IMPROVING THE PLANTING PROCESS BY USING CUP OPERATING CYCLE DIAGRAM

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Abstract

The study carried out on the qualitative indicators of work for planting seedlings requires knowledge of the cyclogram of the operation of the cup of the planting device.This involves knowing and correctly setting the operational phases of the bucket at a full rotation of the distributor disc.The realization of the cyclogram takes into account the kinematic elements of the transmission that determine the peripheral speed of rotation of the cup and influence the time of placing the seedling in the cup by the user.Consisting of several sectors, namely the sector of placing the seedling in the cup, moving the seedling cup until it opens and leaving the seedling in the ground, moving the open cup without seedling, closing the cup for feeding the seedling by the user, mainly influences the distance between the plates at a time.At the same time, the peripheral speed of rotation and the times for completing the operational phases of the cup have an influence on the state of fatigue of the user, in the conditions where an experienced user can place 60-70 seedlings/minute.Following the conducted research, conclusions were drawn on the operation of the planter with different number of cups at different work speeds on the achievement of the respective work quality indices: the distance between plants in a row, the position of the plant in the soil. The obtained results led to observations for the optimization of the cyclogram.

Keywords: *planting machine, seedling, cups*

INTRODUCTION

The importance of the seedling planting process results from the acute need to approach the mechanized seedling planting operation in a pragmatic and scientific way, due to the importance of growing vegetables for the economy in general but especially for the population, vegetables representing one of the main sources of food.

From the specialized literature and from the scientific works studied, several main directions have been highlighted in which actions are being taken in order to make the technologies and equipment for planting seedlings more efficient, among which we mention: increasing the work speed and implicitly the productivity, improving the quality of planting the seedlings and the precision with which is distributed in the soil, on the one hand, and the expansion, perhaps even the generalization, of the planting of seedlings obtained in nutrient pots, on the other hand, represent important and current factors for the field addressed.

Perfecting the planting technology of agricultural crops cultivated by using seedlings produced in nutrient pots, in parallel with the research and development of planting equipment that can work with such seedlings, with the aim of increasing the work speed of the planting aggregate as well as the advantages mentioned, represent some of the current concerns of specialists in the field [1,2,3].

The problem of perfecting these planting technologies involves, among other things, the provision of high-performance seedling planting equipment that has a decisive role in increasing agricultural production,

reducing specific energy consumption, improving working conditions for growers and reducing production costs. These can be achieved if, through improved planting technologies, an increase in work capacity is obtained through increased planting speeds or the increase in the number of working sections of the equipment used, while respecting the requirements of the planting technology [4,5,6,7,8].

MATERIAL AND METHOD

To carry out the experiments, a planting machine was used in a row, equipped with a distributor with articulated cups, fig. 1.

Fig.1**.** Machine for planting vegetable seedlings and herbs in a row, MPA symbol (**** INMA Bucharest, 2018)
1-Frame, 2- planter, 3- transmission, 4- rear support wheels,5 –rcompaction wheels, 6- rack or crate holder, 7- track marker

Seedlings used in experiments

The type and characteristics of the seedlings used in field trials and the type of nutrient pots in which they were obtained are presented in tables 1-2.

Table 1. Seedlings used in experiments

Nr. crt.	Plant	Dimensions of the nutrient pot [mm]	The stage of plant development		
			Height [mm]	Stem diameter [mm]	The number of leaves
1	Tomatoes	40x30x40	150-220	3-5	5-7
2	Pepper	40x30x40	100-140	2-3	4-6
3	Cabbage	40x30x40	80-120	1,5-2,5	5-7

Table 2. Seedlings used in experiments

Nr. crt.	Plant	Dimensions of the nutrient pot [mm]	The stage of plant development		
			Height [mm]	Stem diameter [mm]	The number of leaves
1	Tomatoes	50x40x50	150-220	3-5	5-7
2	Pepper	50x40x50	100-140	2-3	4-6
3	Cabbage	50x40x50	90-120	1,5-2,5	5-7

The type and stage of seedling development at the time of planting are shown in fig.2.

a) b) c)

Fig.2.The type of seedlings planted
a) tomatoes; b) pepper; c) cabbage

The purpose of realizing the cyclogram of the operation of the planting bucket is to identify the operational phases of the bucket on its working route in order to establish the times for each phase.

The value of the determined times depends on the construction and the kinematic and functional elements of the motion transmission, from the drive wheel to the cup distributor, elements made up of the working speed, the diameter of the drive wheel, the transmission ratio between the drive wheel and the cup distributor, the diameter of the arrangement of the cups on the dispenser and the number of cups.

Cyclogram

The operational phases of the cup, at a complete rotation of the distributor disc, for which the times in which they are properly developed comprise five sectors of the distributor with cups, fig. 2 and these are:

1 - placing the seedling in the cup by the operator, sector S1;

2 - moving the cup with the seedling until it contacts the cup opening cam, sector S2;

3 - moving the cup on the cam profile (first section) during the opening period
the cup and the release of the seedling in the soil, sector S3;

4 - moving the open cup, without seedling, on the second section of the cam, sector S4;

5 - moving the cup from leaving the cam to the area that allows the operator to place the seedling in the cup, phase that overlaps with phase 1, of placing the seedling in the cup, sector S5.

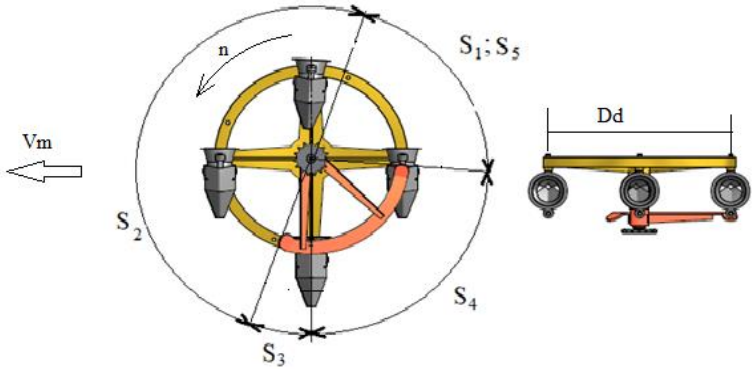

Fig.2. The operational phases of the cup
at one full rotation of the distributor disc

The method used during the tests is in accordance with the specialized literature.
The phases and implicitly the operational times of the planting process, which can influence the quality of the planting work and the working capacity of the planting equipment, are:

- the travel time of the cup in the S1 area in which the operator can place the seedling in the cup;
- the time to place the seedling in the cup, which depends on the operator's experience and skill (0.64-0.89 seconds).

For the mentioned phases, their travel times are determined according to the established working speed, the diameter of the cups arrangement Dd =0.52 m, the transmission ratio i=1.018, between the drive wheel and the distributor with previously established and used cups to experiments.
The first important phase of the cyclogram is the one in which the operator places the seedling in the cup. The number of cups mounted on the distributor has importance on the time of the phases, influencing the distance between the cups and implicitly their unfolding times. For the tests, a number of four cups on the disk were used distributor.
To create the cyclogram, depending on the kinematic elements of the transmission, the peripheral speed of the cups is determined, which depends on the diameter of their arrangement on the distributor, followed by the determination of the perimeter of the arrangement of the cups.
The perimeter of the cups is divided into length sectors, corresponding to each operational phase separately, in this way it is possible to determine the correlation between these sectors and the peripheral speed of the cups in order to determine the times in which each operational phase of the process is completed.

RESULTS AND DISCUSSIONS

Using the above data, the speed of the distributor with cups n2 was determined, using the relation (1) necessary to calculate the peripheral speed Vp of the cups.

$$n_2 = n_1 \cdot i = n_{1\cdot} \cdot i_1 \cdot i_2 = n_1 \frac{z_1}{z_2} \cdot \frac{z_3}{z_4} = \frac{30 \cdot V_l}{\pi \cdot R_r} \cdot \frac{z_1}{z_2} \cdot \frac{z_3}{z_4}$$

$$V_p = R_d \cdot \omega = R_d \cdot \frac{\pi \cdot n_2}{30}$$

$$i = i_1 \cdot i_2 = \frac{z_1 \cdot z_3}{z_2 \cdot z_4}$$

(1)

in which:
Rr- drive wheel radius, m;
Rd-radius of cups on the distributor, m;
Vl – working speed of the planting machine, m/s;
n_1-speed of the drive wheel, s-1;
n_2 – speed of the vertical distributor with cups, s-1;
i_1 – the transmission ratio between the drive wheel and the intermediate shaft;
i_2- transmission ratio intermediate shaft and rotary distributor with cups.

Following the calculations, the results were: n2 = 14.4 rpm and Vp = 0.39 m/s.
After analyzing the functionality of the dispenser with cups, at a complete rotation of it, the operational phases and their deployment sectors from the perimeter of the cups arrangement were identified.
Knowing the time, in seconds, in which the dispenser with cups makes a complete rotation (travels a perimeter), the times in which the individual operational phases take place were determined.
The values for the length of the perimeter sectors, in which the operational phases

are carried out, for the studied equipment, are:

- for the sector where the seedling is placed in the cup by the operator S1= 0.25 m;
- for the movement sector of the cup with the seedling until the contact with the opening cam of the cup S2= 0.903 m;
- for the sector of the movement of the cup on the cam profile (the first section), the period in which the opening of the cup and the release of the seedling in the soil are carried out S3= 0.04 m;
- for the movement sector of the open cup, without seedling, on the second section of the cam S4= 0.44 m;
- for the bucket movement sector from leaving the cam to the area that allows the operator to place the seedling in the bucket, the phase that overlaps with phase 1- S5 = l1= 0.25 m.

Taking into account that a complete rotation of the disc with cups is made in 4.17 s, the running times of each operational phase were determined, with the help of which the cyclogram was made, according to table 1

Table 1. Cyclogram of operation of the planting cup

Nr. crt.	Operational phase	Time [s]	Time [s]				
			1	2	3	4	5
1	Placing the seedling in the cup	0,64					
2	Moving the seedling cup to the opening cam	2,31					
3	Moving the cup on the cam and releasing the seedling into the ground (section I)	0,1					
4	Moving the open cup on the cam (section II)	1,12					
5	Moving the closed cup after leaving the cam and placing the seedling in the cup - overlaps with phase 1						
Total time[s]		4,17					

Taking into account the fact that, for this type of planter, an experienced operator could place in cups max. 60-70 seedlings per minute (1-0.85s/seedling), in order to achieve an increased working capacity of the equipment, the working speed can be increased, the number of cups per distributor can be increased, along with the reduction of the ratio of transmission so that the placement time of the seedling in the cups of the distributor is not less than 0.85 s/seedling and does not influence the distance between plants in a row.

In the case of the studied equipment, the time in which the operator can place the seedling in the cup can be increased simultaneously with the reduction of the period in which the cup moves on the cam, on its II section, by changing the position of the cup opening cam or reducing the length of the cam by 0.1 m. Thus, the time of placing the seedling in the cup can be increased by up to 0.255 s. The cyclogram of the working process of the planting cup in the improved version is presented in table 2.

Table 2. Cycle diagram of the improved planting cup

Nr. crt.	Operational phase	Time [s]	Time [s]				
			1	2	3	4	5
1	Placing the seedling in the cup	0,895					
2	Moving the seedling cup to the opening cam	2,31					
3	Moving the cup on the cam and releasing the seedling into the ground (section I)	0,1					
4	Moving the open cup on the cam (section II)	0,865					
5	Moving the closed cup after leaving the cam and placing the seedling in the cup - overlaps with phase 1						
Total timp [s]		4,17					

CONCLUSIONS

The cycle diagram of the bucket of the planting device indicates the working times of the bucket in all the phases required for mechanized planting.

It offers the user the possibility of acting on the operating phases of the planting devices without changing its working parameters and ensures the time needed to place the seedling in the cup.

The most useful and quick modification of the cyclogram refers to the 2nd phase when the travel time of the cup on the cam is reduced.

REFERENCES

Boa W., 1984.The design and performance of an automatic transplanter for field vegetables, Journal of Agricultural Engineering Research, Volume 30, Pages 123-130.

I. Saracin, Olimpia Pandia, Marin Gh, Florea G., 2007. Energy base for agriculture, horticulture and foresty, Ed. Aius, ISBN 978-606-8021-16-4.

I. Saracin, G. Paraschiv, Olimpia Pandia, 2014.Proposals for improving the process of seed distribution, Metalurgija Journal Croatia Vol XV, nr 54/3.

I. Saracin, Olimpia Pandia, 2016. Section for machine of seedling plant in nutritive pots: precise, fast and secure, Scientific Papers Series Management, ISSN 2284 – 795.

Prasanna K., G., V., Hifjur R., 2008.Vegetable Transplanters for Use in Developing Countries—A Review, International Journal of Vegetables Science 14(3):232:255.

Ruxandra Ciofu, 2004. Tratat de Legumicultură, Coordonator, Editura Ceres, București.

Vignesh G., Pugazhenthi T., Santhoshkumar A., Sanjai Kumar S., Design and Development of Vegetable Planting Machine, International Journal Of Modern Engineering Research, vol. 7, Issue 3:69-74, 2017.