of the soil in the cultivation of tubers. Journal of Physics: Conference Series International Conference on Applied Physics, Power and Material Science. 2019. С. 012083. DOI: 10.1088/1742-6596/1172/1/012083.

20. Ларюшин А.М. Энергосберегающие технологии и технические средства для уборки лука: дис. … докт. техн. наук: 05.20.01 / Ларюшин Андрей Михайлович. Пенза, 2010. 426 с.

of food losses in primary production: Austrian and German case studies using the example of potato harvest. *Waste Management*. 2019. 86. S. 106-113. DOI: 10.1016/j.wasman.2019.01.020.

18. Starovoytov V.I., Sizov N.A., Popov A.V., Pavlova O.A., Alakin V.M., Chernetsov N.N., Surovtsev R.A., Chernikov V.I. Mashina dlya uborki korneklubneplodov [Machine for harvesting root crops]: Patent No. 2001127724 RF, 2003. (In Rus.)

19. Starovoitova O.A., Starovoitov V.I., Manokhina A.A. The study of physical and mechanical parameters of the soil in the cultivation of tubers. Journal of Physics: Conference Series International Conference on Applied Physics, Power and Material Science. 2019. S. 012083. DOI: 10.1088/1742-6596/1172/1/012083.

20. Laryushin A.M. Energosberegayushchie tekhnologii i tekhnicheskie sredstva dlya uborki luka: dis. … dokt. tekhn. nauk: 05.20.01. Penza, 2010: 426.

Критерии авторства

Старовойтова О.А., Старовойтов В.И., Манохина А.А. выполнили теоретические исследования, на их основании провели эксперимент. Старовойтова О.А., Старовойтов В.И., Манохина А.А. имеют на статью авторские права и несут ответственность за плагиат.

Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Статья поступила 23.01.2020

Опубликована 27.04.2020

Contribution

O.A. Starovoitova, V.I. Starovoitov, A.A. Manokhina carried out the experimental work, summarized the material based on the experimental results, and wrote the manuscript. O.A. Starovoitova, V.I. Starovoitov, A.A. Manokhina have equal author's rights and bear equal responsibility for plagiarism.

Conflict of interests

The authors declare no conflict of interests regarding the publication of this paper.

The paper was received on January 23, 2020

Published 27.04.2020

ТЕХНИКА И ТЕХНОЛОГИИ АПК / FARM MACHINERY AND TECHNOLOGIES
ОРИГИНАЛЬНАЯ СТАТЬЯ / ORIGINAL PAPER
УДК 631.316.022 (470.331)
DOI: 10.26897/2687-1149-2020-2-9-16

STUDY OF SEEDBED PREPARATION WITH ROD-TYPE SOIL COMPACTION ROLLER

NIKOLAY V. ALDOSHIN, *DSc (Eng), Professor*[1]
E-mail: naldoshin@yandex.ru

ALEKSANDR S. VASILIEV, *PhD (Ag), Associate Professor*[2]
E-mail: vasilevtgsha@mail.ru

ANDREI V. KUDRYAVTSEV, *PhD (Eng), Associate Professor*[2]
E-mail: akud@tvgsha.ru

VYACHESLAV V. GOLUBEV, *DSc (Eng), Associate Professor*[2]
E-mail: slavasddg@mail.ru

ALEKSEI YU. ALIPICHEV, *PhD (Ed), Associate Professor*[1]
E-mail: al_new2003@mail.ru

[1] Russian Timiryazev State Agrarian University; 127550, Russian Federation, Moscow, Timiryazevskaya Str., 49.

[2] Tver State Agricultural Academy; 170904, Russian Federation, Tver, Marshala Vasilevskogo Str., 7.

A prerequisite for high-quality cultivation of field crops is pre-sowing leveling of the soil surface and creating an optimal soil structure. However, insufficient attention is paid to analytical studies of the influence of working surfaces of tillage machines during seedbed preparation for small-seed crops, in particular. The purpose of this work is to study the impact model of the soil compaction roller, which, while performing the main cultivation, will ensure compliance with agrotechnical requirements for sowing. The authors applied system approach for conducting analytical studies to develop a scheme of interaction of the rod-type soil compaction roller with the soil. They applied mathematical models to determine its optimal parameters and operating modes. The formalized mathematical model was used to design a rotating roller with specified parameters and operation modes. In particular, the design of a soil compaction roller-leveler was developed. The roller is a hollow drum mounted on a support frame attached to a tractor or a cultivator. The working tool rotates using closed-type bearings mounted on the axle. A hollow drum consists of disks having an arcuate cross-section with a convexity. The disks hold replaceable mesh elements, which can be changed depending on the required conditions for the coefficient of structure and alignment. Movable straps are fixed in the cavities of hollow drum disks. When performing a laboratory field experiment, the response signals were determined by instruments from the Litvinov Field Laboratory (LFL). Soil samples were taken from the surface horizon with a depth of 5…6 cm. The experiments were carried out on sod-medium podzolic sandy loam and light loamy soils in accordance with the approved method. Field tests on the use of the new tool have shown an increase in the amount of agronomically valuable fraction during seedbed preparation on sandy loam soils by 4.0%, on light loam soils by 4.2%, while ensuring an increase in the structural coefficient by 0.66 and 0.55 points, respectively.

Key words: interaction model, seedbed preparation, soil compaction roller-leveler parameters, soil compaction roller-leveler operation modes, soil properties, degree of change in soil properties.

For citation: Aldoshin N.V., Vasiliev A.S., Kudryavtsev A.V., Golubev V.V., Alipichev A.Yu. Study of seedbed preparation with rod-type soil compaction roller. Agricultural Engineering, 2020; 2 (96): 9-16. (In Eng.). DOI: 10.26897/2687-1149-2020-2-9-16.

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ ПРЕДПОСЕВНОЙ ОБРАБОТКИ ПОЧВЫ ПРУТКОВЫМ КАТКОМ

АЛДОШИН НИКОЛАЙ ВАСИЛЬЕВИЧ, *докт. техн. наук, профессор*[1]
E-mail: naldoshin@yandex.ru

ВАСИЛЬЕВ АЛЕКСАНДР СЕРГЕЕВИЧ, *канд. с.-х. наук, доцент*[2]
E-mail: vasilevtgsha@mail.ru

КУДРЯВЦЕВ АНДРЕЙ ВАСИЛЬЕВИЧ, *канд. техн. наук, доцент*[2]
E-mail: akud@tvgsha.ru

ГОЛУБЕВ ВЯЧЕСЛАВ ВИКТОРОВИЧ, *докт. техн. наук, доцент*[2]
E-mail: slavasddg@mail.ru

АЛИПИЧЕВ АЛЕКСЕЙ ЮРЬЕВИЧ, *канд. техн. наук, доцент*
E-mail: al_new2003@mail.ru

[1] Российский государственный аграрный университет – МСХА имени К.А. Тимирязева; 127550, Российская Федерация, г. Москва, ул. Тимирязевская, 49.

[2] Тверская государственная сельскохозяйственная академия; 170904, Российская Федерация, г. Тверь, ул. Маршала Василевского, 7.

Обязательным условием качественного возделывания полевых культур является предпосевное выравнивание поверхности почвы и создание оптимальной её структуры. Недостаточно уделяется внимания аналитическим исследованиям по воздействию рабочих поверхностей почвообрабатывающих машин при предпосевной подготовке почвы под мелкосеменные культуры. Целью работы является исследование модели воздействия почвообрабатывающего катка, который в совокупности с основной обработкой позволит обеспечить соответствие агротехнических требований к посеву. Аналитические исследования выполнены с применением системного подхода, в результате предложена схема взаимодействия пруткового катка с почвой, рациональные параметры и режимы работы которого описаны математическими моделями. Формализация составленной математической модели дала возможность реализовать конструкцию ротационного катка с установленными параметрами и режимами его работы. В частности, разработана конструкция почвообрабатывающего катка-выравнивателя, представляющего собой пустотелый барабан, установленный на опорной раме крепления к трактору или культиватору. Вращение рабочего органа осуществляется посредством подшипников закрытого типа, установленных на оси. Пустотелый барабан составляется из дисков, имеющих дугообразную форму сечения с выпуклостью, на которых закреплены сетчатые элементы с возможностью их замены в зависимости от требуемых условий по коэффициенту структурности и выравненности. Во впадинах дисков пустотелого барабана закреплены подвижные планки. При выполнении лабораторно-полевого эксперимента отклик определялся приборами из полевой лаборатории Литвинова (ПЛЛ). Почвенные образцы брались с поверхностного горизонта глубиной 5…6 см. Опыты проводились на дерново-среднеподзолистых супесчаных и лёгкосуглинистых почвах в соответствии с апробированной методикой. Полевые испытания нового органа при предпосевной обработке супесчаных почв показали повышение количества агрономически ценной фракции на 4,0%, лёгкосуглинистых – на 4,2%, обеспечивая при этом увеличение коэффициента структурности на 0,66 и 0,55 единиц соответственно.

Ключевые слова: модель взаимодействия, предпосевная обработка почвы, параметры выравнивателя, режимы работы выравнивателя, свойства почвы, степень изменения свойств почвы.

Формат цитирования: Алдошин Н.В., Васильев А.С., Кудрявцев А.В., Голубев В.В., Алипичев А.Ю. Результаты исследования предпосевной обработки почвы прутковым катком // Агроинженерия. 2020. № 2(96). С. 9-16. DOI: 10.26897/2687-1149-2020-2-9-16.

Introduction Technological processes associated with soil preparation for sowing small-seed crops, in particular, are considered the most important stage that affects the basic characteristics of physical, mechanical, and technological properties of the soil. High-quality performance of technological operations aimed at ensuring the required density, structural features, flatness, and ridgeness is possible only when the parameters and modes of the working tools are set in accordance with the initial state of the soil [1, 2]. Direct interaction of the working tools with the soil should be carried out taking into account agrotechnical requirements and biological characteristics of crops [3]. At the same time, one of the most important agrotechnical operations in pre-sowing tillage is soil compaction with rollers of various designs, as a rule, directly preceding the stage of interaction of the working tools of sowing machines – coulters and stubblers – with the soil, evenly distributing the sowing material at the seedbed level of the working tools and contributing to increasing the contact area of seeds with soil particles. The rational use of working tools in the conditions of the prescribed characteristics of the main tillage results and setting reasonable design parameters of the soil compaction roller provide for the required structure of the soil horizon, as well as the necessary leveling and compaction of the seedbed without increasing the erosion level [2, 4, 5]. It is an obvious fact that, despite a significant number of mass-produced domestic and foreign soil compaction tools, the development of a technological and constructive design of the working surface for structuring and leveling the soil profile still remains an urgent task.

Research purpose. Modeling the impact of the soil compaction roller on the soil surface to ensure compliance with agrotechnical requirements for sowing while performing the main soil cultivation.

Materials and methods. When developing a working tool, it is necessary to study a theoretical interaction model, taking into account the influence of a certain number of factors: the technological mode of operation, geometric parameters, shape and type of the working tool. The system approach made it possible to draw up a flowchart of the model technological operation of compacting and leveling soil layers with an appropriate structure, ensuring the necessary agrotechnical requirements for seedbed preparation for small-seed crops (Fig. 1) [1].

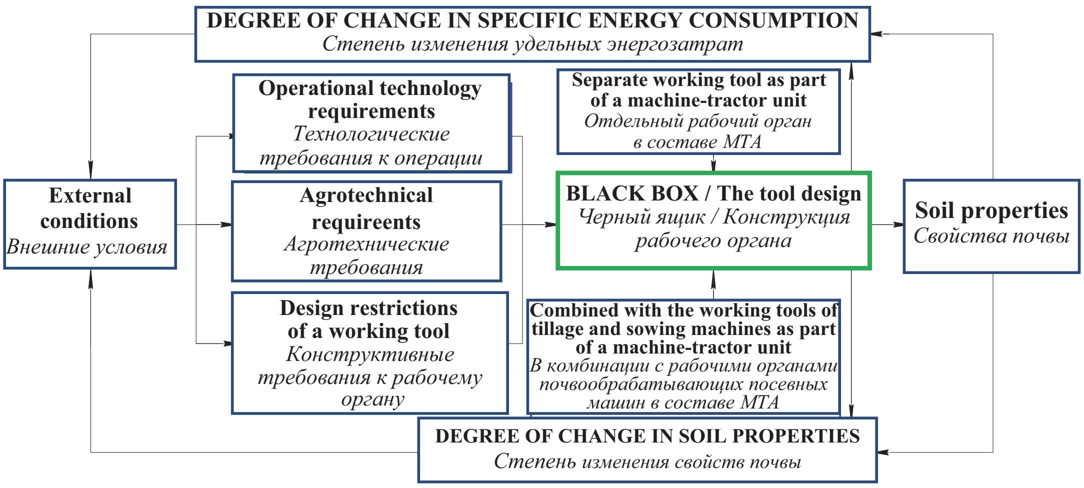

Figure 1. Flowchart of the "External environment – working tool – soil" model

Рис. 1. Блок-схема модели «Внешняя среда – рабочий орган – почва»

External conditions under consideration include soil and climatic characteristics, performed technological operations, the level of the selected cultivation technology. The agricultural requirements should include the conditions for technological operations for seedbed preparation [3], taking into account the biological characteristics of cultivated crops.

When forming a set of technological requirements, it is necessary to make a leveled layer with the optimal structure of the surface soil horizon, in accordance with modern technologies and agricultural practices of seedbed preparation, by determining the sequence of technological processes, taking into account soil and climatic conditions expressed by physicomechanical and technological properties of the soil (PMTP) [5, 6].

Design limitations include the type and shape of the working surface, as well as the basic geometric parameters (length, width, operating angle) and the working tool modes (speed, distributed load, vibration amplitude), taking account of optimal specific energy and metal consumption values [7].

The formalized flowchart in the form of mathematical models of the system based on subsystems is expressed by analytical regression dependences and databases obtained taking into account the agrotechnical requirements for the degree of change in the soil horizon characteristics – combing, evenness, relative humidity, density, hardness, lumpiness, and structure coefficient.

The surface of the soil horizon as an object of treatment has the corresponding initial PMTP characteristics of the soil [8]. Consequently, the main task of the impact of the working tool of an optimal shape and geometric parameters, as well as operating modes, is to ensure a qualitative change in the characteristics of the initial soil conditions, in accordance with the agrotechnical requirements for seedbed preparation.

The analysis of the compiled flowchart of the interaction of the working tool with the soil indicated the need to identify the missing mathematical models in the form of theoretical or regression data.

The obtained regression dependences of the variation degree of agrophysical and technological properties of the soil on the influence of working tools in laboratory and field conditions [9] provides for algorithm-based designing and automated functioning of the working tool when preparing the seedbed for various sowing methods [10]. Further establishing of a database of missing indicators will allow for taking into account a wide range of initial soil properties, ranging from the restoration of fallow lands to old arable farmlands. The rationale for the optimal parameters and modes of the working tool for seedbed preparation is provided in the design algorithm.

Based on earlier laboratory and field studies conducted in 2017-2019 [10], it was established that the structure of the soil profile and soil characteristics should correspond to the following requirements (Fig. 2).

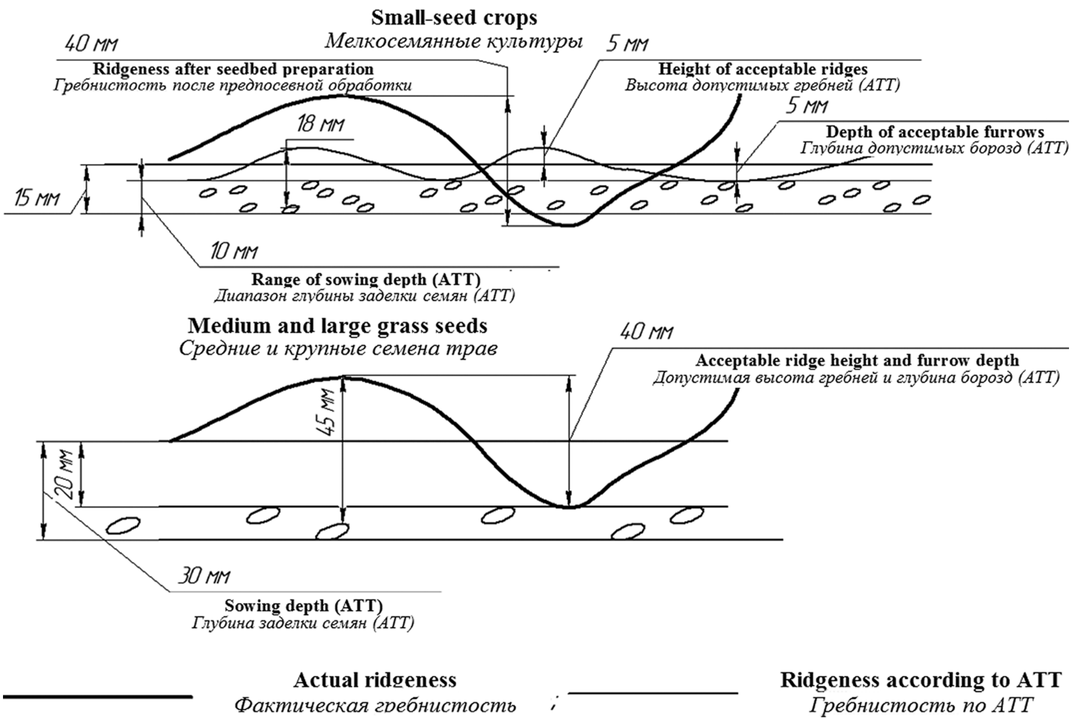

Figure 2. Required soil profile structure in the pre-sowing period

Рис. 2. Требуемое строение почвенного профиля в предпосевной период

When implemented in seedbed preparation for small-seed crops, this method of designing and manufacturing the working tool brings both soil refining rollers and elements of other tillage machines into the production environment.

Results and discussion. The main task of seedbed preparation is to provide the necessary conditions for the growth and development of agricultural crops, which is determined by the favorable combination of physico-mechanical and technological properties of the soil. The most important characteristics of the surface soil horizon include density, structural features, flatness, and ridgeness. The analysis of scientific, technical and patent-licensed literature failed to offer an unambiguous solution on the surface shape of the working unit used for presowing tillage to form the necessary conditions for sowing small-seed field crops. The working tool designed by researchers of Tver State Agricultural Academy in collaboration with their colleagues from Russian Timiryazev State Agrarian University taking into account the requirements for computer-aided design systems [11], includes a number of simple structural elements (Fig. 3).

The design of the soil compaction roller-leveler includes hollow drum 1 mounted on support frame 5 attached to a tractor or a cultivator. The working tool is rotated by means of closed-type bearings mounted on axle 2. Hollow drum 1 consists of disks having an arcuate cross-sectional shape with a convexity. The disks hold fixed mesh elements 3, which can be changed depending on the required conditions for the coefficient of structural properties and alignment. Movable straps 4 are fixed in the disk cavities of hollow drum 1.

The proposed design of a rotary soil leveler can be implemented in various tillage machines, including those used for primary and secondary tillage. The developed design provides for the improved quality of surface tillage due to the simultaneous deformation of large soil peds, compacting and leveling the cultivated field surface horizon in accordance with agricultural requirements.

To study the influence of the factors of the leveling roller on the quality of the seedbed preparation before sowing, full-factor experiment FFE3[2] was carried out [12].

The results of experimental and reconnaissance studies in laboratory and field conditions have shown that the following factors have a significant impact on the degree of flatness – kinetic indicators: frame movement speed (2.3, 2.5, 2.7 m/s) and specific load (20, 40, 60 N/m), as well as geometric parameters: mesh size of the working surface, mesh pitch, the outer surface diameter of the soil compaction roller.

Having used the method of mathematical planning, we have determined two research factors (A and B). To increase the accuracy of measurements, the number of test levels is considered equal to three, the frame speed with intervals of variation – 0.7 m/s and specific load – 20 N/m. The data are entered in Table 1.

Responses in the studied model (optimization parameters) are:

ρ – soil density, g/cm^3;

R – ridgeness of the field surface, mm;

W – soil moisture, %;

K – soil lumpiness, %.

Currently, to determine the soil density, moisture, and other indicators characterizing agrophysical and technological properties, the most widely used is the method and a set of tools developed by N.A. Kachinsky [13].

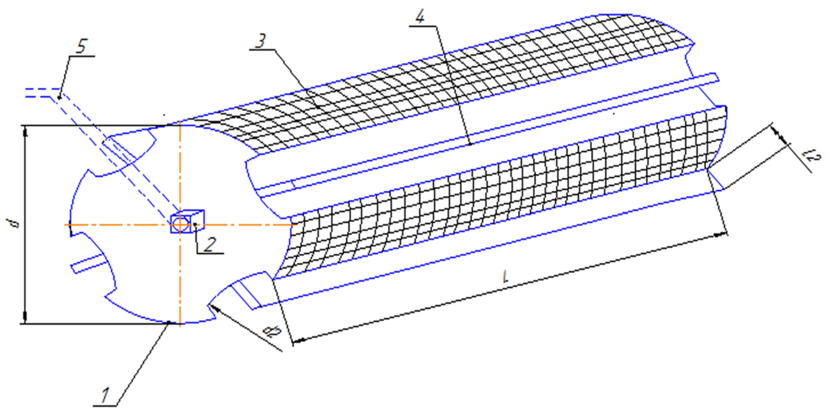

Figure 3. Schematic diagram of the rotational roller-leveler:
1 – a hollow drum; 2 – an axle; 3 – mesh elements;
4 – a flail knife (a movable level); 5 – a tractor mounting frame

Рис. 3. Схема ротационного выравнивающего органа:
1 – пустотелый барабан; 2 – ось; 3 – сетчатые элементы;
4 – бич (подвижная планка); 5 – рама крепления к трактору

Table 1

Matrix of a full-factor experiment of type 23

Таблица 1

Матрица полнофакторного эксперимента типа 23

Factors *Факторы*	**Code designation** *Кодовое обозначение*	**Unit of measurement** *Единица измерения*	**Variation levels** *Уровни варьирования*			**Variation interval** *Интервал варьирования*
			minimum *минимальный* (–1)	**average** *средний* (0)	**maximum** *максимальный* (+1)	
Specific load, A *Удельная нагрузка, A*	X1	Н/м	40	-	60	20
Translational speed, B *Поступательная скорость, B*	X2	м/с	2,0	-	2,7	0,7
Type of soil compaction roller, C *Тип катка, C*	X3	%	30	-	100	70

When performing a laboratory field experiment, the response was determined by instruments from the Litvinov Field Laboratory (LFL). Soil samples were taken from the surface horizon to no more than a depth of 5…6 cm. Measurements were retaken three times. The obtained data were statistically processed using the methodology proposed by G. Khailis and implemented in [14], as well as licensed software product Mathcad Prime – 3.0 to obtain a regression equation.

$$\rho(P,V,S) = 1,2 + 0,47VS - 0,47V - 0,85S, \quad (1)$$

where ρ – soil density, g/cm^3; P – specific load, N/m; S – impact degree of the working surface on the soil, %.

The adequacy of the compiled regression equation was verified with experimental data using the Fisher's ratio test (F test). Based on the calculations, it was found that

$$F = 1.08 < 2.78 = F(0,05;4;24), \quad (2)$$

and proceeding from which, we can conclude that the model is adequate.

In a similar way, the data on alignment, ridgeness, and lumpiness were measured to construct response surfaces (Fig. 4).

The practical application of the experimental rotary working tool was studied as part of the re-equipment of the KBM-8NU block-modular cultivator, on which the original rotary rollers were replaced by experimental working tools. The experiment was carried out on sod-mid-podzolic sandy loam and light loamy soils in accordance with the approved method [15]. In the course of research, a change in the soil structure was determined (Tab. 2).

The operation analysis of the experimental working tool has revealed the predominance of its use on sod-podzolic soils relative to the rotor roller, used in the conventional layout scheme of the modular block cultivator. The use of a new tool has increased the amount of agronomically valuable fraction during seedbed preparation on sandy loam soils by 4.0%, on light loamy soils by 4.2%, while increasing the structural coefficient by 0.66 and 0.55 points, respectively.

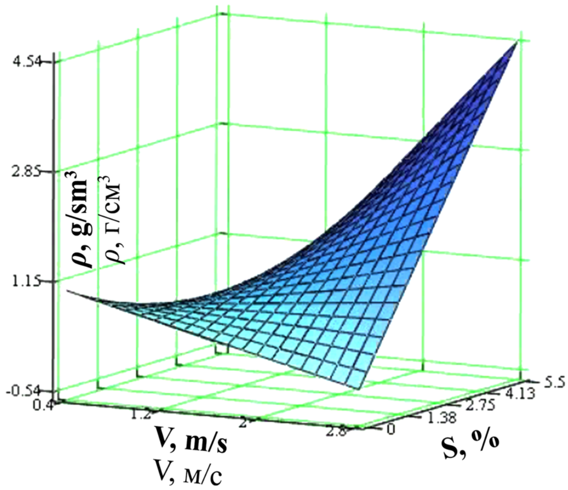

Figure 4. Response surface of density changes from the studied factors

Рис. 4. Поверхность отклика изменения плотности от исследуемых факторов

Table 2

Effect of rotary working tools on the structure of the sod-podzolic soil

Таблица 2

Влияние ротационных рабочих органов на структурно-агрегатный состав дерново-подзолистой почвы

Fractions of soil peds, mm *Фракции почвенных агрегатов, мм*	**KMB-8NU with original rotary rollers** *КМБ-8НУ с заводскими роторными катками*		**KMB-8NU with experimental rotary working tools** *КМБ-8НУ с экспериментальными ротационными рабочими органами*	
	Soil particle size distribution / *Гранулометрический состав почв*			
	sandy loam *супесчаная*	**light loam** *легкосуглинистая*	**sandy loam** *супесчаная*	**light loam** *легкосуглинистая*
<3	5.2	4.4	6.0	5.2
3…5	17.1	15.9	18.6	17.4
5…10	51.1	49.8	52.8	51.7
10…20	16.6	17.8	15.7	16.5
20…30	8.7	10.4	6.5	8.6
>30	1.3	1.7	0.4	0.6
Structural coefficient, points *Коэффициент структурности ед.*	2.76	2.34	3.42	2.89

Conclusions

As exemplified by designing a working rotary tool model, the initial parameters describing the interaction of the working tools of farm machines with soil were determined. This is necessary to determine the form and type of technical and technological characteristics of interacting surfaces. The formalization of the compiled mathematical model made it possible to implement the design of a rotary roller with the set parameters and operating modes. Field tests on the use of the new tool have shown an increase in the amount of agronomically valuable fraction during seedbed preparation on sandy loam soils by 4.0%, on light loamy soils by 4.2%, while providing an increase in the structural coefficient by 0.66 and 0.55 units, respectively.

References

1. D'yachkov A.P., Shatskiy V.P., Kolesnikov N.P. Primeneniye sistemnogo podkhoda pri issledovanii operatsionnoy tekhnologii

Библиографический список

1. Дьячков А.П., Шацкий В.П., Колесников Н.П. Применение системного подхода при исследовании операционной

i tekhnicheskikh sredstv vneseniya defekata [Application of a system approach to the study of operating technology and technical means for introducing a lime scum]. *Vestnik Voronezhskogo gosudarstvennogo agrarnogo universiteta*. 2013; 1: 101-109. (In Rus.)

2. Shishlov S.A. Povysheniye effektivnosti predposevnoy podgotovki pochvy i poseva soi v usloviyakh Primorskogo kraya [Improving the efficiency of seedbed preparation and soybean sowing in the Primorsky Krai]: Self-review of DSc (Eng) thesis. Blagoveshchensk, 2016: 42. (In Rus.)

3. Artyushin A.A., Kovalov M.M., Ushchapovskiy I.V. Iskhodnyye trebovaniya na tekhnologiyu vozdelyvaniya l'na – dolguntsa s uchotom printsipov tochnogo zemledeliya [Initial requirements for fiber flax cultivation technology taking into account the principles of precision farming]. Tver': FGBNU VNIIML, 2011: 16. (In Rus.)

4. Shapar', M.S. Sovershenstvovaniye protsessa prikatyvaniya pochvy pod soyu vibrokatkom v usloviyakh Primorskogo kraya [Improving soil rolling for soybean cultivation with a vibratory roller in the Primorsky Krai]: PhD (Eng) thesis. Ussuriysk, 2015: 155. (In Rus.)

5. Golubev V.V., Safonov V.V. Issledovaniye deformatsii pochvy pod deystviyem trubchatogo katka [Study of soil deformation under the action of a tubular roller]. *Vestnik of Moscow Goryachkin Agroengineering University*. 2006; 5: 85-86. (In Rus.)

6. Golubev V.V., Firsov A.S. Obosnovaniye posledovatel'nosti tekhnologicheskikh operatsiy pri poseve l'na-dolguntsa [Rationale for the sequence of technological operations for sowing fiber flax]. *Vestnik NGIEI*. 2015; 2: 24-28. (In Rus.)

7. Nikiforov M.V., Golubev V.V., Kudryavtsev A.V. Analiz konstruktivnykh osobennostey rabochikh organov dlya vyravnivaniya pochvy pri poseve melkosemennykh kul'tur [Analyzing the design features of working tools for soil leveling when sowing small-seed crops]. *Konkurentosposobnost' i innovatsionnaya aktivnost' APK regionov. Sbornik nauch. tr. po mater. nauch.-prakt. konf. Febrauary 6-8, 2018*. Tver': TGSKHA. 200-203. (In Rus.)

8. Panov I.M., Vetokhin V.I. Fizicheskiye osnovy mekhaniki pochv [Physical foundations of soil mechanics]. Kiyev: Feniks, 2008: 267. (In Rus.)

9. Morozov P.V., Andreyev A.N., Golubev V.V. Metodika provedeniya laboratornogo eksperimenta rotatsionnogo vyravnivayushchego organa [Methodology for conducting a laboratory experiment of a rotating leveling tool]. *Innovatsionnyye podkhody k razvitiyu nauki i proizvodstva regionov. Sb. nauch. tr. po mater. Natsion. nauch.-tekhn. konf. Tver'*: Tverskaya GSKHA. 2019: 238-242. (In Rus.)

10. Nikiforov M.V., Golubev V.V. Opredeleniye kriteriya kachestva predposevnoy obrabotki pochvy pri ispol'zovanii razlichnykh pochvoobrabatyvayushchikh mashin [Determination of the quality criterion for pre-sowing tillage when using various tillage machines]. *Vestnik of Moscow Goryachkin Agroengineering University*. 2018; 3: 11-16. (In Rus.)

11. Bakhadir Mirzaev, Farmon Mamatov, Nikolay Aldoshin, Mansur Amonov Anti-erosion two-stage tillage by ripper. *Proceeding of 7th International Conference on Trends in Agricultural Engineering 2019 – Czech University of Life Sciences Prague – Faculty of Engineering*. 391-395. (In English)

12. Aldoshin N.V., Ismailov I.I. Razrabotka tekhnologii podgotovki pochvy k posevu bakhchevykh kul'tur [Developing seedbed preparation technology for sowing gourds]. *Vestnik of Moscow Goryachkin Agroengineering University*. 6 (88); 2018: 17-23. (In Rus.)

технологии и технических средств внесения дефеката // Вестник Воронежского государственного аграрного университета. 2013. № 1. С. 101-109.

2. Шишлов С.А. Повышение эффективности предпосевной подготовки почвы и посева сои в условиях Приморского края: автореф. дис. … д-ра. техн. наук. Благовещенск, 2016. 42 с.

3. Артюшин А.А., Ковалёв М.М., Ущаповский И.В. Исходные требования на технологию возделывания льна-долгунца с учётом принципов точного земледелия. Тверь: ФГБНУ ВНИИМЛ, 2011. 16 с.

4. Шапарь М.С. Совершенствование процесса прикатывания почвы под сою виброкатком в условиях Приморского края: дис. … канд. техн. наук. Уссурийск, 2015. 155 с.

5. Голубев В.В., Сафонов В.В. Исследование деформации почвы под действием трубчатого катка // Вестник ФГОУ ВПО «МГАУ имени В.П. Горячкина». 2006. № 5. С. 85-86.

6. Голубев В.В., Фирсов А.С. Обоснование последовательности технологических операций при посеве льна-долгунца // Вестник НГИЭИ. 2015. № 2. С. 24-28.

7. Никифоров М.В., Голубев В.В., Кудрявцев А.В. Анализ конструктивных особенностей рабочих органов для выравнивания почвы при посеве мелкосеменных культур // Конкурентоспособность и инновационная активность АПК регионов: Сб. науч. тр. по матер. науч.-практ. конф. 6-8 февраля 2018 г. Тверь: ТГСХА. С. 200-203.

8. Панов И.М., Ветохин В.И. Физические основы механики почв. Киев: Феникс, 2008. 267 с.

9. Морозов П.В., Андреев А.Н., Голубев В.В. Методика проведения лабораторного эксперимента ротационного выравнивающего органа // Инновационные подходы к развитию науки и производства регионов: Сб. науч. тр. по матер. Национ. науч.-техн. конференции. Тверь: Тверская ГСХА. 2019. С. 238-242.

10. Никифоров М.В., Голубев В.В. Определение критерия качества предпосевной обработки почвы при использовании различных почвообрабатывающих машин // Вестник ФГБОУ ВПО «МГАУ имени В.П. Горячкина». 2018. № 6. С. 11-16. DOI 10.26897/1728-7936-2018-6-11-16

11. Bakhadir Mirzaev, Farmon Mamatov, Nikolay Aldoshin, Mansur Amonov. Anti-erosion two-stage tillage by ripper // Proceeding of 7th International Conference on Trends in Agricultural Engineering 2019 – Czech University of Life Sciences Prague – Faculty of Engineering, p. 391-395. ISBN978-80-213-2953-9.

12. Алдошин Н.В., Исмаилов И.И. Разработка технологии подготовки почвы к посеву бахчевых культур // Вестник ФГБОУ ВПО «МГАУ имени В.П. Горячкина». 2018. № 6(88). С. 17-23. DOI 10.26897/1728-7936-2018-6-17-23

13. Доспехов Б.А. Методика проведения полевого опыта. М.: Агропромиздат, 1985. 352 с.

14. Мазиров М.А., Шеин Е.В., Корчагин А.А. и др. Полевые исследования свойств почв. Владимир: Изд-во ВлГУ. 2012. 72 с.

15. Доспехов Б.А., Васильев И.П., Туликов А.М. Практикум по земледелию. М.: КолосС, 1987. 383 с.

13. Dospekhov B.A. Metodika provedeniya polevogo opyta [Field experiment methodology]. Moscow, Agropromizdat, 1985: 352. (In Rus.)

14. Mazirov M.A., Shein Ye.V., Korchagin A.A. et al. Polevyye issledovaniya svoystv pochv [Field studies of soil properties]. Vladimir: Izd-vo VlGU. 2012: 72. (In Rus.)

15. Dospekhov B.A., Vasil'yev I.P., Tulikov A.M. Praktikum po zemledeliyu [Practical training guide on soil cultivation]. Moscow, KolosS, 1987: 383. (In Rus.)

Критерии авторства

Алдошин Н.В., Васильев А.С., Кудрявцев А.В., Голубев В.В., Алипичев А.Ю. выполнили теоретические исследования, на основании полученных результатов провели обобщение и написали рукопись. Алдошин Н.В., Васильев А.С., Кудрявцев А.В., Голубев В.В., Алипичев А.Ю. имеют на статью авторские права и несут ответственность за плагиат.

Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Статья поступила 21.01.2020

Опубликована 27.04.2020

Contribution

N.V. Aldoshin, A.S. Vasiliev, A.V. Kudryavtsev, V.V. Golubev, A. Yu. Alipichev performed theoretical studies, and based on the results obtained, generalized the results and wrote a manuscript. N.V. Aldoshin, A.S. Vasiliev, A.V. Kudryavtsev, V.V. Golubev, A. Yu. Alipichev have equal author's rights and bear equal responsibility for plagiarism.

Conflict of interests

The authors declare no conflict of interests regarding the publication of this paper.

The paper was received on January 21, 2020

Published 27.04.2020

ТЕХНИКА И ТЕХНОЛОГИИ АПК / FARM MACHINERY AND TECHNOLOGIES
ОРИГИНАЛЬНАЯ СТАТЬЯ / ORIGINAL PAPER
УДК 621.928.13
DOI: 10.26897/2687-1149-2020-2-16-22

РАЗРАБОТКА АВТОМАТИЗИРОВАННОЙ ЛИНИИ ПОСЛЕУБОРОЧНОЙ ОБРАБОТКИ КАРТОФЕЛЯ ДЛЯ ХОЗЯЙСТВ НАСЕЛЕНИЯ

ДОРОХОВ АЛЕКСЕЙ СЕМЕНОВИЧ, *докт. техн. наук, член-корреспондент РАН, профессор*
МОСЯКОВ МАКСИМ АЛЕКСАНДРОВИЧ, *канд. техн. наук, старший научный сотрудник*
E-mail: Maks.Mosyakov@yandex.ru

САЗОНОВ НИКОЛАЙ ВИКТОРОВИЧ, *аспирант*
E-mail: Sazonov_Nikolay@mail.ru

Федеральный научный агроинженерный центр ВИМ (ФГБНУ ФНАЦ ВИМ), 109428, Российская Федерация, г. Москва, 1-й Институтский проезд, дом 5.

В статье представлен результат анализа уровня производства картофеля на территории Российской Федерации. Отмечается, что по данным Росстата площади под картофелем в крестьянских (фермерских) хозяйствах и у индивидуальных предпринимателей за последние годы увеличились в 3,6 раза, а средняя урожайность в России выросла на 61,9% и составила 170,4 ц/га. Одним из сдерживающих факторов более интенсивного увеличения площадей возделывания картофеля является процесс послеуборочной обработки, на который приходится до 70% трудозатрат при ручной сортировке. Повсеместно используемые отечественные картофелесортировальные пункты КСП-15Б, КСП-15В, КСП-25 не способны обеспечить повреждение клубней картофеля в пределах агротехнических требований 1%. В Агроинженерном центре ВИМ была разработана и запатентована конструктивная схема автоматизированной линии для послеуборочной обработки клубней картофеля. Изложен принцип ее действия и технические характеристики. В программе Diagram Designer была построена принципиальная блок-схема подключения камеры высокого разрешения, позволяющей производить сканирование и съемку объектов с большей детализацией. Отмечено, что применение в хозяйствах населения автоматизированного устройства для послеуборочной обработки корнеплодов и картофеля позволит: снизить трудоёмкость работ до 85% за счёт сокращения количества обслуживающего персонала; повысить качество и точность сортирования клубней картофеля по размерному признаку в пределах 95…98%; идентифицировать материал на сортирующей поверхности с учётом внешних его повреждений и примесей перед закладкой картофеля на длительное хранение или его предпродажной подготовке, обеспечив при этом повреждения в пределах агротехнических требований.