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# RESEARCH OF CONTACT HOLE-DIGGER WHEEL OF PLANTING SEEDLINGS OF MULCHING MACHINE WITH SOIL AT ITS POSSIBLE ROLLING

## SODINAMOSIOS MULČIUOJANČIOSIOS MAŠINOS DARBINIO RATO SĄVEIKOS SU DIRVOŽEMIU TYRIMAS ESANT GALIMAM JO PRABUKSAVIMUI

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The article highlights the need for using polyethylene plastic as mulch in growing vegetable crops. The advantages of mulch plastic are described the most extensively. Technological scheme and operation of the proposed seedling plating and mulching planter for planting vegetable seedlings is presented. For a substantiation the parameters of hole-digger wheel, wrote the system of equations. The results of graphic dependence of a trajectory of hole-digger wheel during contact with soil were turned out by computer modeling

*Plastic for mulching, spectral transparency, hole making device, hole making wheel, irrigation furrow, microclimatic conditions, soil offset.*

## Introduction

In perspective, in order to improve soil fertility and produce ecologically-friendly products in sufficient volume while reducing the total area of crops, it is necessary to develop radically new technologies for production of vegetables and melons. One of these trends is the use of polythene plastic for growing vegetables and melon crops. [1].

The most effective direction for increasing the productivity of vegetable crops is mulching of soil with plastic materials because this technique allows to save the expenditure of irrigation water, period of plant vegetation, increase the temperature of the root zone, reduce weeds in the field without using herbicides and as a consequence, eliminate pollution of the environment by toxic substances [6].

Polyethylene plastic as soil mulching material is used in field conditions and in protected ground for increasing the yield and quality of the most valuable food crops.

## Purpose

Describe the trajectory peaks holl- digger by computer simulation.

## Materials and Methods

The conducted analysis of designs of the devices for laying mulching plastic, its perforation, planting and seeding works show that the complex of devices for growing sown crops on mulching plastic should include a special seeding machine that performs synchronous punching of holes in the plastic, making holes, seeding in a certain distance in the row. The common element of all mentioned solutions is the perforating wheels designed for punching the holes in the plastics, making holes in the soil and seeding [7].

In the Kazakh National Agrarian University the design of combined device for planting seedlings through mulching plastic is developed [11]. The proposed design has a soil offset (2), in the form of a wedge, which forms a furrow in the soil for further putting the edge of mulching plastic in it. The plastic in a roll is placed over the frame of the device and a roller (4) is set between the soil and pressing roller (5). Edge of the plastic is fixed by soil with the help of pressing roller of the furrow (6) and blade (14). So, the blade forms a new furrow. Thus, after laying the plastic, its edges are fixed with the soil. In the cross sections, the location of the plastic looks like it's shown in the scheme presented in Fig 1.

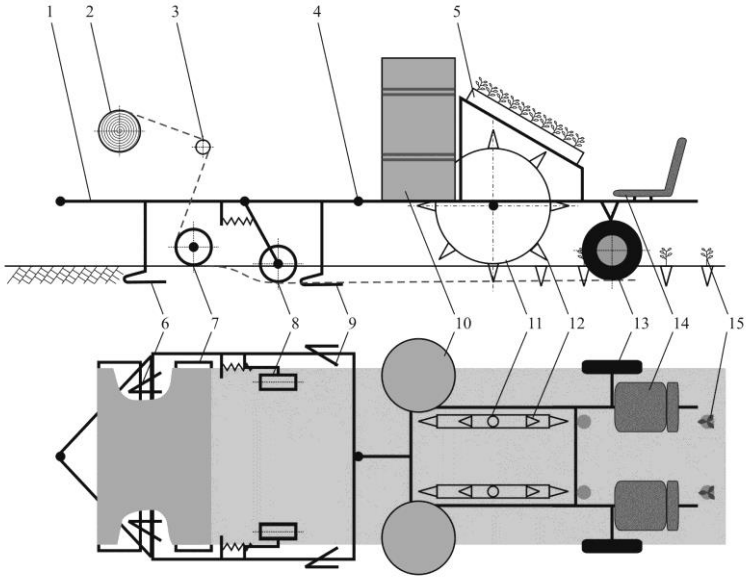


**Fig.1**. Technological scheme of the proposed design: 1– frame; 2 – plastic roll; 3 – strain roller; 4 – hinge; 5 – box for seedlings; 6 – soil offset; 7 – pressing roller; 8 – pressing roller; 9 – blade; 10 – capacity; 11 – hole making wheel; 12 – hole forming tool; 13 – bearing wheel; 14 – seat; 15 – seedling

**Рис. 1.** Технологическая схема предлагаемой конструкции: 1– рама; 2 – ролик с пленкой; 3 – натяжной ролик; 4 – шарнир; 5 – ящик для рассады; 6 – почва отвод; 7 – прижимной валик; 8 – прижимной валик: 9 – отвал; 10 – емкость; 11 – колесо лункообразователя; 12 – лункообразователь; 13 – опорное колесо; 14 – сиденье; 15 – рассада

Along the surface of the plastic the seedling planting device is moving along two rows. Seedling planting device is designed as a wheel in which the radial ones are placed on the rim that penetrates through the plastic into the soil and forms the holes for seedlings. In this case, water from tanks located in front of the hole forming mechanism, goes to the wheel of the hole making mechanism. Hole making wheel is designed for storage of irrigation water. Through one side of the surface of the wheel, water gets inside the wheel and maintains a certain level. Water from one side wheel surface goes through the holes made on the basis of the cone into the hole, i.e. when the wheel rotates. When hole making device is located in the down position, water goes into the hole. According to the adopted scheme of the proposed device, the frame is used for attaching the main mechanisms. The device contains two mechanisms: the mechanism of putting plastic cover and planting seedlings. Therefore, these mechanisms are made separately, and are joined with the help of the hinge. Each of these parts should have two cross beams. Connection of cross beams should be done using the end beams.

On the top of the laying mechanism, the plastic in a roll should be set, which rotates together with the shaft. Shaft should rotate freely on the bearings. Shaft diameter is determined by the weight of the plastic in the roll. Shaft length is chosen with consideration of the width of the plastics. The tension roller is set according to the same scheme, which ensures the leveling of the plastic. Pressing roller is placed at the bottom of the frame of the mechanism which lays the plastic and performs bearing function. 90 cm, i.e. equal to the width of the plastic, on the size of bending part, which should go into the soil.

In the back part, at the bottom of the frame two holding rollers of the furrow are fixed. These rollers are pressing the edges of the plastic to the inside part of the furrow. After the rolls, behind it and symmetrically to the longitudinal axis, two blades are set. The distance between them is 140 cm, i.e. the width of the plastic. The blades, in addition, make the furrow for further irrigation and for the passage of the bearing wheel of the seedling planting device.

## Building a computing model

For research of process of interaction following assumptions are accepted:

- speed of aggregate is constant;
- under hole-digger wheel, it doesn't make channel;
- the hole-digger wheel moves as rolling on soil.

At movement aggregate, the speed $V_0$ of the center of hole-digger wheels is equivalent to speed of aggregate $V_{agr}$. For studying of process of interaction hole-digger wheels with soil we accept initial position of a wheel at which any hole-digger will concern a soil surface Fig.2.

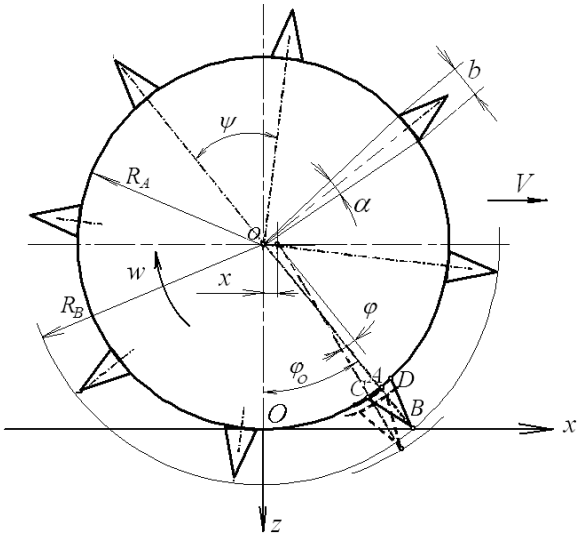


**Fig.2.** The settlement scheme of interaction of hole-digger wheels with soil: b - hole - digger base length, m; ψ - angle between adjacent hole-digger, radian; ω - angular velocity of the wheel, $s^{-1}$ ; $\varphi_o$ - deflection angle hole- digger at movings on small size, radian ; α -angle to the hole -digger hall on the ground surface of the impeller, radian; φ - angle of rotation of the impeller, with a small step, radian; V - linear speed of the aggregate, m/s; $R_A$ - radius of the work wheel, m; $R_B$ - radius of the circle on the top hole- digger, m; A, B, C, D - Points coordinates describing the shape hole-digger motion, m.

**Рис. 2**: Расчетная схема взоймодействия лункообразовательного колеса с почвой: b - длина основания лункообразователя, м; ψ - угол между соседними лункообразователями, рад; ω - угловая скорость колеса, $c^{-1}$; $\varphi_o$ - угол отклонения лункообразователя при перемещений на малую величину, рад; α - угол по основанию лункообразователя на поверхности основания рабочего колеса, рад; φ - угол поворота рабочего колеса, при малом шаге, рад; V - линейная скорость агрегата, м/с; $R_A$ - радиус рабочего колеса, м; $R_B$ - радиус окружности по вершине лункообразователя, м; A, B ,C, D - координаты точки характеризующие очертания лункообразовательного процесса движения, м.

Having chosen system of coordinates, we will define a deviation comer hole-digger from axis OZ

$$\varphi_0 = arctg \frac{\sqrt{1-\left(\frac{R_A}{R_B}\right)^2}}{\frac{R_A}{R_B}}. \qquad (1)$$

In this position of coordinate of a point *B* will be defining by following expressions

$$\begin{aligned} X_{B0} &= R_B \sin\varphi_0; \\ Z_{B0} &= R_B \cos\varphi_0 - R_A = 0. \end{aligned} \qquad (2)$$

The hole-digger is established at width *b* on a surface of wheel. It is captured by the central angle $\alpha$ . Its size is equal

(3)

From here

$$\alpha = arctg \frac{b/2R_A}{\sqrt{1-(b/2R_A)^2}}. \quad (4)$$

In this initial position of coordinate of point's C, D are equal

$$\begin{aligned} X_{C0} &= R_A \sin(\varphi_0 - \alpha/2); \\ Z_{C0} &= R_A(1-\cos(\varphi_0 - \alpha/2); \\ X_{D0} &= R_A \sin(\varphi_0 + \alpha/2); \\ Z_{D0} &= R_A(1-\cos(\varphi_0 + \alpha/2). \end{aligned} \quad (5)$$

At movement aggregate any point of the wheel, except its center, makes difficult movement: portable - rectilinear forward; relative - rotary. At wheel turn on angle $\varphi$ the wheel center will move on size $x = \varphi R(1+\delta)$, with a glance its rolling. Then coordinates of point's B**,** C, D will equal

$$\begin{aligned} X_B &= \varphi R_A(1+\delta) + R_B \sin(\varphi_0 - \varphi); \\ Z_B &= R_B \cos(\varphi_0 - \varphi) - R_A; \\ X_C &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 - \alpha/2 - \varphi); \\ Z_C &= R_B \cos(\varphi_0 - \alpha/2 - \varphi) - R_A; \\ X_D &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + \alpha/2 - \varphi); \\ Z_D &= R_B \cos(\varphi_0 + \alpha/2 - \varphi) - R_A. \end{aligned} \quad (6)$$

Apparently from the equations of coordinate of points of system interesting us depend from wheel angle of rotation. Reception of the equations of movements of the given points by an analytical is make difficulties, as these equations aren't transfer by the ordinary. In this connection, the problem decision to carry out is accepted computer modeling of process. Which essence consists in definition of coordinates of points at a small step of angle of rotation $\varphi$ and by connection of points by lines BC and BD to receive outlines hole-digger in the course of their movement. Their set at different increments of comer $\varphi$ should show us outlines which made in soil hole.

For full representation of work hole-digger wheels we will consider possibility of definition of coordinates of characteristic points of the second and the third hole-diggers. The hole-diggers are located on a surface of a wheel with equal angular step.

$$\psi = \frac{360^0}{n}, \quad (7)$$

where n - quantity hole-diggers on a wheel.

Hence, next to position of hole-diggers in its initial position, before movement aggregate, will be defined by an angle of a deviation from axis OZ

$$\varphi_0+i\psi, \tag{8}$$

where *i* - serial number of hole-diggers after starting the first.

For example, for the second hole-diggers i =1, and for the third - i=2. Taking into account it, coordinate of characteristic points of the second and the third hole-diggers: at *i* =1

$$\begin{aligned}
X_{B1} &= \varphi R_A(1+\delta) + R_B \sin(\varphi_0 + \psi - \varphi),\\
Z_{B1} &= R_B \cos(\varphi_0 + \psi - \varphi) - R_A,\\
X_{C1} &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + \psi - \alpha/2 - \varphi),\\
Z_{C1} &= R_B \cos(\varphi_0 + \psi - \alpha/2 - \varphi) - R_A,\\
X_{D1} &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + \psi + \alpha/2 - \varphi),\\
Z_{D1} &= R_B \cos(\varphi_0 + \psi + \alpha/2 - \varphi) - R_A.
\end{aligned} \tag{9}$$

when *i*=1

$$\begin{aligned}
X_{B2} &= \varphi R_A(1+\delta) + R_B \sin(\varphi_0 + 2\psi - \varphi),\\
Z_{B2} &= R_B \cos(\varphi_0 + 2\psi - \varphi) - R_A,\\
X_{C2} &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + 2\psi - \alpha/2 - \varphi),\\
Z_{C2} &= R_B \cos(\varphi_0 + 2\psi - \alpha/2 - \varphi) - R_A,
\end{aligned} \tag{10}$$

**The analysis of results on calculation**

For revealing of influence of rolling on profile formation hole it is made calculating work by program in QBASIC. Here coordinates of characteristic points are calculated at angle $\varphi$ which changes with the set step. Making analytical works, the numerical values of coordinates of characteristic points , evaluated in mm. And for reception of an evident picture of formation of a profile of hole it is possible to include and to the program schedule.

Being set by value of factor of rolling $\delta$ hole-digger wheels in its possible limits ($0{,}025 \le \delta \ge 0{,}10$ and at the established geometrical sizes of the hole-digger wheels ($R_A$=3,18 mm, h=100 mm, b=100 mm) have being (Fig.3) results.

Here it is visible, that increase in value of factor of rolling $\delta$ the longitudinal size hole are cut down, in particular in the bottom part located decreases. However, back lip the part of hole is formed in an initial stage by consolidation a back surfa-

ce hole-digger, and forward lip the part of hole is formed by an edge of hole-digger in first half of process. The front surface of the hole-digger in second half of process makes consolidation before have made forward edge of parts hole. Such expiration of process, in our opinion, should be favorable to make a hole as, edge parts of hole are strengthened by consolidation of soil and danger of their collapse can be essentially decrease. Besides, condensed walls of hole absorb less intensively and the arrived water during the period making a hole. And it can be estimated as the positive phenomenon as after making a hole in it submit butt a part seedlings and the water rest being absorbed in walls improves formation of connection of soil with seedlings root. Such position can essentially improve establishment the landed seedlings. Considering the above-stated is undertaken to consider process making hole at other combinations of parameters of hole-digger, in particular, parities *b: h,* i.e. width of arrangement on a wheel and heights.

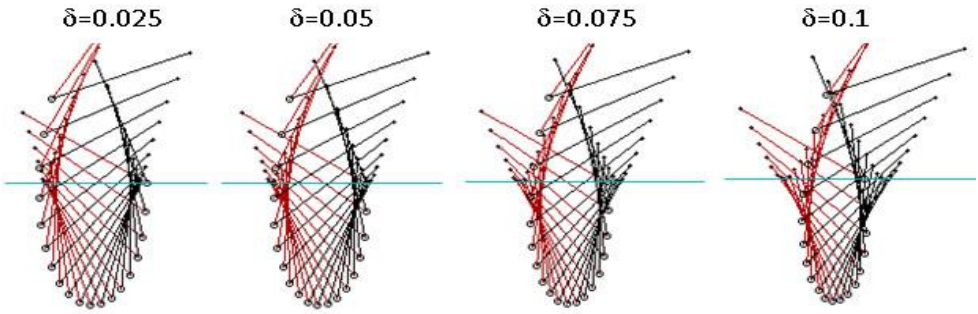


**Fig.3.** Changing the profile of hole depending on factor
**Рис.3** Изменение профиля лунок в зависимости от коэфициента

In consideration of values $100 \le b \le 200$ mm and $80 \le h \le 120$ mm are defined by us, that with height increase of hole-digger (figure 4), exactly both depth of hole and its longitudinal width are enlarge. The top part, of hole at the big height of hole-digger has available almost vertically and danger of its collapse enlarges.

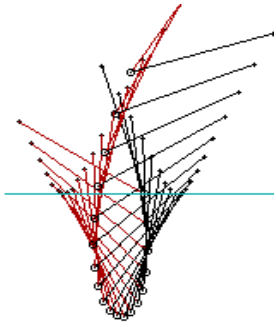

**Fig 4**. The rational profile of hole
**Рис 4.** Рацинольный профиль лунки

Especially, the rather poorly condensed edge of a back part of hole in the beginning of its formation in final phase of its formation is exposed to influence of a back surface and an edge of hole-digger. And it chances to destruction of a back wall hole. Exactly, the destruction soil fills a bottom of hole, changing its depth. It is proved scientifically, that for formation the hole with the steady sizes the rational combination *b:h* is necessary. So, necessary limits of depth of hole are 80…100 mm [14].

In the table number 1 was show the numerical values of settlement points drawing fig.3 and fig.4 for simplification of the analysis are presented.

**The table 1**.Coordinate of characteristic point's hole-digger from a comer φ
**Таблица 1.** Координаты характерных точек лункообразователя от угла φ

| φ | $X_B$, mm | $Z_B$, mm | $X_C$,mm | $Z_C$,mm | $X_D$, mm | $Z_D$, mm |
|---|---|---|---|---|---|---|
| 0.00 | 239.33 | 0.00 | 148.32 | 36.71 | 229.25 | 97.62 |
| 5.00 | 239.15 | 19.65 | 151.68 | 24.85 | 237.62 | 78.48 |
| 10.00 | 237.37 | 36.73 | 154.11 | 15.23 | 244.39 | 61.16 |
| 15.00 | 234.21 | 51.11 | 155.79 | 7.90 | 249.73 | 45.79 |
| 20.00 | 229.91 | 62.68 | 156.94 | 2.94 | 253.83 | 32.50 |
| 25.00 | 224.74 | 71.35 | 157.77 | 0.38 | 256.86 | 21.38 |
| 30.00 | 218.93 | 77.06 | 158.47 | 0.23 | 259.01 | 12.52 |
| 35.00 | 212.76 | 79.77 | 159.26 | 2.51 | 260.50 | 5.98 |
| 40.00 | 206.49 | 79.44 | 160.36 | 7.18 | 261.51 | 1.82 |
| 45.00 | 200.37 | 76.09 | 161.97 | 14.22 | 262.27 | 0.06 |
| 50.00 | 194.68 | 69.75 | 164.30 | 23.57 | 262.98 | 0.73 |
| 55.00 | 189.67 | 60.45 | 167.54 | 35.16 | 263.86 | 3.80 |
| 60.00 | 185.60 | 48.27 | 171.89 | 48.91 | 265.10 | 9.27 |
| 65.00 | 182.72 | 33.30 | 177.52 | 64.70 | 266.93 | 17.09 |
| 70.00 | 181.26 | 15.66 | 184.62 | 82.42 | 269.54 | 27.20 |
| 75.00 | 181.45 | -4.52 | 193.35 | 101.93 | 273.13 | 39.52 |
| 80.00 | 183.50 | -27.08 | -203.85 | 123.09 | 277.89 | 53.96 |
| 85.00 | 187.63 | -51.86 | 216.26 | 145.73 | 283.99 | 70.41 |

## Conclusion

1. At increase in width of hole-digger *b* danger of destruction of a back wall hole decreases, as the edge of hole-digger at an exit from hole practically does not touch the generated back wall of hole. In which consequence soil consolidation occurs at the expense of pressure a back wall of hole-digger.

2. The front surface of hole-digger is active at small importance of the basis hole-digger *b*. The front surface since the middle of process of formation hole-digger enters active actions and by that carries out consolidation of a front wall of hole. During this moment hole-diggers of wheels are made the sliding.

3. The lateral faces of hole are not condensed, as dynamic influences do not occur from the party of hole-digger, as lateral walls of hole-digger is not con-

tact, so the lateral walls of hole are not compression. Irrigation water leaks from lateral walls of hole-digger.

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## SODINAMOSIOS MULČIUOJANČIOSIOS MAŠINOS DARBINIO RATO SĄVEIKOS SU DIRVOŽEMIU TYRIMAS ESANT GALIMAM JO PRABUKSAVIMUI

### Santrauka

Straipsnyje nagrinėjama galimybė panaudoti polietileno plėvelę kaip mulčiavimo priemonę augalininkystėje. Aprašyti polietileno kaip mulčio privalumai. Pateikta polietileno plėvelės klojimo technologinė schema ir procesas mulčiuojant dirvą daigų sodinimo metu. Sudaryta lygčių sistema darbinio rato parametrams pagrįsti. Kompiuterinio modeliavimo pagalba gautos darbinio rato trajektorijos grafinės priklausomybės kontakto su dirva metu

*Mulčiuojanti plėvelė, spektrinis skaidrumas, darbinis ratas.*

Гульнар Ахметканова, Жанат Хазимов, Марат Хазимов

## ИССЛЕДОВАНИЕ ВЗАИМОДЕЙСТВИЯ ЛУНКООБРАЗОВАТЕЛЬНОГО КОЛЕСА РАССАДОПОСАДОЧНОЙ МУЛЬЧИРУЮЩЕЙ МАШИНЫ С ПОЧВОЙ ПРИ ЕГО ВОЗМОЖНОМ ПРОКАТЫВАНИИ

### Резюме

В статье рассмотрена потребность в использовании полиэтиленовой пленки как мульчи при выращивании растительных культур. Описано преимущества мульчи из полиэтилена. Представлена технологическая схема и процесс растила полиэтиленовой пленки для мульчирования почвы при посадке рассады. Для обоснования параметров рабочего колеса лункообразователя составлена система уравнений. Получены результаты графической зависимости траектории лункообразователя во время контакта с почвой с помощью компьютерного моделирования.

*Мульчирующая пленка, спектральная прозрачность, лункообразующий механизм, лункообразующее колесо, поливная борозда, микроклиматические условия, почвоотвод*.