A machine for oriented planting of garlic teeth

Oleg Semen, Dmytro Kuzenko, Yaroslav Semen

Lviv National Agrarian University
V. Velykogo Str. 1, Dubliany, Ukraine. E-mail: kuzenko-dv@meta.ua

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Summary. The problem of mechanized planting of garlic teeth with forced placement in the soil with a bottom down, and a germ upwards is considered. It is established that to date, semi-mechanized and mechanized methods of planting this crop have been used predominantly. Used in this machines and equipment have certain design features and innovative solutions that allow the planting of garlic teeth at a given depth and the prepared rows, but do not provide the necessary orientation during direct laying in the soil.

The existing machines and separate working bodies intended for garlic planting are analyzed. The overwhelming majority of them are equipped with disk-gripper, tape-gripper, chain-gripper, pneumatic, mechanical-air and disk planting units. During the work, the seeds released from them, under the action of gravity, fall into the groove, formed on the field by a coulter, which is immediately flooded by the soil with the help of coverers. In this case, teeth of garlic are distributed in the soil chaotic and without the necessary orientation.

The construction of a machine for semi-mechanized planting of garlic teeth with a pneumatic mechanical system for picking them out of a bunker, orientation and internal-machine transport and a chain-plunger planting machine is proposed. The constructive-technological scheme of the developed planter is given. The constructive features and the principle of work of its separate units and working bodies are substantiated. The technological process of planting garlic teeth with their forced laying in a wedge-shaped groove with a bottom down, and a germ up is described. The interaction of the roller rod of the plunger with the guide of the planting unit is theoretically investigated. The analytical dependences for determining the main kinematic parameters of the interaction of the roller, fixed on the rod of the plunger with the guide when the jaw with a garlic tooth in the ground is dug, are obtained.

Key words: garlic tooth, planter, planting unit, plunger, jaw, guide, roller.

INTRODUCTION

Garlic planting is one of the most labor-intensive and most responsible stages in the technology of its cultivation, during its mechanized performance the problem remains unresolved, the main problem is to put the tooth in the ground downwards, and germ upwards. The machines used in this way can adequately put the garlic teeth on the side in the formed groove, which partially solves the problem [1].

In view of the increased attention and growth of garlic production in our country and in the world, the question of the quality of mechanized planting is gaining momentum. But if it was possible to create working bodies of machines that reduce the probability of damaging the teeth during their capture, reduce the flaws due to the absence of teeth in the grippers of the planting unit, keep a given distance between the seeds in a row, the process of direct stacking of the teeth in the soil remains unmanageable [2]. The low level of introduction of the technique for the planting of garlic is also due to the fact that the working bodies of the planting units have not been adapted to different sizes and shapes of the surfaces of the teeth, which may be oval, columnar, rounded, cylindrical [3].

That is why most modern machines for garlic planting work on the principle of seeders. They ensure high-quality dosing of the teeth, their capture and internal transport, but the process of immediate laying of the sowing material into the soil is reduced to chaotic seeding in the open groove with subsequent embedding.

It is obvious that the solution of the actual problem of placing the garlic in the soil of the ground with the bottom down, and the germ upwards is possible due to the creation of planters, whose working bodies will be maximally adapted to a wide range of dimensional-mass indicators and various forms of planting material, with each tooth to be individually stuck in the groove in the upright position.

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Modern agriculture is based on creating the optimal conditions for the growth and development of cultural plants. Due to this, the researchers pay much attention to the preparation of seeds for sowing, using the various methods of its pretreatment and means of stimulating growth [4, 5, 6]. However, it is not enough to prepare the sowing material qualitatively. It is believed that it is

during sowing or planting that the seeds should not only be strictly distributed at the place of entry into the soil, but also be placed in the groove in such a way as to make the best use of the biological potential of each seed with the greatest benefit for each one [3, 7, 8, 9]

The vast majority of scientific works related to the cultivation of garlic are devoted to its cultivation and agricultural machinery. They consider modern technologies and methods of planting, fertilizing and protection against diseases, but very little information is given to the question of the mechanization of the planting of this agricultural crop [10, 11, 12, 13, 14]. This is especially true of the design features of planters and their working bodies.

That is why the article [1] is accentuated not only on methods but also a substantive review of existing means for planting garlic teeth. In particular, it was established that in one of the predominant use in Ukraine one-four-row machines SLR-1/2, SLM-4, Yarylo and others were equipped with bowl, chain-gripper and disk-gripper planting (sowing) units. Machines SLS-12 and SLS-5,4 are used for planting garlic in a straightforward manner on the flat, heap or planar surfaces of the field [15]. They are equipped with a planting machine in the form of an infinite chain with a step of 63.5 mm and jaws, the angle between which is 50 °. To fix the bulbs (teeth), when moving the chain in the case of the planting machine it uses a flexible limiter. During the work of the above-mentioned planter, the seeds released from them, under the action of gravity, fall into the groove formed on the field by a coulter, which immediately embeds them with the soil with the help of coverers. In this case, teeth of garlic are distributed in the soil chaotic and without the necessary orientation.

In the countries of Europe are widely used machines for planting garlic companies J.J. Broch (Spain), Zocapi (Spain), Erme (France). They are equipped with predominant pneumatic or disk-gripper planting units with variable clips [1]. According to the technological process, they are similar, but each model has its own design features. Immediately, during the work, freed from the clamps of the planter, the teeth are driven by gravity in a forward formed groove, stacked in it and embedded around with the coverers. As in the previous case, there is an arbitrary placement of teeth in the soil, which may negatively affect the future harvest.

The scientific publications [16, 17] are devoted to solving the problem of garlic planting with a strict orientation of the teeth. The authors offer a new semi-mechanized technology and a machine for its implementation, which is based on the use of a special, soluble tape in the soil, which is placed on the surface of the field, and the workers are placed directly on the planter, manually insert garlic teeth in the glued nests of a stretched strap.

The semi-mechanized method of planting garlic can be realized in several ways. One of them is the use of a planter with an organic-mineral mixture placed in its hopper, from which it is dosed, by means of screws and the directed air flow, is fed into the zone of the laying of the tooth, and it is enclosed at the same time from all sides [18, 19]. At the same time, the teeth themselves are transported by a special device, which holds them in an orientated position down the bottom [20].

On the basis of the analysis of publications, we can conclude that a lot of attention is paid to the issue of creating new working bodies of machinery for mechanized garlic planting. But the quality and efficiency of their work must be confirmed practically, using the operating models of planters.

OBJECTIVES

To substantiate the design of a machine for planting garlic teeth, oriented down the bottom, and germ upwards and theoretically investigate the interaction of separate executive mechanisms of its planting unit.

THE MAIN RESULTS OF THE RESEARCH

The proposed machine has a hopper 2 (fig. 1), filled with garlic garlic 3 teeth. It has an active bottom and indirectly contacts the drum 1, directing to it the teeth, oriented germ forward. Drum 1 itself is a hollow cylinder, on the surface of which holes are made after every 40 deg. It rotates on the bearing supports, and in the middle of it a vacuum is created, with the help of which the garlic teeth are sucked to these openings. In the bottom of the drum, a casing 19 is mounted to prevent spontaneous falling out of the teeth.

The machine is equipped with a planting unit of a chain-plunger type. It consists of two parallel branches of chain conveyors 7, interconnected by transversal bars, on which the plungers 6 are rigidly fixed. For actuation and displacement of the planting unit, the sprockets are applied.

In the upper part of the planting unit the plungers 6 rest on the supports 17, providing an optimal gap between their bent jaw and the drum 1. The jaw has two fingers held by the arm 16 in the position "opened" before the tooth is seized and closed when it is seized when the teeth are at the bottom of the drum. The plunger 6 has a spring-loaded rod and a movable sleeve on it. This design ensures that the jaw is fixed in the vertical (at the time of direct planting of the garlic tooth in the ground) or in the horizontal position (at the time of grabbing the tooth with the fingers of the jaw). When the conveyor 7 envelops the sprocket 5, the sleeve of the plunger 6 begins to move freely to its stem downwards, releasing the jaw, while during the bending of the lower sprocket 15, the sleeve moves freely downward and fixes the jaw of the plunger 6 in an upright position.

Under the hopper 2, a beater cleaner 4 is mounted, having working bodies in the form of elastic brushes, and acts the role of the jaw cleaner which is removing it from the ground and forcibly casts a jaw released by the sleeve on the plunger rod 6 immediately after the branches of the chain conveyors 7 turn around the sprocket 5. The jaw occupies a horizontal position and moves fingers forward until they are opened and captured the garlic tooth, which is compulsorily detached from the bottom of the drum 1 due to the absence of a vacuum in this zone.

The coulter 14 of the planter has side wings, and in the front of them there is a sharp sock that forms a wedge-shaped groove with a sealed bottom to a depth of 7-9 cm. To hold the tooth in an upright position, the coulter 14 must form a groove whose profile should be not only as

much as possible adapted to the planting of the teeth 3 in it upside down, but also to hold them in such a position after the release of the plunger 6 of the jaw and the final embedding with the coverers 9.

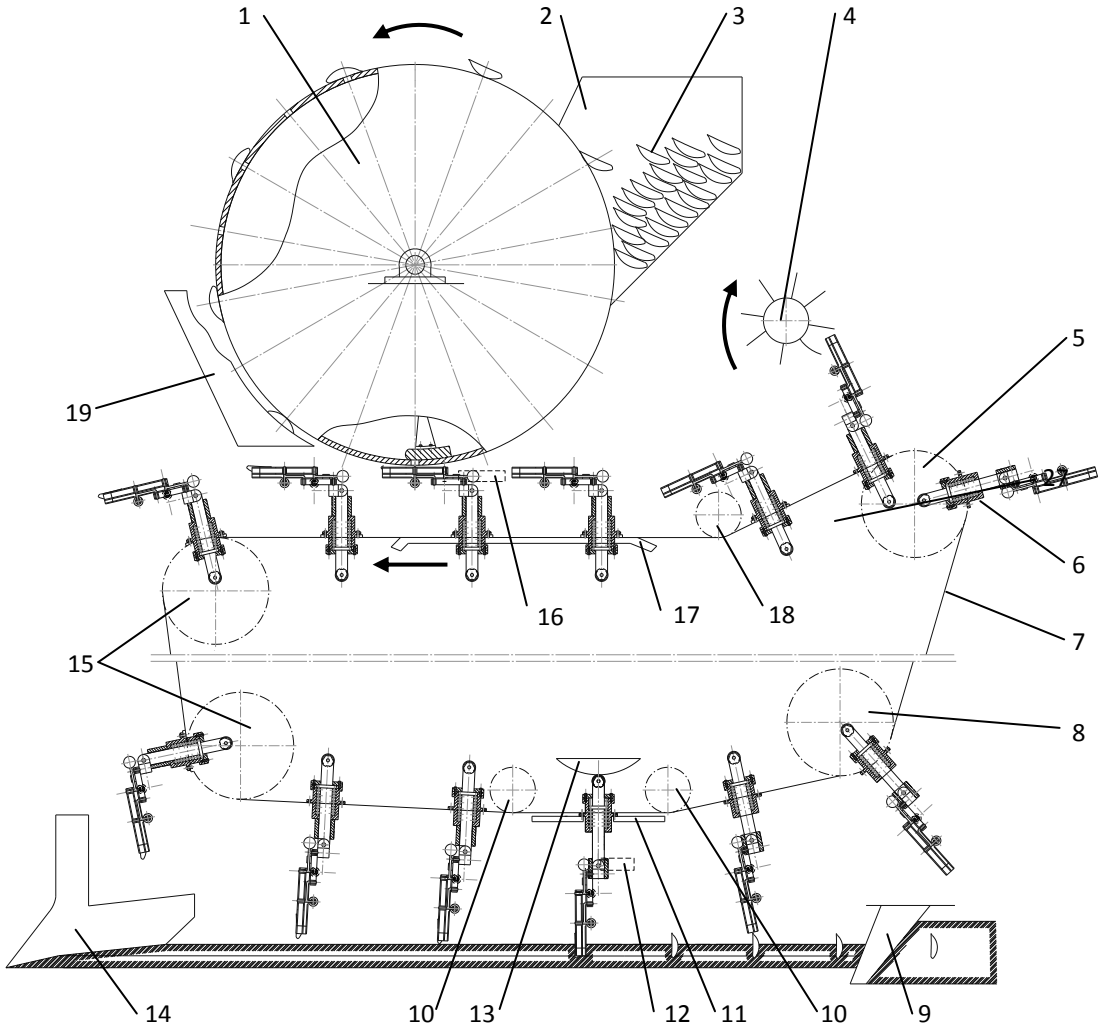

Fig. 1. Structural and technological scheme of a planter of garlic teeth: 1 – drum; 2 – hopper; 3 – garlic tooth; 4 – beater cleaner; 5, 8, 10, 15, 18 – sprockets; 6 – plunger; 7 – chain conveyor; 9 – coverer; 11, 17 – supports; 12, 16 – arms; 13 – guide; 14 – coulter; 19 – casing

In the lower part of the planting unit the sprockets 10, support 11 and the guide 13 are mounted. In aggregate, these constructive elements provide a strictly horizontal movement of the chain conveyor 7 and the vertical movement of the plunger rod 6 during the interaction of its roller with the guide 13.

The planter works as follows. Turning counter clockwise, the drum 1 takes from the hopper 2 the oriented with germ upwards garlic teeth 3 that are suctioned to its surface due to the created vacuum. At the same time, the chain conveyor 7 with plungers 6 moves along the movement of the planter, pushing them open the jaws to the bottom of the drum 1, where the teeth are released and immediately fascinated by the fingers of the jaw, which hold them until the moment the roll of the rod plunger 6 is pulled to the guide 13. Because of them the interaction of the stem with the jaw is instantly moved vertically, striking the teeth with the bottom down into the groove formed by the coulter 13. After the rollers of the control mechanism of the jaw at the support 17, their fingers diverge and release the tooth 3, which is immediately embedded by the coverer 9.

By analyzing the design-technological scheme and the principle of the proposed machine, one can conclude that the problem of orientation of the planting of garlic teeth with a bottom down should be solved systematically, taking into account the biological peculiarities of the agricultural crop and the design of each of the working bodies of the planter. Since the final task of planting is to put the teeth in the soil with the bottom down, this particular elemental operation performed by the machine must guarantee their strict orientation during contact with the soil and the embedding, and all other working bodies of the planter must be constructively and technologically adapted to such a condition.

Considering this, we believe that it is first and foremost to study the dynamics of movement of a jaw with a tooth when it is directly embedded in a groove.

Such a process occurs at the moment of interaction of roller 4 (fig. 2), mounted on the end surface of the plunger rod with a guide 3, which serves as a pole-bearing support for it. When in contact with its surface, the roller moves in the body of the plunger 6, a rod 2 with a jaw 1 and a garlic tooth 7 in it, until it is fully inserted into the ground.

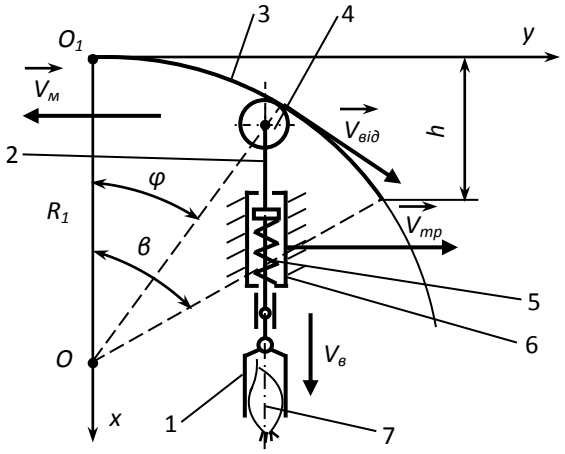

Fig. 2. Scheme of the interaction of the roller with the guide: 1 – jaw; 2 – stem; 3 – guide; 4 – roller; 5 – spring; 6 – plunger; 7 –a tooth of garlic

In the initial interaction of the roller with the guide, there should be no shock phenomenon, because periodic impacts will lead to rapid wear of the contacting surfaces, and the stem itself may deviate from the vertical movement and the garlic teeth also fall into the soil in the same position.

It is obvious that the shock event will be absent if, at the initial moment of contact, the normal to the guide will pass along the axis of the stem of the jaw. This can be achieved if the guide has the form of the arc of the circle radius R_1 (see Figure 2) with the center at the point O.

According to the given scheme, the arc is based on the central angle β. The dimensions of the guides should ensure that the jaw moves vertically up to the value h (depth of plunging into the ground together with a garlic tooth).

Obviously, the following dependence exists between the guide parameters:

$$h = R_1 - R_1 \cos\beta . \tag{1}$$

In order not to have a large lateral pressure on the jaw (roller), and even more jamming, the angle β should be not large and not exceed the value of $\beta = 45° \div 50°$. If we assume the angle β in advance from condition (1) we find the radius of the arc of the circle:

$$R_1 = \frac{h}{1-\cos\beta} . \tag{2}$$

Consider the kinematics of the jaw roller when it occupies an arbitrary position, which is determined by an alternating angle φ $(0 \le \varphi \le \beta)$. The roller is in a complicated motion: he carries a transportation movement along with a guide $\vec{V}_{trans} = \vec{V}_м$ and moves relative to the moving line with the velocity V_{mov}, which is directed from the tangent to the guide and is determined from the condition

$$V_{rel} = R_1 \frac{d\varphi}{dt} . \tag{3}$$

Then, as it is known [21], the absolute velocity $\vec{V}_a$, is equal to:

$$\vec{V}_a = \vec{V}_{trans} + \vec{V}_{rel} \tag{4}$$

Since the jaw moves along with the conveyor, and its speed $\vec{V}_{conv}$ is equal to the speed of the machine $\vec{V}_m$, but opposite to the direction ($\vec{V}_{conv} = -\vec{V}_m$), then the projection of the absolute speed on the horizontal (on the axis O_1y) is zero, that is, taking into account (4) we will have:

$$0 = -V_м + R_1 \frac{d\varphi}{dt} \cdot \cos\varphi , \tag{5}$$

$$\text{or} \quad \frac{d\varphi}{dt} = \frac{V_м}{R_1 \cos\varphi} \tag{6}$$

Integrate equation (6) and obtain the regularity of the angle φ change over time

$$\int_0^{\varphi} \cos\varphi \; d\varphi = \int_0^{t} \frac{V_м}{R_1} dt ;$$

$$\sin\varphi = \frac{V_м}{R_1} t ;$$

$$\varphi = arcsin\left(\frac{V_м}{R_1} t\right) . \tag{7}$$

If (7) substitute the condition $\varphi = \beta$, then we find the time T, during which the roller interacts with the guide, that is, the duration of immersion of the jaw with the garlic teeth in the soil:

$$T = \frac{R_1}{V_м} \sin\beta . \tag{8}$$

We design equation (4) on the axis O_1x and find the rate of immersion of the jaw in the soil:

$$V_{rel} = R_1 \frac{d\varphi}{dt} \sin\varphi = V_м tg\varphi ,$$

$$\text{or } V_{rel} = V_м \frac{\mathrm{V_м t}}{\sqrt{\mathrm{R_1^2} - (V_м t)^2}} \quad (9)$$

Find the absolute acceleration of the jaw roller. Since the transportation movement is translatable with a constant velocity V_m, the transportation acceleration and acceleration of the Coriolis are also zero, and there are only two constituents of relative acceleration - normal and tangent.

Normal acceleration is directed to the center of the circle and is:

$$a^n_{від} = \frac{V^2_{rel}}{R_1} = \mathrm{R_1}\left(\frac{d\varphi}{dt}\right)^2 = \frac{V^2_м}{\mathrm{R_1}\cos^2\varphi},$$

$$\text{or } a^n_{rel} = \frac{V^2_м \cdot R_1}{(\mathrm{R_1^2} - (V_м \mathrm{t})^2)} \quad (10)$$

The tangential acceleration is directed at the tangent at the contact point of the roller with the guide and is determined from the condition:

$$a^\tau_{rel} = \frac{d}{dt}(V_{rel}) = \mathrm{R_1}\frac{\mathrm{d}}{\mathrm{dt}}\left(\frac{d\varphi}{dt}\right) = \frac{V_м \sin\varphi}{\cos^2\varphi}\cdot\frac{d\varphi}{dt} = \frac{V^2_м}{\mathrm{R_1}}\cdot\frac{\sin\varphi}{\cos^3\varphi},$$

$$\text{or } a^\tau_{rel} = V^2_м \cdot \frac{R_1 V_м \mathrm{t}}{(R_1^2 - (V_м \mathrm{t})^2)^{\frac{3}{2}}} \quad (11)$$

We design the vector of absolute acceleration on the axis O_1x and find the acceleration of the jaw in the vertical direction:

$$a_в = a^\tau_{rel}\cdot\sin\varphi + \mathrm{a^n_{rel}}\cdot\cos\varphi = \frac{V^2_м}{R_1}\cdot\frac{1}{\cos^3\varphi} = \frac{V^2_м}{\mathrm{R_1}}\cdot\frac{1}{(R_1^2 - (V_м t)^2)^{\frac{3}{2}}}. \quad (12)$$

Thus, the obtained dependences (9) - (12) make it possible to determine the main kinematic parameters of the relationship of the roller, fixed on the jaw with the guide while dipping the garlic to the ground.

However, the main dimensions of the roller and rod of the jaw, as well as the stiffness of the spring remain ungrounded. For their establishment, it is necessary to investigate the forces and reactions acting in this mechanism at various stages of the entry of the jaw with a garlic tooth into the soil.

CONCLUSIONS

The proposed construction of a machine for semi-mechanized garlic planting allows one of the main problems to be solved, namely, strict orientation of the teeth with a bottom down, and a germ upwards during their direct laying in the soil to a given depth. The peculiarity of the planter is the presence of a pneumatic mechanical system for the artificial picking of teeth from the hopper of the machine and a chain plunger planting machine with lateral capture of each tooth and forced depression into the groove in an upright position.

The quality of the planter's technological process will be ensured when the speed of its movement and the speed of movement of the chain drive conveyor of the plunger will be the same, but opposite to the directions directly at the moment of contact of the jaw with the tooth surface of the field.

Theoretical researches have established that when the initial interaction of the roller with the guide, the impact of the impact will be absent, if the guide has the form of the arc of a circle, the radius R_1 of which depends on the structural parameters of the plunger unit, and the normal to it will pass along the axis of the rod of the jaw.

To prevent clamping of the roller and the vertical immersion of the jaw to the ground together with the teeth of garlic at a given depth h, the central angle β on which the arc of the guiding circle rests must not exceed $\beta = 45 \div 50$ °.

The obtained dependences (9) - (12) make it possible to determine the main kinematic parameters of the interaction of the roller, fixed on the jaw with the guide while digging the garlic tooth in the soil, namely the speed, the normal tangential and absolute acceleration of the immersion of the jaw in the vertical direction.

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МАШИНА ДЛЯ ОРИЕНТИРОВОЧНОЙ ПОСАДКИ ЗУБКОВ ЧЕСНОКА

Олег Семен, Дмитрий Кузенко, Ярослав Семен

Аннотация. Рассмотрена проблема механизированой посадки зубков чеснока с принудительным их размещением в почве донышком вниз, а ростком вверх. Установлено, что на сегодняшний день преимущественное использование нашли полумеханизированные и механизированный способы посадки указанной сельскохозяйственной культуры. Использованные при этом машины и оборудование имеют определенные конструктивные особенности и новаторские решения, которые позволяют высаживать зубки чеснока на заданную глубину, и установлены междурядья, но не обеспечивают необходимой их ориентации во время непосредственного заключения в почве.

Проанализированы существующие машины и отдельные рабочие органы, предназначенные для посадки чеснока. Подавляющее большенство из них оборудованы ложечково-дисковыми, ленточно-ложечковимы, моторной-ложечковимы, пневматичными, пневмомеханические и дисковыми посадочные аппаратами. Во время работы, освобожденное из них семена, под действием силы тяжести, попадает в бороздку, образованную на поле сошником, которая сразу засыпается грунтом с помощью лапы загортача. В таком случае зубчика чеснока распределяются в почве хаотично и без необходимой ориентации.

Предложена конструкция машины для полумеханизированной посадки зубков чеснока с пневмо-механической системой извлечения их из бункера, ориентирования и внутри машинной транспортировки и цепно-плунжерным посадочным аппаратом. Приведено конструктивно-технологическую схему разработанной посадочной машины. Обоснованно конструктивные особенности и принцип работы отдельных ее узлов и рабочих органов. Описаны технологический процесс посадки зубков чеснока с принудительным их укладкой в клиновидную бороздку донышком вниз, а ростком вверх. Теоретически исследовано взаимодействие ролика штока плунжера с направляющей посадочного аппарата. Получены аналитические зависимости для определения основных кинематических параметров взаимодействия ролика, закрепленного на штоке плунжера с направляющей при углубление вилки с зубками чеснока в почву.

Ключевые слова: зубок чеснока, сажалка, посадочный аппарат, плунжер, вилка, направляющая, ролик.