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

**Summary**

The article highlights the need for using polyethylene plastic as a mulch in growing vegetable crops. The advantages of mulch plastic are described. Technological scheme and operation of the proposed seedling plating and mulching planter for planting vegetable seedlings is presented, for the design of which the authors have received a patent. For a substantiation the parameters of hole-digger wheel, wrote the system of equations. At contact the hole-digger wheel with soil, it was result of dependence describing a trajectory.

*Key words*: 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.

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 [1-6].

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.

**The aim of this article** is to justification a parameters of working wheel of aggregate for mulching soil.

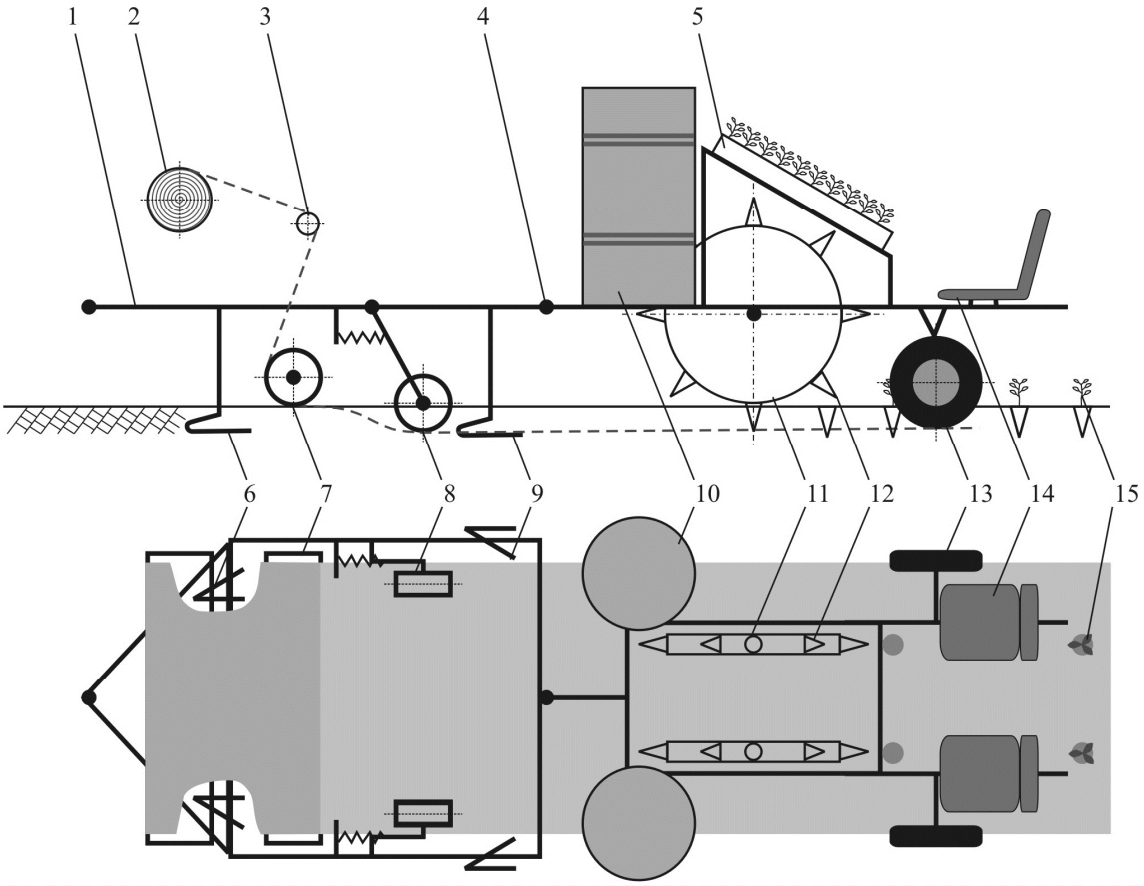
**Materials and methods**

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 [7-15].

In the Kazakh National Agrarian University the design of combined device for planting seedlings through mulching plastic is developed [16, 17]. 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 Figure 1.

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 cones 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.




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

Figure -1. Technological scheme of the proposed design

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 of 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 (drawing 2).

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

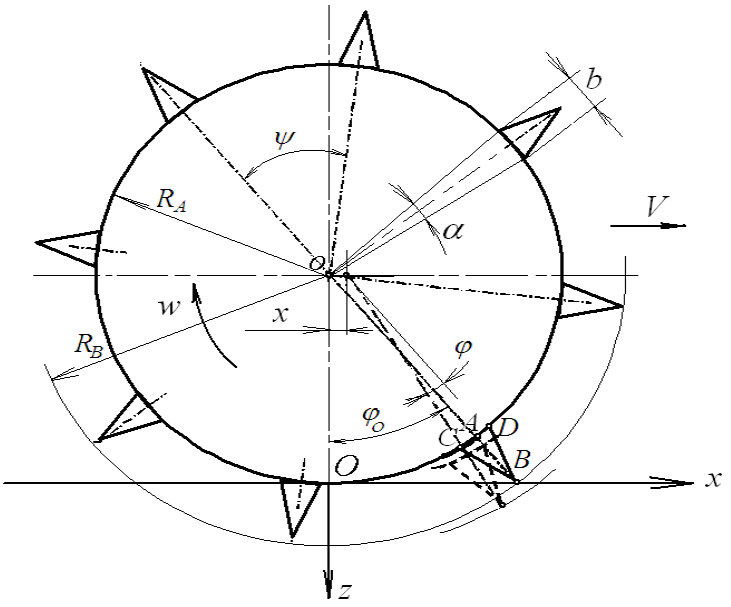



Figure – 2. The settlement scheme of interaction of hole-digger wheels with soil

$$\varphi_0 = arctg \frac{\sqrt{1-\left(\frac{R_A}{R_B}\right)^2}}{\frac{R_A}{R_B}}. \qquad (2.1)$$

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

$$X_{B0} = R_B \sin \varphi_0;$$

$$Z_{B0} = R_B \cos \varphi_0 - R_A = 0. \qquad (2.2)$$

The hole-digger is established at width b on a wheel surface. It is captured by the central angle α. Its size is equal

$$\sin\ \alpha\ = \frac{b\ /\ 2}{R_{A}}. \tag{2.3}$$

From here

$$\alpha\ = arctg\ \frac{b\ /\ 2R_{A}}{\sqrt{1-(b\ /\ 2R_{A})^{2}}}. \tag{2.4}$$

In this initial position of coordinate of points C, D are equal

$$\begin{aligned} \tilde{O}_{\tilde{N}0} &= R_{A}\sin(\varphi_{0}-\alpha/2); \\ Z_{\tilde{N}0} &= R_{A}(1-\cos(\varphi_{0}-\alpha/2); \\ X_{D0} &= R_{A}\sin(\varphi_{0}+\alpha/2); \\ Z_{D0} &= R_{A}(1-\cos(\varphi_{0}+\alpha/2). \end{aligned} \tag{2.5}$$

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 $x=\varphi R_{A}(+\delta)$, with a glance its rolling. Then coordinates of points B, C, D will equal

$$\begin{aligned} X_{B}\ &=\ \varphi R_{A}(1+\delta)+R_{B}\sin(\ \varphi_{0}-\varphi); \\ Z_{B}\ &=\ R_{B}\cos(\ \varphi_{0}-\varphi)-R_{A}; \\ X_{C}\ &=\ \varphi R_{A}(1+\delta)+R_{A}\sin(\ \varphi_{0}-\alpha\ /\ 2-\varphi); \\ Z_{C}\ &=\ R_{B}\cos(\ \varphi_{0}-\alpha\ /\ 2-\varphi)-R_{A}; \\ X_{D}\ &=\ \varphi R_{A}(1+\delta)+R_{A}\sin(\ \varphi_{0}+\alpha\ /\ 2-\varphi); \\ Z_{D}\ &=\ R_{B}\cos(\ \varphi_{0}+\alpha\ /\ 2-\varphi)-R_{A}. \end{aligned} \tag{2.6}$$

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 corner $\varphi$ 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.

$$\psi = \frac{360^0}{n}, \tag{2.7}$$

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

$$\varphi_0 + i\psi, \tag{2.8}$$

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*

$$\begin{aligned}
X_{B1} &= \varphi R_A(1+\delta) + R_B \sin(\varphi_0 + \psi - \varphi),\\
Z_{B1} &= R_B \cos(\varphi_0 + \psi - \varphi) - R_A,\\
X_{C1} &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + \psi - \alpha/2 - \varphi),\\
Z_{C1} &= R_B \cos(\varphi_0 + \psi - \alpha/2 - \varphi) - R_A,\\
X_{D1} &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + \psi + \alpha/2 - \varphi),\\
Z_{D1} &= R_B \cos(\varphi_0 + \psi + \alpha/2 - \varphi) - R_A.
\end{aligned} \tag{2.9}$$

при $i$=*1*

$$\begin{aligned}
X_{B2} &= \varphi R_A(1+\delta) + R_B \sin(\varphi_0 + 2\psi - \varphi),\\
Z_{B2} &= R_B \cos(\varphi_0 + 2\psi - \varphi) - R_A,\\
X_{C2} &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + 2\psi - \alpha/2 - \varphi),\\
Z_{C2} &= R_B \cos(\varphi_0 + 2\psi - \alpha/2 - \varphi) - R_A,\\
X_{D2} &= \varphi R_A(1+\delta) + R_A \sin(\varphi_0 + 2\psi + \alpha/2 - \varphi),\\
Z_{D2} &= R_B \cos(\varphi_0 + 2\psi + \alpha/2 - \varphi) - R_A.
\end{aligned} \tag{2.10}$$

**The analysis of results of 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. To make 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 ≤ □ ≥0,10) and at the established geometrical sizes of the hole-digger wheels (RA=318,5 mm, h=100 mm, b=100 the mm) is had the following (figure 3) results.

Here it is visible, that increase in value of factor of rolling □□ 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 by a back surface hole-digger, and forward lip the part 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 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 parametres of hole-digger, in particular, parities *b:h*, i.e. width of arrangement on a wheel and heights.

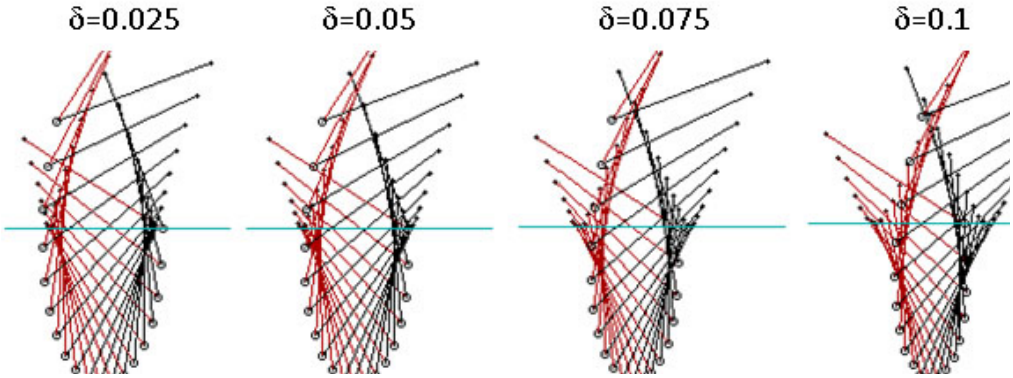



Figure-3. Changing the profile of hole depending on factor

In consideration of values *100* □ *b* □ *200* mm and *80* □ *h* □ *120* mm are defined by us, that with height increase of hole-digger (figure 3), exactly both depth of hole and its longitudinal width are enlarge. The top part, of hole at the big height of hole-digger have available almost vertically and danger of its collapse enlarges.

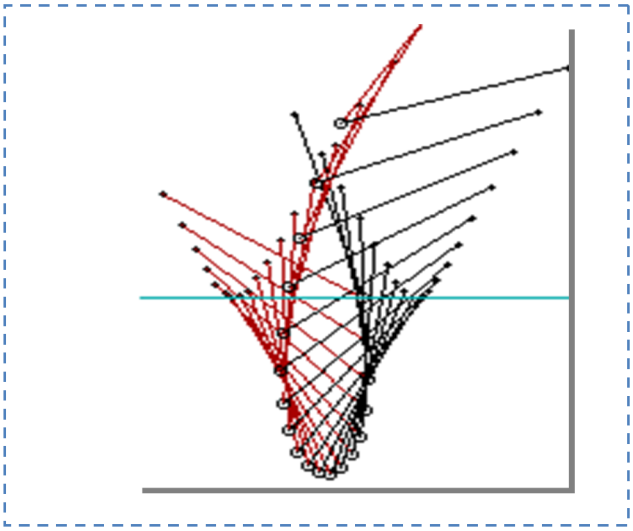


Figure - 4. The rational profile of hole

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 *h=80 ... 100* mm [18].

The table Coordinate of characteristic points hole-digger from a corner □

| φ, degree | XB, mm | ZB,mm | XC ,mm | ZC,mm | XD, mm | ZD, 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**

At increase width of installation of hole-digger *b,* danger of destruction of a back wall hole all decreases, as the edge hole at an exit from hole practically does not touch the generated back

wall of hole. Besides the front surface of hole-digger becomes active, that it is not observed at small size *b*.

It since the middle of process of formation a hole comes into effect and carries out consolidation of a front wall of hole. That is important, it happens while hole-digger wheel starts to slide.

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## МУЛЬЧАЛАУШЫ МАШИНА ШҰҢҚЫР ЖАСАУШЫСЫНЫҢ СЫРҒАНАУ МҮМКІНДІГІ БОЛҒАН ЖАҒДАЙДА ТОПЫРАҚПЕН БЕТТЕСУІН ЗЕРТТЕУ

Мақалада полиэтилендік үлдірдің көк өністі өндіруде мульча ретінде қолданылуы қарастырылған. Мульчалаушы үлдірдің артықшылығы көрсетілген. Ұсынылған көк өніс көшетін отырғызушы және мульчалаушы агрегаттың технологиялық сұлбасы мен жұмысы келтірілген. Агрегаттың құрылысын авторлары патентпен бекіткен. Агрегаттың шұңқыр жасаушы дөңгелегінің параметрлерін негіздеу үшін теңдеу құрылған. Шұңқыр жасаушы дөңгелегінің траекториясын жазатын теңдеу алынған.

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## ИССЛЕДОВАНИЕ ВЗАИМОДЕЙСТВИЕ ЛУНКООБРАЗОВАТЕЛЯ МУЛЬЧИРУЮЩЕЙ МАШИНЫ С ПОЧВОЙ ПРИ ЕГО ВОЗМОЖНЫМ ПРИКАТЫВАНИЙ

В статье рассмотрена необходимость применения полиэтиленовой пленки в качестве мульчи при производстве овощных культур. Описаны преимущества мульчирующей пленки. Представлена технологическая схема и работа предлагаемого рассадопосадочного и мульчирующего агрегата для посадки рассады овощей, конструкция которого патентована авторами. Для обоснования параметров лункообразовательного колеса агрегата составлено уравнение. Получена зависимость описывающей траекторию лункообразовательного колеса.