets, thus achieving two distances between plants in a row, of 620 mm and 460 mm.

Figure 1. Machine for planting vegetable seedlings and medicinal plants in a row, MPA symbol (INMA, 2018)

RESULTS AND DISCUSSIONS

The vertical position of the plant after planting, for the two distances between plants tested in turn, 620 mm and 460 mm, for the two tested variants, is presented in Tables 3- 4, in which:

v_l - working speed, km/h;

α_i - position of the plant in relation to the vertical, degrees;

α_m - average position of the plant relative to the vertical, degrees.

Aspects during the experiments are shown in Figure 2.

Table 3. Vertical position of the plant after planting, Variant I

Nr. crt.	The distance between plants on row, 620 mm - 3 buckets			The distance between plants on row, 460 mm - 4 buckets		
	v_l km/h	α_i degrees	α_m degrees	v_l km/h	α_i degrees	α_m degrees
1	1.1	1.2	1.4	1.2	1.4	1.48
		1.8			1.8	
		1.3			1.7	
		1.5			13	
		1.2			1.2	
2	1.54	1.5	1.88	1.59	1.9	2.48
		1.8			2.8	
		2.1			2.6	
		2.3			3.3	
		1.7			2.7	
3	2.25	2.2	2.2	2.35	3.2	3.16
		2.4			3.4	
		1.9			2.9	
		2.3			3.0	
		2.2			3.3	
4	2.95	3.2	2.96	2.86	3.7	3.34
		2.6			3.6	
		2.8			2.8	
		3.0			3.3	
		3.2			3.3	

Table 4. Vertical position of the plant after planting, Variant II

Nr. crt.	The distance between plants on row, 620 mm - 3 buckets			The distance between plants on row, 460 mm - 4 buckets		
	v_l km/h	α_i grade	α_m grade	v_l km/h	α_i grade	α_m grade
1	1.18	3.5	4.92	1.11	4.5	4.90
		4.6			4.3	
		4.8			4.4	
		5.4			5.3	
		6.3			6.0	
2	1.55	5.5	5.8	1.52	4.5	5.76
		6.3			5.8	
		4.8			5.8	
		6.3			6.4	
		6.1			6.3	
3	2.15	12	15.4	2.25	21	22.8
		14			23	
		14			23	
		17			22	
		20			25	
4	2.88	25	30.5	2.86	27	31.8
		32			28	
		28			32	
		25			35	
		25			32	

a b

Figure 2. MPA: a- seedling planting machine during experiments; b- planted seedling

The comparative diagram of the variation of the plant position with the speed of work is presented in Figure 3.

The assessment of planting faults (covered with soil, left on the soil) and of damaged plants is made as a percentage, and its value must be less than 5%, according to the requirements (Popescu, 2006).

The results determined in experiments in order to assess the faults and the degree of damage at planting, for the two tested variants, are presented in Tables 5-6, in which: g_i - mistake or identified damaged plant, %.

The comparative diagram of the variation of faults and damaged plants with working speed is presented in Figure 4.

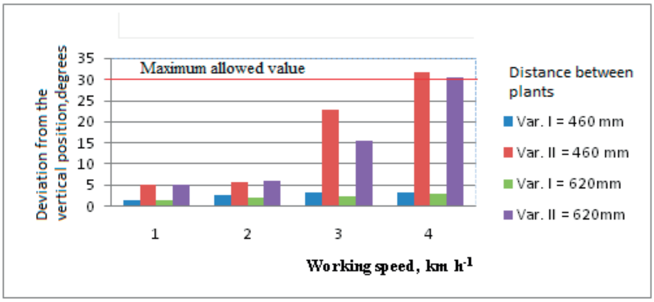

Figure 3. Comparative variation of plant position with working speed

Table 5. Mistakes and damaged plants, Variant I

Number of seedlings planted	The distance between plants on row, 620 mm - 3 buckets			The distance between plants on row, 460 mm - 4 buckets		
	v_l km/h	Mistakes and damaged plants, g_i		v_l km/h	Mistakes and damaged plants, g_i	
		buc.	%		buc.	%
30	1.1	0	0	1.2	0	0
30	1.54	0	0	1.59	0	0
30	2.25	1	3.33	2.35	1	3.33
30	2.95	2	6.67	2.86	3	10

Table 6. Mistakes and damaged plants, Variant II

Number of seedlings planted	The distance between plants on row, 620 mm - 3 buckets			The distance between plants on row, 460 mm - 4 buckets		
	v_l km/h	Mistakes and damaged plants, g_i		v_l km/h	Mistakes and damaged plants, g_i	
		buc.	%		buc.	%
30	1.18	0	0	1.11	0	0
30	1.55	1	3.33	1.52	1	3.33
30	2.15	1	3.33	2.25	3	10
30	2.88	3	10	2.86	4	13.33

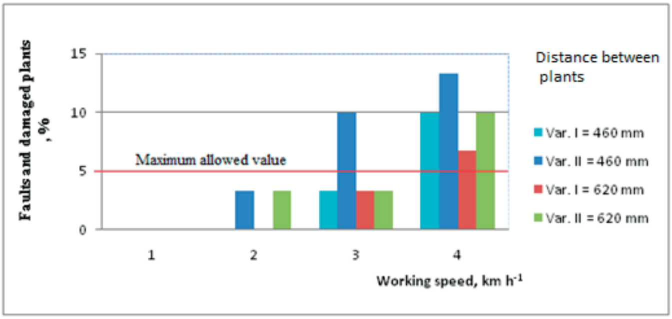

Figure 4. Comparative variation of faults and damaged plants with working speed

CONCLUSIONS

1. The planting position of the seedling is a qualitative index of work for the planting work, respectively the deviation from the vertical position of the plant, which according to the agro-technical requirements, must not exceed 30°.
2. From the performed determinations it resulted that the inclination angle is less than 30° for working speeds lower than 2.15-2.25 km/h, according to Tables 3-4, there was a tendency to increase the inclination of the plant to the vertical with increasing working speed, Figure 3. However, the angle of inclination is much higher for the planting Variant II Tab. 4, at speeds of over 2.25 km/h, approaching the maximum limit accepted by planting technologies.
3. It is therefore recommended that when using the Variant II, the working speed does not exceed 3 km/h, regardless of the distance between plants per row or the number of buckets used.
4. Regarding the mistakes and damage of the plants, registered in the planting process, it can be stated that they tend to increase with the increase of the working speed in the gutter.
5. From the analysis of Table 5 it is found that up to working speeds of approx. 1.6 km/h in Variant I, no mistakes or injuries were registered and at a speed of approx. 2.35 km/h, they have determined values of 3.33%, lower than the accepted ones of 5%, while at speeds of approx. 3 km/h the values of faults and injuries exceed the acceptable limit, the determined values being between 6.67-10%.
6. In the case of planting Variant II, the percentage of determined faults and injuries is higher than in Variant I, the percentage being between 10-13.33% for working speeds of approx. 3 km/h, which means more than double the accepted values.

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