The study of the working body of a ridge seeder in laboratory settings

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Abstract. The authors consider the design of a ridge seeder in the article, the practical implementation of which will allow the machine and tractor unit to perform pre-sowing cultivation for one pass, sowing seeds in a moist soil on a compacted bed, form a soil ridge of a required size over the seeds and roll it on three sides, finally forming the soil crest with a required size and density. The authors have also substantiated the design features and operation parameters of the working bodies of the ridge seeder.

1 Introduction

The initial element of any cultivation technology of row crops is the preparation of the topsoil of required quality to ensure satisfactory conditions for seed germination and the subsequent development of cultivated plants. Mechanized tillage should not destroy the optimal soil structure when implementing these measures, but it should conserve its soil fertility, protect the soil from erosion processes and retain moisture as much as possible [1, 2, 3, 4, 5, 6, 7, 8, 9, 10].

The use of agricultural machines of higher technical and technological levels is one of the important requirements for the successful implementation of the ridge cultivation technology of row crops, making it possible to radically change the traditional technologies of tillage and seeding.

Having analyzed the existing technologies of pre-sowing tillage and ridge sowing of row crops, one can make a conclusion that when sowing, the soil ridges are formed by various technical means with active and passive working bodies, in particular, with flat discs. However, the problem of high-quality formation of soil ridges by flat discs is not sufficiently studied and solved, therefore, it is necessary to substantiate the optimal design and operating parameters of a new ridge seeder equipped with such working bodies.

2 The study objects and research methods

To carry out the ridge method of sowing row crops [11] under real production conditions, a ridge seeder was developed [12], that at the same time performs pre-sowing cultivation, sows seeds in a wet soil layer on a compacted bed, forming a soil hillock of the required

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size over the seeds, rolling the soil hillock from three sides and provides the final formation of the soil ridge of the required size and density.

A coulter, two working bodies with flat discs and a roller-ridge former are mounted on each section (Fig. 1) of the ridge seeder.

Fig. 1. The seeder gang: 1 - parallelogram mechanism; 2 - ridge; 3 - support wheel; 4 - coulter; 5, 6 - working bodies with right and left flat discs; 7 - roller-ridge former

The formation of a soil hillock over the sown seeds is carried out by the working bodies of the ridge seeder with flat discs. The working bodies are set and mounted in such a way that the flat discs at a sharp angle are directed towards the movement of the seeder, and the lower points of the flat discs and the cutting edges of the wings of A blades are located in the same horizontal plane.

3 Research results

When the ridge seeder moves, the coulter raises the layer of soil 2...3 cm thick and moves it to the right and left sides, forming a moist compacted bed on which the seeds are laid. The working parts that follow, also lift the soil by the wings of A blades and the right and left flat discs throw it away from the space between the rows toward the longitudinal axis of symmetry of the ridge (on sown seeds). When the soil falls at an angle of natural slope γ over the sown seeds, a hillock of the soil is formed, and the roller-ridge former mounted behind the working bodies of the seeder gang compacts the hillock of the soil from three sides and finally forms the ridge of the soil.

The geometric dimensions of the soil hillock depend on the diameter d of flat discs, their angle of attack, the depth h of their movement in the soil, and the speed of movement v of the ridge seeder.

Laboratory studies were performed in the tillage bin with the soil moisture of 19...23 % with flat disks of 0.2; 0.25; 0.3 and 0.35 m in diameter. The depth of the movement of working bodies with flat disks was 0.06 m, since it is specified in the agrotechnical requirements for pre-seeding cultivation. As a result of exploratory experiments, the ranges of variation of the main independent factors of the soil hillock formation process were determined: the speed of movement of the seeder gang with working bodies was changed from 1.2 to 2.4 m/s with an interval of 0.4 m/s; the angle of attack of flat discs to the direction of movement of the gang - from 5 to 30° with an interval of 5°.

When the soil is moved from the inter-row spacing to the sown seeds, flat discs should provide the required dimensions of the soil hillock for its subsequent high density compaction. Therefore, as an optimization criterion, we have adopted the coefficient of

compliance with the $k_{сэ}$, standard, which allows one to characterize the quality of the formed hillock of the soil from the position of conformity with its profile, specified in the agrotechnical requirements.

The ratio of compliance with the standard can be expressed by the following dependence:

$$k_{сэ} = 1 - \left| \frac{S_{эт} - S_{ф}}{S_{эт}} \right|, \quad (1)$$

where $S_{эт}$ – the cross-sectional area of the standard soil hillock, the dimensions of which are given in the agrotechnical requirements for sowing, м^2; $S_{ф}$ – the cross-sectional area of the soil hillock formed after the pass of the working bodies, m^2.

After conducting the experiments and processing their results with the help of the Statistica-6 computer program, we obtained mathematical models of the process of forming the soil hillock in natural values of factors.

The equation of the response surface from the interaction of the speed of movement v of the unit and the angle of attack α of flat disks with a diameter of 0.2; 0.25; 0.3 and 0.35 m has the following form (equations 2, 3, 4 and 5, respectively):

$$k_{сэ} = 0{,}0994 + 0{,}1358\ v + 0{,}0527\ \alpha - 0{,}0558\ v^2 - 0{,}0002\ v\ \alpha - 0{,}0011\ \alpha^2, \quad (2)$$

$$k_{сэ} = -\ 0{,}655 + 1{,}2591\ v + 0{,}0568\ \alpha - 0{,}2724\ v^2 - 0{,}021\ v\ \alpha - 0{,}0006\ \alpha^2, \quad (3)$$

$$k_{сэ} = -\ 0{,}7615 + 1{,}4606\ v + 0{,}041\ \alpha - 0{,}34\ v^2 - 0{,}0146\ v\ \alpha - 0{,}0005\ \alpha^2, \quad (4)$$

$$k_{сэ} = 0{,}1922 + 0{,}5632\ v + 0{,}0212\ \alpha - 0{,}1635\ v^2 + 0{,}0005\ v\ \alpha - 0{,}0005\ \alpha^2, \quad (5)$$

where $k_{сэ}$ – the coefficient of compliance with the standard; v – the speed of movement of the unit, m/s; α – the angle of attack of each flat disc, degrees.

The coordinates of the extreme point were determined with the differentiation of equations (2-5) at which the maximum value of the optimization parameter is reached:

from equation (2): v = 1,2 m/s and α = 24 degrees, $k_{сэ}$ = 0,81.

from equation (3): v = 1,5 m/s and α = 21 degrees, $k_{сэ}$ = 0,89.

from equation (4): v = 1,85 m/s and α = 14 degrees, $k_{сэ}$ = 0,87.

from equation (5): v = 1,76 m/s and α = 22 degrees, $k_{сэ}$ = 0,92.

From the calculations given it follows that the maximum value of the coefficient of compliance with the standard $k_{сэ}$ = 0,92 is achieved at a speed of movement of the ridge seeder of 1.76 m/s and angles of attack α = 22 degrees of flat discs with a diameter of 0.35 m. The response surface corresponding to equation (5) is shown in Fig. 2.

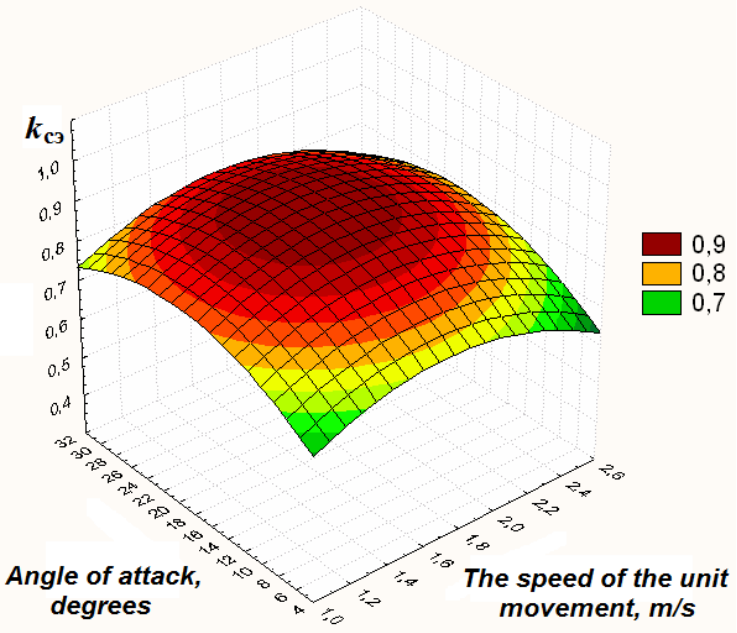

Fig. 2. Response surface from the interaction of the speed of the ridge seeder and the angle of attack of flat discs

The studies of a ridge seeder under production conditions showed that with optimal parameters identified in the course of laboratory experiments, the soil ridge is formed within the required dimensions, and the density of the soil in the ridge was 1090...1260 kg/m^3, which corresponds to the ones that are specified in the agrotechnical requirements, and large values related to the soil were at the base of the ridge, and the smaller ones were at its top. The specified density values fully comply with agrotechnical requirements. The height of the ridge ranged from 6...8 cm, the width of the upper base of the soil ridge - 8...11 cm, the width of the lower base of the soil ridge - 30...35 cm.

4 Conclusions

Thus, to achieve the maximum value of the coefficient of compliance with the standard $k_{сэ}$ = 0,92 when forming a soil hillock, it is necessary to choose flat discs with a diameter of 0.35 m, to ensure that the unit moves at a speed of 1.76 m/s (6.34 km/h) which corresponds to agrotechnical requirements of sowing row crops (6...8 km/h), and mount them to the direction of movement of the unit at an angle α = 22 degrees.

References

1. Kurdyumov, V.I. Energy-saving means of mechanization of comb cultivation of row crops / V.I. Kurdyumov, E.S. Zykin // Bulletin of the Ulyanovsk State Agricultural Academy. - 2013. - № 1 (21). - pp.144-149.
2. Milyutkin, V.A. The highly efficient unit for in-soil fertilizer application xtender with cultivator Cenius – TX (Amazonen-Werke, JSC «Evrotekhnika») technology No-Till, Mini-Till and the Crest-Ridge /V.C. Milyutkin, V.E. Buksman // In the collection of works: Agri-environmental aspects of sustainable development of the agro-industrial

complex. Proceedings of the XIV International Scientific Conference, 2017. - pp. 488-493.

3. Milyutkin, V.A. Possibilities of increasing farmland productivity with moisture-saving technologies using high-efficiency AMAZONEN-WERKE equipment / V.A. Milyutkin, A.P. Tsirulev // Proceedings of the International scientific conference: The current state and prospects for the development of the agro-industrial complex. - Kurgan State Agricultural Academy named after T.S. Maltsev, 2016. - pp. 220-224.
4. Milyutkin, V.A. Energy-resource-moisture-saving technologies in agriculture and recommended machines / V.A. Milyutkin, S.A. Tolpekin, V.V. Orlov // Proceedings of the International Scientific Conference: Strategic Guidelines for the Innovative Development of the AIC under current economic conditions. - Volgograd: Volgograd State Agrarian University, 2016. - pp. 232-236.
5. Milyutkin, V.A. "Strip-Till" - energy-resource-moisture-saving technology of soil preparation for row crops / V.A. Milyutkin, V.V. Orlov // Proceedings of the VII International Scientific Conference: Agrarian science and education at the present stage of development: experience, problems and ways to solve them. - Ulyanovsk: Ulyanovsk State Agricultural Academy named after P.A. Stolypin, 2016. - pp. 259-264.
6. Milyutkin, V.A. Soil-protecting agricultural technologies and equipment for the cultivation of agricultural crops / V.A. Milyutkin, N.V. Dolgorukov // Proceedings of the Samara State Agricultural Academy. - 2014. - № 3. - pp. 37-44.
7. Soybean cultivation in the Ulyanovsk region: practical recommendations / A.V. Dozorov, A.Yu. Naumov, Yu.V. Yermoshkin, M.N. Garanin, A.V. Voronin, Yu.M. Rakhimov. - Ulyanovsk: UGSHA named after P.A.Stolypin, 2014. - p. 59.
8. Emelyanov, P.A. Theoretical and experimental studies of the disc embedding organ of a seeder: monograph / P.A. Yemelyanov, A.V. Sibirev, A.G. Aksenov. - Penza: Penza State Agricultural Academy, 2015. - p.174.
9. Sydyk D.A. Recommendation on resource-saving technologies of cultivation of cereal crops under rainfed conditions of southern Kazakhstan / D.A. Sydyk, A.D. Karabalaeva, M.A. Sydykov. - Chymkent: Ministry of Agriculture of the Republic of Kazakhstan, 2014. - 19 p.
10. Akramkhanov A. Technology of planting crops along the ridges / A. Akramkhanov // TECHNOLOGIES & BEST PRACTICES FACTSHEET (http://www.cacilm.org/articles/detail/493).
11. Patent 2265305 Russian Federation, IPC A01C7 / 00. The method of sowing row crops / V.I. Kurdyumov, E.S. Zykin; applicant and patent holder of FGOU VPO "Ulyanovsk State Agricultural Academy". - No. 2004109411/12; declare March 29, 2004; publ. 10.12.2005, Bull. No. 34.
12. Patent 2435352 Russian Federation, IPC A01C7 / 00, A01B49 / 06. Rowers / V.I. Kurdyumov, E.S. Zykin; applicant and patent holder of FSEI HPE "Ulyanovsk State Agricultural Academy". - № 2010129255/13; declare 07/14/2010; publ. 10.12.2011, Bull. No. 34.