UDK 631.33.024.3 ***DOI 10.52578/2305-9397-2023-2-3-70-77***
IRSTI 68.85.29, 55.57.33

Isenov K. G., Ph.D., Senior Lecturer, **the main author**, https://orcid.org/0000-0002-5193-9646
JSC «Kazakh Agrotechnical Research University named after S. Seifullin», Astana, 62 Zhenis avenue, 010011, Kazakhstan, isenov-kz@mail.ru
Iskakova Sh. G., senior lecturer https://orcid.org/0000-0002-7715-357X
JSC «Zhangir khan West Kazakhstan Agrarian Technical University» Uralsk, Zhangir khan 51, 090009, Kazakhstan, shynar_iskakova@mail.ru
Makhasheva S. S., master of technical sciences, lecturer https://orcid.org/0000-0002-2369-6579
NAO «West Kazakhstan Agrarian and Technical University named after Zhangir Khan» Uralsk, st. Zhangir khan 51, 090009, Kazakhstan, simbat.salimovna@mail.ru
Kubasheva Zh. K., Candidate of Technical Sciences, associate professor https://orcid.org/0000-0002-4712-492X
JSC «Zhangir khan West Kazakhstan Agrarian Technical University» Uralsk, Zhangir khan 51, 090009, Kazakhstan, kubashevazhanna@mail.ru
Sarsenov A. E., PhD, associate professor https://orcid.org/0000-0002-0265-0141 JSC «Zhangir khan West Kazakhstan Agrarian Technical University» Uralsk, Zhangir khan 51, 090009, Kazakhstan, sarsenov_1966@mail.ru

GEOMETRIC CLAMPING PLATE DIMENSIONS OF THE IMPROVED OF GRAIN SEEDER COULTER SZ-3,6

ANNOTATION

The article notes that the improvement of operating tools of sowing machines is a solution to one of the many tasks of increasing crop yields. It is also noted that a two-disc coulter and its inherent advantages and disadvantages have been widely used on sowing machines, and the final sowing operation is considered the most important for seeds, since it creates conditions for their germination and further development.

Significant factors affecting the germination and development of plants after sowing with seeders equipped with disc coulters are given, one of which is the tight contact of seeds with the bottom groove with a loose surface layer.

The scheme for improving a two-disc coulter with pressure plate installed in the inter-disc space is proposed, and the details of the coulters are maximally unified with the coulters of grain seeders of the type SZ-3.6, mass-produced by domestic manufacturers. The pressure plate, moving together with the coulter, crushes small soil lumps with the inclined part and pushes the seeds into the bottom groove with a horizontal shank, ensuring their tight contact with the soil. A method for determining the main geometric parameters of the pressure plate depending on external forces acting from the soil is proposed, the dependence of the characteristics of the cross-section of the plate on the geometric dimension is given.

Key words: *two - disc coulter, pressure plate, cross section, moment of inertia, moment of resistance*

Introduction. The improvement of operating tools of sowing machines and technological processes is a solution to one of the many tasks of increasing crop yields [1, 2, 3]. Sowing is one of the important and responsible operations in the cultivation of agricultural crops. Sowing of agricultural crops is carried out by special machines – the seeding [1, 2, 3, 4 p. 68-71].

For seeding have a set of similar operating device designed to perform certain functions, the main of them are: a grain box, a seeding apparatus, seed ducts, sealing operating devices – coulters and corkscrews.

The final operation of sowing is the formation of a groove, laying seeds in the groove, closing them from above with loose soil. It is the final operation that is considered the most important for seeds; it creates favorable conditions for their germination, further development of plants and obtaining a high yield.

Based on the available types of coulter designs, many different sealing of operating tools and seed sealing technologies have been developed and investigated.

At sowing machines, the two-disc coulter was widely used, which is installed on seeders SZ-5,4, SZ-3,6 and their modifications, as well as sowing complexes of foreign manufacturers: 5100 («Case International», USA); 8000 («John Deer», USA); End Wheel («Great Plains», USA); TC-4 («Hestair», UK); 40 DJ 150 («Ross», Czech Republic) and others [1].

It should be noted the advantages and disadvantages inherent in the two-disc coulter: ability to work on soils clogged with plant residues and its main advantage, and the disadvantage of uneven sealing seeds in depth, etc. and the fact that this coulter does not seal the bottom groove [1, 2, 5-12].

Many researchers cite the following reasons for the uneven embedding of seed material into the soil with two-disc coulter: the capture of seeds by rotating discs with their ejection outside the coulter into the upper layers of the soil; the capture of seed material by the soil discarded by coulters; the shedding of groove, as a result of which the seeds reflected from the bottom groove fall into the upper layers of the soil. The small supporting surface of the two-disc coulter does not provide sufficient sealing of the bottom of the groove.

In order to ensure soil compaction in the furrow, many seeders are equipped with rolling of rollers, which are installed behind the coulters. After soil is rolled over seed material, the furrow is heavily compacted, which increases the intensity of moisture evaporation from such soil, and the seed material is not provided with sufficient oxygen. A number of researchers have identified these circumstances [1, 2, 5-12].

In this regard, to ensure an increase in crop yields and the effectiveness of the use of two-disc coulter is an urgent task. The simplest and most effective is the equipping of coulters with spring elastic elements that ensure the contact of the sown seeds with the soil and the uniformity of their location in the groove depth.

Based on the analysis of existing technologies for embedding seeds in the soil, means of mechanization of sowing, patent funds, technological process of sowing is proposed, which includes the formation of groove in the soil with a compacted bottom with simultaneous laying and pressing of seed material into the bottom of the groove, as well as the closure of seed material from above with loose soil.

For implementation of the proposed technology, we have developed the sealing of operating tools – coulters (patents of the Republic of Kazakhstan № 30296, № 30401 and RF № 2435356 [13-15]). Details of the coulters are maximally unified with the coulters of grain seeders of the type SZ-3,6, the mass-produced by domestic manufacturers [1, 13-21].

Materials and methods of research. In the design of the improved disc coulter [1, 13-15], the pressure plate is provided, which ensures the formation of denser seedbed. It is located between disks 1 (figure 1) behind the seed guide and compresses the seedbed with simultaneous pressing of seeds into the bottom of groove. At the same time, the density of the upper loose soil layer does not change. Combining of the groove bottom causes an influx of moisture and nutrients to the seeds and increases their germination. The loose top layer above the seeds in the groove does not allow moisture to evaporate, and provides air flow to the seeds, which gives beneficial effect on their germination.

The pressure plate is installed in the inter-disk space with possibility of elastic deformation under the resistance of soil lumps force action to destruction and does not interfere with the rotation of the disks. The width b of the working part of the plate in contact with the soil deforming it is determined in accordance with design parameters of the coulter: radius R or diameter D, angle between disks γ and angle α, determining the location of vanishing point disks (picture 1).

The pressure plate is made of main spring-spring steel 65G according to GOST 14959-79, characterized by increased wear resistance and relatively low cost. According to [1, 13-15], it is made concave in the form of beam equal resistance, the upper part is attached to the parallel seed guide with forward tilt. The inclined section – deformer 3 (figure 1) – pressure plate 2 is equipped with horizontal shank 4.

So that the pressure plate slides down to the groove bottom, excluding the unloading of soil in front of it, and push the seeds into the soil with horizontal shank, ensuring uniform distribution of seeds in depth and compacted environment around them, angle of inclination of the deformer ψ relative to the bottom groove should be less than the angle of friction φ soil about the material of pressure plate, i.e. $\psi < \varphi$.

The geometric shape of the pressure plate determines its location on the coulter. The width of the elements of pressure plate depends on the place of its attachment and the width of groove formed by the coulter during operation. In the serial coulter, wipers are installed at the attachment point of pressure plate to prevent soil sticking. The width of the upper part of pressure plate – handle– b_p.

The width of the groove b formed by two-disc coulter with the angle of the disks γ, in the lowest part – point A (figure 1).

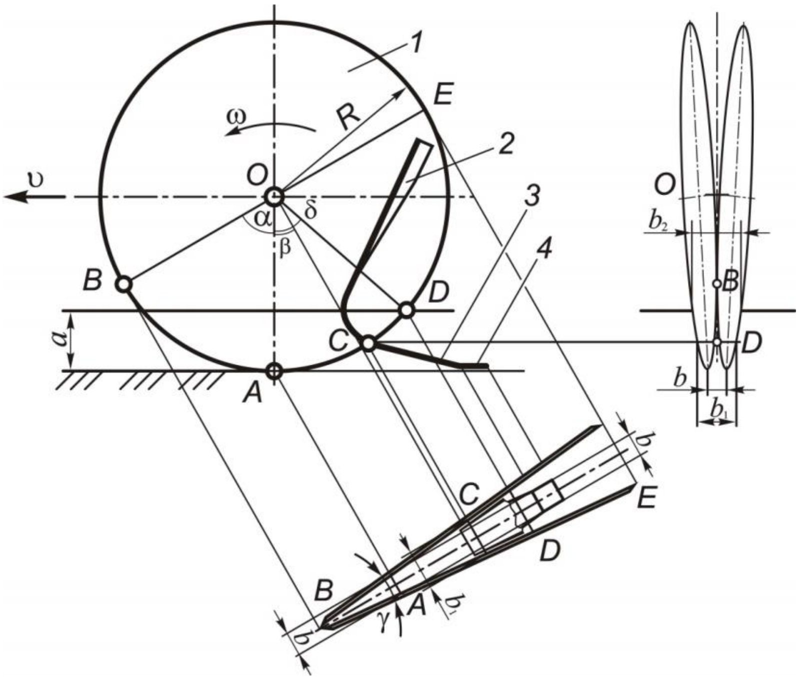


Figure 1 – Diagram of the disc coulter with pressure plate:
1 – discs, 2 – pressure plate, 3 – deformer, 4 – shank

$$b = 2R(1-\cos\alpha)\sin\frac{\gamma}{2}, \tag{1}$$

where R - radius of the disks; α -the angle determining and location of the point B, the descent of disks; γ -the angle between disks. Taking into account the gaps Δb between coulter part and discs

$$b = 2R(1-\cos\alpha)\sin\frac{\gamma}{2} + \Delta b$$

The dimension b determines the width of a shank 4 of the pressure plate (figure 1).

The distance between the discs b_1 at the level of pressure plate output from the dimensions of the discs - at point C

$$b_1 = 2R\left[1-\cos(\alpha+\beta)\right]\cdot\sin\frac{\gamma}{2} \tag{2}$$

The greatest distance between the disks b_2 at the level of the field surface at the stroke depth is equal to a

$$b_2 = 2R[1 - \cos(\alpha + \delta)] \cdot \sin\frac{\gamma}{2} \tag{3}$$

where

$$\delta = \arccos\frac{R - \alpha}{R} \tag{4}$$

For creation of compacted seedbed at the seeding depth with the density of the soil skeleton of the furrow bottom ρ, the pressure p and the angle of external friction of steel and soil $\varphi \geq \psi$ are necessary. Length l of the straight inclined section of the pressure plate– deformer – depends on the values of the angles β and ψ and the depth a'

$$l = \frac{a'}{\sin\psi} \tag{5}$$

Results of the study. For determining the geometric parameters of the plate from the strength conditions, it is necessary to conduct a force analysis. The pressure plate is a cantilevered curved beam loaded with forces: $F_{н}$ – resistance of the loosened soil layer to deformation by inclined element of the pressure plate (figure 2, *a*), $F_{тн}$ – friction of the inclined part on the deformable layer, $F_{х}$ – resistance to the indentation of seeds and soil mass around seeds at the bottom of furrow with horizontal shank, $F_{тх}$ – friction of shank on the soil. At the point of A fastening the pressure plate, the reaction R_A and the reactive moment m_A are applied. The forces acting on the plate in the dangerous section of beam cause compression stresses σ_c and bending $\sigma_и$. The compression stress in the dangerous section of plate is relatively small in comparison with the bending stress. In this regard, the prevailing bending stress from the action of total bending moment to external forces acting on the elements of the plate is determined.

If you take that the resistance to crumpling of soil lumps by inclined part of the plate is proportional to the amount of deformation, then the plot of normal soil pressures on the plate deformer will have the shape of a triangle (figure 2, *b*). The maximum value of soil pressure p at the point K of the transition of inclined part to the shank

$$p = qa',$$

where q – the volumetric crumpling coefficient of soil (proportionality coefficient), H/mm, a' – the thickness of soil layer crushed by inclined part of the plate,mm.

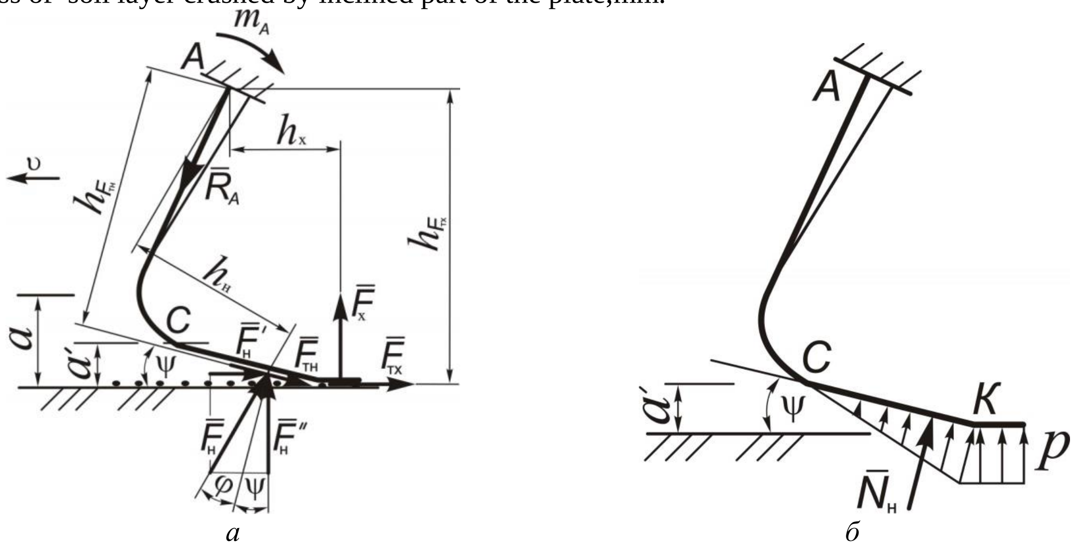


Figure 2 – Forces acting on the pressure plate:
a – general scheme of forces, *b* – soil pressure plate

The cross section of pressure plate in the upper concave part – the attachment point – the form of a circular ring sector with radius: r – circumscribed circle (figure 3), r_1 – the inscribed circle, the central angle α and the coordinates x and y center of gravity O.

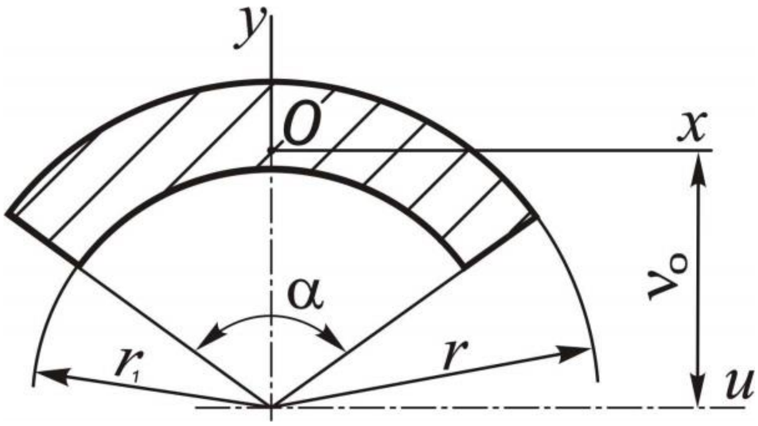


Figure 3 – Calculation scheme for determining the moment of inertia of the plate section pressure: v_O – the distance from the center of circumscribed and inscribed circles to the center of gravity; u – the circumscribed and inscribed circles center

Distance ν_0 from the center of circumscribed and inscribed circles to the center of gravity [1], mm.

$$\nu_0 = \frac{4r^3 - r_1^3 180°}{3r^2 - r_1^2 \pi\alpha°} \sin\frac{\alpha}{2} \tag{6}$$

The moment of inertia to the center circles, mm^4.

$$J_u = \frac{r^4 - r_1^4}{8}\left(\pi\frac{\alpha°}{180°} + \sin\alpha\right) \tag{7}$$

The moment of inertia to the relational axis x, mm^4.

$$J_x = J_u - A\nu_o^2, \tag{8}$$

where A- cross-section area, mm^2.

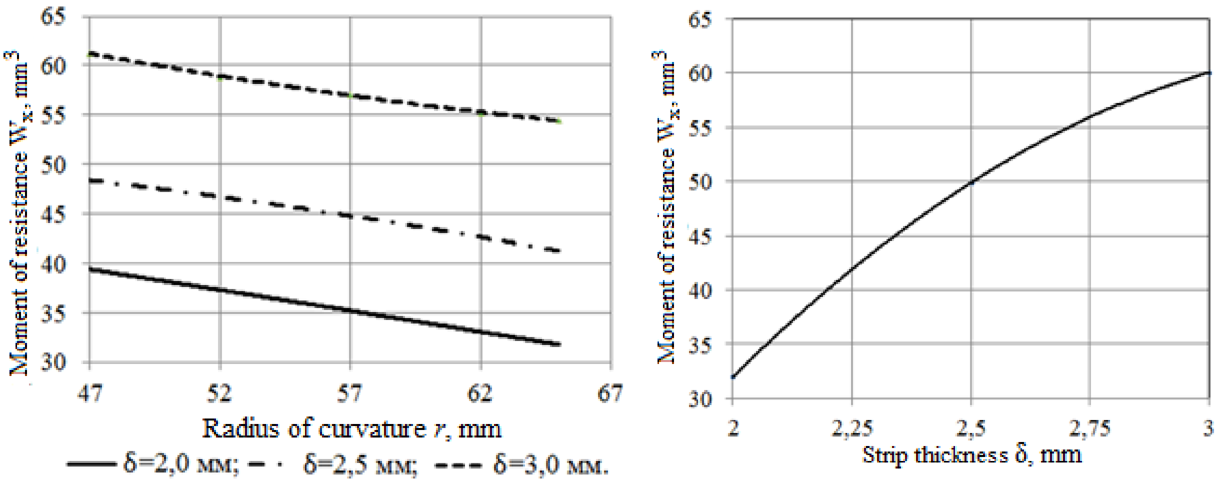
The moment of resistance to the relational axis x, mm^3.

$$W_x = \sqrt{\frac{J_x}{r - \nu_o}}. \tag{9}$$

The required moment of resistance W_x is determined by the values of the bending moment $M_и$ and the allowable bending stress $[\sigma_и]$

$$W_x = \frac{M_и}{[\sigma_и]}.$$

For a pressure plate made of the same thickness along the entire length, the dependences of the moment of resistance of the dangerous section to bending from the radius *r* (figure 4, *a*) and the thickness δ (figure 4, *b*) are determined.



a *b*

Figure 4 – Dependence of the plate section modulus on geometric parameters:
a – radius of curvature r, *b* – thickness δ

Conclusion. The presented expressions and dependencies will allow to determine the geometric parameters of the pressure plate installed in the interstitial space of the most common coulters of grain seeders with dimensions: $D = 350$ *mm*, $\alpha = 50 - 60$ °, $\gamma = 10 - 12$ °.

REFERENCES

1 Sarsenov, A.E. Mekhaniko-tekhnologicheskie osnovy povysheniya effektivnosti diskovyh soshnikov [Tekst]: monografiya / A.E. Sarsenov, I.M. Pavlov // - Ural'sk: Izd-vo Zap-Kaz agrar-tekhn. un-ta im. ZHangir hana, 2020. – 166 s

2 Bokov D.V. Sovershenstvovanie tekhnologii zadelki semyan v pochvu i obosnovanie konstrukcii zadelyvayushchego rabochego organa [Tekst]: dis. ... kand. tekhn. nauk : 05.20.01 : zashchishchena 28.10.04. : utv. 10. 04. 05 / Bokov Dmitrij Vladislavovich. – Saratov, 2004. – 171s.

3 Peretyat'ko, A. V. Sovershenstvovanie tekhnologii raspredeleniya semyan pri podpochvenno-razbrosnom sposobe poseva i obosnovanie konstrukci lapovogo soshnika [Tekst] : dis. ... kand. tekhn. nauk : 05.20.01 : zashchishchena 26.04.07. : utv. 02. 10.07 / Peretyat'ko Andrej Vladimirovich. – Saratov, 2007. – 187 s.

4 Vysochkina, L. I. Tekhnologiya mekhanizirovannyh rabot v sel'skom hozyajstve [Tekst] / L. I. Vysochkina [i dr.]. — SPb. : Lan', 2020. — 288 s.

5 Nuralin, B. Study of Combined Tool Tiller Modes Intended for Graded Tillage [Text] / B. Nuralin [and etc.] // FME Transactions, 2021 - №49 (2). – R. 463–471.

6 Nuralin, B. The working part of a reversible plough: design and experiments [Text] /

B. Nuralin [and etc.] // Acta Agriculturae Scandinavica Section B: Soil and Plant Science, 2020. – №70(8). – R. 679–685.

7 Sarauskis, E. Effect of different design coulters on seedbed hardness [Text] / E. Sarauskis [and etc.] // 12th International Scientific Conference «Engineering for rural development». – Jelgava, 2013. – R. 79-84.

8 Borresen, T. The effect of straw management and reduced tillage on soil properties and crop yields of spring-sown cereals on two loam soils in Norway [Text] / T. Børresen // Soil and Tillage Research, 1999. - №51. – P. 91-102.

9 Sarauskis, E. Influence of soil hardness on traction force of different design coulters [Text] / E. Sarauskis [and etc.] // Engineering for Rural Developments, 2013. - №1 – R. 85-92.

10 Orhan, N. The effects of using coulter attached to the subsoiler on performance characteristics. Dipkazanda keski demiri kullanımının performans karakteristiklerine etkisi [Text] / N. Orhan, T. Korucu, A. Dizibüyük // Tarim Bilimleri Dergisi, 2014.- №20(3).- R. 317-330.

11 Hemmat, A. Use of an instrumented disc coulter for mapping soil mechanical resistance [Text] / A. Hemmat, V. Adamchuk, P. Jasa // Soil and Tillage Research, 2008. - №98(2).- R.150-163

12 Ranta, O. Study regarding the forces that occurs in a no-till technology process in relation with geometrical parameters of the coulter discs [Text] / O. Ranta [and etc.] // Bulletin UASVM, Agriculture. – 2008. -Vol.65- №1. – R. 223-228.

13 Pat. 2435356 Rossijskaya Federaciya, MPK A 01 S 7/20. Soshnik [Tekst] / Ivzhenko S.A., Peretyat'ko A.V., Sarsenov A.E.; zayavitel' i patentoobladatel' Saratovskij GAU. - №2010125627/13; zayavl. 22.06.10; opubl. 10.12.11, Byul. №34 – 4 s.

14 Pat. № 30296 Respublika Kazahstan, MPK A 01 S 7/20. Soshnik [Tekst] / Sarsenov A.E., Pavlov I.M., Peretyat'ko A.V., Muhamedzhanov V.H., Braliev M.K.; zayavitel' i patentoobladatel' ZKATU im.ZHangir hana. - № 2014/1714.1; zayavl. 18.11.14; opubl. 15.09.15, Byul. №9 – 5 s.

15 Pat. № 30401 Respublika Kazahstan, MPK A 01 S 7/20. Soshnik [Tekst] / Sarsenov A.E., Pavlov I.M., Peretyat'ko A.V., Muhamedzhanov V.H., Braliev M.K.; zayavitel' i patentoobladatel' ZKATU im.ZHangir hana. - № 2014/1714.1; zayavl. 18.11.14; opubl. 15.10.15, Byul. №10 – 5 s.

16 Pavlov, I. M. Soshnik [Tekst] / I. M. Pavlov, A. V. Peretyat'ko, A. E. Sarsenov // Mekhanizaciya i elektrifikaciya sel'skogo hozyajstva, - 2016. – № 4. – S. 28-29.

17 Sarsenov, A.E. Auyl şaruaşylyk dakyldaryn sebude SZ – 3,6 dan sepkışının japartylğan ekя dяskяlя sяnяrgяşя [Matяn] / A. E. Sarsenov, Я. M. Pavlov // Ғylym jane bяlяm.- 2019.- №3 (56) – B. 319-324.

18 Sarsenov, A. E. Dяskяlя sяnяrgяşterdя jetяldяru arkyly SZ-3,6 dan sepkяştяñ paidalanu tяımdяlяgяn arttyru [Matяn] / A. E. Sarsenov, J. K. Kubaşeva, A. S. Яbraev, Я. M. Pavlov // Ғylym jane bяlяm, – 2022. – №2-2. – B. 130-140.

19 Sarsenov, A. E. Sovershenstvovanie tekhnologicheskogo processa poseva sel'skohozyajstvennyh kul'tur [Tekst] / A. E. Sarsenov, ZH. K. Kubasheva, S. G Hajrullina, A. S Ibraev, G. N. Utepov // Nauka i obrazovanie, - 2022. - № 3-2 –S. 209-221.

20 Sarsenov, A.E., Issledovanie koefficientov treniya razlichnyh tipov trushchihsya poverhnostej soshnika [Tekst] / A. E. Sarsenov, ZH. K. Kubasheva, S. G. Hajrullina, A. S. Ibraev, B. U. Bektasov // Nauka i obrazovanie, - 2022. - № 4-3. S. 146-156.

21 Pavlov, I.M. Tekhnologiya zadelki semyan v pochvu usovershenstvovannym rabochim organom zernovoj seyalki / I. M. Pavlov, A. E. Sarsenov, ZH. K. Kubasheva // Novosti nauki Kazahstana. – 2020. – №1. S. 188-192.

ТҮЙІН

Мақалада сепкіш машиналарының жұмыс органдарын жетілдіру ауылшаруашылық дақылдарының өнімділігін арттырудың көптеген міндеттерінің бірі болып табылатындығы атап өтілді. Сондай-ақ, сепкіш машиналарында екі дискілі сіңіргіш кеңінен қолданатындығы және оған тән артықшылықтар мен кемшіліктер атап өтілді, ал соңғы себу операциясы тұқымдар үшін ең маңызды болып саналады, өйткені бұл олардың көктеуі мен одан әрі дамуына жағдай жасайды.

Дискілі сіңіргіштермен жабдықталған сепкіштермен себілгеннен кейін көктеуі мен дамуына әсер ететін маңызды факторлар келтірілген, олардың бірі борпылдақ беткі қабаты бар тұқымның қарық түбімен тығыз байланысы.

Екі дискілі сіңіргішті диск аралық кеңістікте орнатылған қысқыш пластинасымен жетілдіру сұлбасы ұсынылған, ал сіңіргіштің бөлшектері отандық өндірушілер сериялық шығаратын СЗ-3,6 типті дән сепкіштердің сіңіргіштерімен максималды үйлесімді. Қысқыш пластина, сініргіш пен бірге қозғала отырып, көлбеу бөлігімен топырақтың ұсақ түйіршіктерін ұсақтайды және көлденең құйрықшасымен тұқымдарды қарық түбіне итеріп, олардың топырақпен тығыз байланысын қамтамасыз етеді. Топырақ жағынан әсер ететін сыртқы күштерге байланысты қысқыш пластинасының негізгі геометриялық параметрлерін анықтау әдістемесі ұсынылған, пластинаның көлденең қимасының сипаттамаларының геометриялық өлшемдерге тәуелділігі келтірілген.

РЕЗЮМЕ

В статье отмечено, что совершенствование рабочих органов посевных машин является решением одной из многих задач по повышению урожайности сельскохозяйственных культур. Также отмечено, что на посевных машинах широкое рапространение получил в применении двухдисковый сошник и присущему к нему преимуществами и недостатками, а заключительная операция посева считается наиболее важной для семян, так как она создаёт условия для их прорастания и дальнейшего развития.

Приведены значимые факторы, влияющие на прорастание и развитие растений после посева сеялками оборудованные дисковыми сошниками, одним из которых является плотный контакт семян с дном бороздки при рыхлом поверхностном слое.

Предложена схема усовершенствования двухдискового сошника прижимной пластиной, установленной в междисковом пространстве, а детали сошников максимально унифицированы с сошниками зерновых сеялок типа СЗ-3,6, выпускаемых серийно отечественными производителями. Прижимная пластина, перемещаясь вместе с сошником, наклонной частью сминает мелкие почвенные комочки и горизонтальным хвостовиком вдавливает семена в дно бороздки, обеспечивая их плотный контакт с почвой. Предложена методика определения основных геометрических параметров прижимной пластины в зависимости от внешних сил, действующих со стороны почвы, приведены зависимости характеристик поперечного сечения пластины от геометрических размеров.

УДК 631.171:636.034 ***DOI 10.52578/2305-9397-2023-2-3-77-86***
МРНТИ 68.85.15

Джапарова Д.А., кандидат технических наук, (РФ), **основной автор,** https://orcid.org/0000-0001-7023-7300
НАО «Западно-Казахстанский аграрно-технический университет имени Жангир хана». г. Уральск, ул. Жангир хана 51, 090009, Казахстан, dinara_jra@mail.ru
Ербаев Е.Т., доктор PhD, и.о. доцента, руководитель высшей школы «Электротехника и автоматика», https://orcid.org/0000-0002-3186-9994
НАО«Западно-Казахстанский аграрно-технический университет имени Жангир хана». г. Уральск, ул. Жангир хана 51, 090009, Казахстан, erbol.erbaev@mail.ru
Утемисова Н. Е., магистр технических наук, https://orcid.org/0000-003-2921-6086
НАО «Западно-Казахстанский аграрно-технический университет имени Жангир хана». г. Уральск, ул. Жангир хана 51, 090009, Казахстан, nyrchi@mail.ru
Буранова Н.Г., магистр технических наук https://orcid.org/0000-0003-0440-5948
ЧВПОУ «Западно-Казахстанский инновационно-технологический университет». г. Уральск, ул. Ихсанова 44/1, 090009, Казахстан, nurslu_1986@mail.ru
Басирова А. Б., магистр технических наук, https://orcid.org/0000-003-2004-6818
НАО «Западно-Казахстанский аграрно-технический университет имени Жангир хана». г. Уральск, ул. Жангир хана 51, 090009, Казахстан, a.bassirova@mail.ru
Сахипова Ш. Б., магистр технических наук, https://orcid.org/0000-003-3970-2993
НАО «Западно-Казахстанский аграрно-технический университет имени Жангир хана». г. Уральск, ул. Жангир хана 51, 090009, Казахстан, sahipova-shynar@mail.ru

Japarova D. A., candidate of technical sciences, **the main author**, https://orcid.org/0000-0001-7023-7300
NJSC «West Kazakhstan Agrarian and Technical University named after Zhangir khan», Uralsk, st. Zhangir khan 51, 090009, Kazakhstan, dinara_jra@mail.ru
Yerbayev Y. T., Doctor PhD, acting associate professor, Head of the Higher School «Electrical Engineering and Automation», https://orcid.org/0000-0002-3186-9994
NJSC «West Kazakhstan Agrarian and Technical University named after Zhangir khan», Uralsk, st. Zhangir khan 51, 090009, Kazakhstan, erbol.erbaev@mail.ru
Utemisova N. E., master of technical sciences,https://orcid.org/0000-003-2921-6086 NJSC «West