DOI: https://doi.org/10.17816/0321-4443-568649

Original Study Article

Agrotechnical performance indicators of the asymmetric working body of a fallow cultivator

Galina G. Parkhomenko[1], Dmitry S. Podlesny[1, 2], Sergey I. Kambulov[1, 2], Igor V. Bozhko[1], Sergey V. Belousov[1, 3]

[1] Agricultural Research Center "Donskoy", Zernograd, Russian Federation;
[2] Don State Technical University, Rostov-on-Don, Russian Federation;
[3] Kuban State Agrarian University named after I.T. Trubilin, Krasnodar, Russian Federation

ABSTRACT

BACKGROUND: Obtaining sustainable and high-quality harvest is important for the production of agricultural products. It is known that up to 40–45% of all energy costs are spent on preparing the soil for sowing when cultivating agricultural crops. Surface-fallow tillage is a subtle technological process, it influences on normal distribution of the seed material in depth and, as a consequence, the further uniformity of seedlings. To ensure the process flow of pre-sowing preparation of the soil for sowing, a new asymmetric working body for a fallow cultivator was developed in the Donskoy Agrarian Scientific Center, the structural subdivision of the SKNIIMESKh, Zernograd. There is a task to conduct a comparative analysis of operation of the new working body with V-shaped sweeps when preparing the soil for sowing.

AIM: Conducting a comparative analysis of operation of a serial V-shaped sweep with the new proposed asymmetric working body of a fallow cultivator by field research in the fields of the Donskoy ANC.

METHODS: The research in the fields of Donskoy ANC was conducted according to the GOST 33687-2015 “Machines and tools for surface tillage” regional standard. Well-known statistical extrapolation methods implemented in the Microsoft Excel environment were used for data processing.

RESULTS: The optimal operating parameters of the new proposed asymmetric working body have been determined in comparison with the serial working body of a fallow cultivator.

CONCLUSIONS: According to the conducted laboratory and field studies, the parameters and operating modes of the new asymmetric working body were obtained.

Keywords: fallow cultivator; working body; crumbling quality; soil; agriculture; working width; agrotechnical requirements.

To cite this article:
Parkhomenko GG, Podlesny DS, Kambulov SI, Bozhko IV, Belousov SV. Agrotechnical performance indicators of the asymmetric working body of a fallow cultivator. *Tractors and Agricultural Machinery.* 2024;91(1):123–132. DOI: https://doi.org/10.17816/0321-4443-568649

Received: 23.08.2023 **Accepted:** 10.10.2023 **Published online:** 15.03.2024

DOI: https://doi.org/10.17816/0321-4443-568649

Оригинальное исследование

Агротехнические показатели работы асимметричного рабочего органа парового культиватора

Г.Г. Пархоменко[1], Д.С. Подлесный[1, 2], С.И. Камбулов[1, 2], И.В. Божко[1], С.В. Белоусов[1, 3]

[1] Аграрный научный центр «Донской», Зерноград, Российская Федерация;
[2] Донской государственный технический университет, Ростов-на-Дону, Российская Федерация;
[3] Кубанский государственный аграрный университет им. И.Т. Трубилина, Краснодар, Российская Федерация

АННОТАЦИЯ

Обоснование. Важным для производства продукции сельского хозяйства является получение устойчивых и качественных урожаев. Известно, что при возделывании сельскохозяйственных культур до 40–45% всех энергетических затрат приходится на подготовку почвы к посеву. Тонким технологическим процессов является поверхностная — паровая обработка почвы, именно от нее зависит нормальное распределение посевного материала по глубине и, как следствие, дальнейшая равномерность всходов. Для обеспечения протекания процесса предпосевной подготовки почвы к посеву, в «Аграрном научном центре «Донской», в структурном подразделение «СКНИИМЭСХ», г. Зерноград, был разработан новый асимметричный рабочий орган для парового культиватора. Перед нами стоит задача провести сравнительный анализ работы нового рабочего органа с серийными стрельчатыми лапами при подготовке почвы к посеву.

Цель работы — проведение сравнительного анализа работы серийной стрельчатой лапы с предлагаемым новым асимметричным рабочим органом парового культиватора путем полевых исследований на полях «АНЦ «Донской».

Методы. Исследования на полях АНЦ «Донской» проводили согласно межгосударственного стандарта ГОСТ-33687-2015 «Машины и орудия для поверхностной обработки почвы». Для обработки данных применялись известные статистические методы экстраполяции, реализованные в среде Microsoft Excel.

Результаты. Определены оптимальные режимные параметры работы предложенного нового асимметричного рабочего органа в сравнении с серийным рабочим органом парового культиватора.

Заключение. Согласно проведённым лабораторно-полевым исследованиям, получили параметры и режимы работы нового асимметричного рабочего органа.

Ключевые слова: паровой культиватор; рабочий орган; качество крошения; почва; сельское хозяйство; ширина захвата; агротехнические требования.

Как цитировать:
Пархоменко Г.Г., Подлесный Д.С., Камбулов С.И., Божко И.В., Белоусов С.В. Агротехнические показатели работы асимметричного рабочего органа парового культиватора // Тракторы и сельхозмашины. 2024. Т. 91, № 1. С. 123–132. DOI: https://doi.org/10.17816/0321-4443-568649

Рукопись получена: 23.08.2023 **Рукопись одобрена:** 10.10.2023 **Опубликована онлайн:** 15.03.2024

BACKGROUND

The advances in the new generation of agricultural technology is characterized by high productivity of the technological component when fulfilling the agrotechnical requirements for a specific method of tillage [1–12].

At Donskoy ANC, in the department of mechanization of crop production, a novel asymmetrical working body of a fallow cultivator has been developed. The new working body comprises a stand with a chisel and left- and right-handed blade cultivators installed on it sequentially (Fig. 1).

Fig. 1. New asymmetric working body of a fallow cultivator.
Рис. 1. Новый асимметричный рабочий орган парового культиватора.

The parameter of determining the effectiveness of the fallow cultivator is the quality of crumbling of soil processed by the working body of the fallow cultivator. The fallow cultivator should ensure a fine-clump structure and uniform loosening depth of the soil.

When these requirements are met, the treated area of the field is leveled, with the height of the ridges and depth of the furrows not exceeding the values that are set by considering agrotechnical requirements.

This study aimed to conduct a comparative analysis of the operation of a serial V-shaped sweep with the proposed new asymmetric working body of a fallow cultivator through field research in the fields of Donskoy ANC.

METHOD

Experimentation in the fields of Donskoy ANC was performed by conforming to the interstate standard GOST-33687-2015 “Machines and tools for surface tillage.”

Measurements of the cultivation depth are performed along the path of the rack of the new asymmetric working body of the fallow cultivator and the standard V-shaped sweep, immersing the ruler into the soil until it reaches the untreated layer. A total of 25 measurements n_{depth} were conducted for each accounting pass for cultivating the soil with the new working body of the fallow cultivator and the standard V-shaped sweep. To determine the movement stability, measurement data (current depth indicators ai) are processed by a statistical method to obtain the arithmetic mean depth value a_{av}, standard deviation σ_{depth}, and coefficient of variation ν_{depth} as follows:

$$\sigma_{depth} = \pm\sqrt{\frac{\sum_{i=1}^{n_{depth}}\left(a_i - a_{av}\right)^2}{n_{depth}-1}},$$

$$\nu_{depth} = \pm\frac{\sigma_{depth}}{a_{av}}\cdot 100\%. \qquad (1)$$

Ridgeness of the soil field characterizes the average height of unevenness on the field surface after the soil tillage with the new working body of a fallow cultivator in comparison with that of a standard V-shaped sweep.

The height of the unevenness on the field is measured using a railing and ruler in four places in the forward and reverse direction of the movement of the working bodies.

After the new working body of the fallow cultivator and the standard V-shaped sweep have passed along the working width, a railing is placed on the top of the unevenness in spots on the field chosen at random.

A ruler is applied perpendicular to the railing to measure the height of unevenness on the field surface. A minimum of 10 measurements are performed at each point.

The quality of soil crumbling (i.e., the presence of lumps in the treated layer should be less than 25 mm in size) was determined after passing the new asymmetric working body of the fallow cultivator and the standard V-shaped sweep along the working width.

The operating width of a standard V-shaped sweep is less than the size of a pallet (0.5 × 0.5 m), divided into squares with a 25 × 25 mm area. Therefore, it is applied to the treated layer to quantitatively determine lumps exceeding the size of 25 mm; the quality of soil crumbling obtained by both working bodies was determined by weight by removing a sample of the treated soil and weighing individual fractions (Fig. 2).

The quality of soil crumbling was determined by samples taken at four points with three repetitions in the forward and reverse direction of the movement of the working bodies; subsequently, a manual analysis of fractions was performed in the laboratory to isolate lumps of sizes larger than 25 mm, followed by their weighing (Fig. 3).

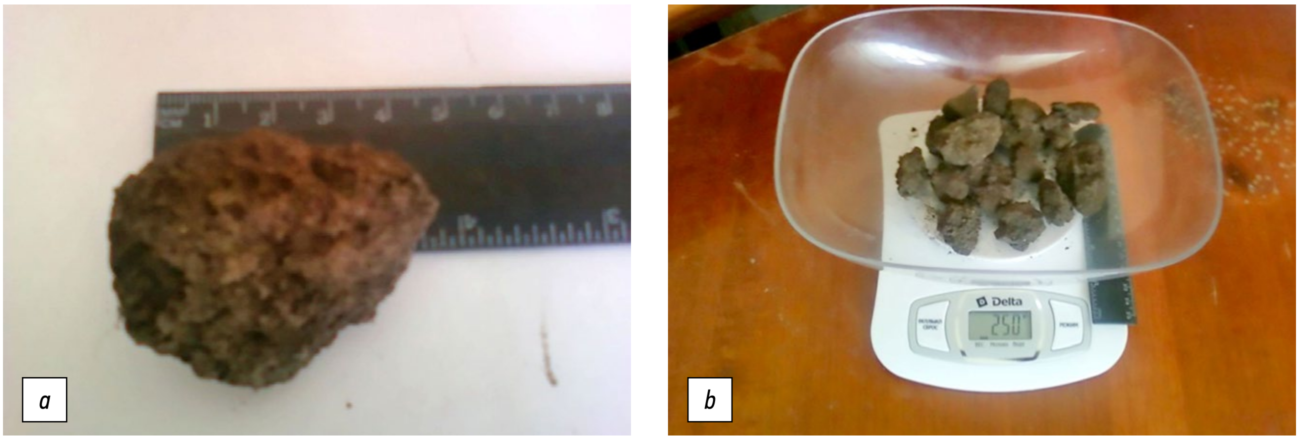

Fig. 2. Selection and weighing of lumps larger than 25 cm.
Рис. 2. Отбор и взвешивание комков, размер которых превышает 25 см.

The mass of isolated lumps m_{Σ} is determined as a percentage of the total sample mass $m_{>25\text{mm}}$ using the following equation:

$$m_{<25\text{mm}} = 100 - \frac{m_{>25\text{mm}} \cdot 100\%}{m_{\Sigma}}. \quad (2)$$

RESULTS

The results of laboratory field research and processing of the obtained data are presented in Tables 1 and 2.

The permissible deviation from the specified depth of tillage with the new working body of the fallow cultivator and the standard V-shaped sweep is ±2 cm.

The obtained data (Table 1 and Table 2) are combined in Table 3 for a comparative assessment of the stability of the stroke depth of the new working body of the fallow cultivator and the standard V-shaped sweep.

Analysis of the obtained data (Table 3) shows that the new working body of the fallow cultivator meets the agrotechnical requirements regarding the stability of the stroke depth throughout the entire speed range, since the mean-square deviation of this indicator is ±0.71–0.89 cm, which does not exceed the permissible value (±2 cm). The standard V-shaped sweep meets the agrotechnical requirements regarding the stability of stroke depth only at movement speeds up to 10.5 km/h inclusive (mean-square deviation ±0.84–2.0 cm); additionally, at the movement speed of 13.0 km/h, it does not comply with the agrotechnical requirements regarding the stability of stroke depth, since the obtained indicator value (±2.1 cm) exceeds the permissible value (±2 cm). The coefficient of variation of 15.21% and 23.30% when cultivating the soil with a standard V-shaped sweep at a movement speed of 10.5 km/h and 13.0 km/h, respectively, indicates an excessive spread relative to the average depth at a given 8 cm.

This confirms the instability of the stroke depth of a standard V-shaped sweep when operating in these modes and the unsuitability of this working body for use in high-speed tillage equipment.

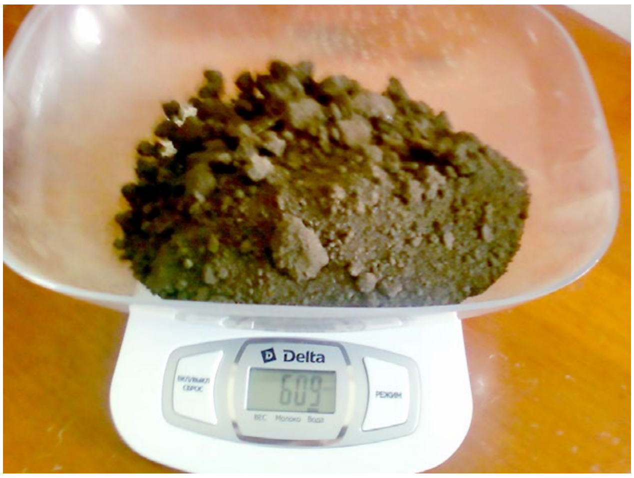

Fig. 3 Weighing of the full soil sample.
Рис. 3. Взвешивание общей пробы почвы.

The uneven depth during the movement of the working bodies affects the leveling of the field surface after tillage.

The obtained ridgeness data are presented in Table 4.

After passing the new asymmetrical working body of the fallow cultivator and the standard V-shaped sweep over the working width, according to the agrotechnical requirements for the ridgeness value of the field surface, the ridgeness value should not exceed 4 cm.

Thus, the new asymmetric working body of the fallow cultivator meets the agrotechnical requirements for the ridgeness value of the field surface after tillage (2.1–2.7 cm) and changes insignificantly (by 4%) with increasing speed.

Simultaneously the greatest ridgeness value of the field surface (on average 2.5 cm), not exceeding the permissible level (up to 4 cm), is noted at an average

Table 1. The results of the study of motion stability of the new asymmetric working body of a fallow cultivator at a tillage depth of 8 cm

Таблица 1. Результаты исследования устойчивости хода нового асимметричного рабочего органа парового культиватора при глубине обработки почвы 8 см

Indicator	Indicator value, % at driving speed, km/h		
	8,0	10,5	13,0
Average depth, cm	9,0	8,6	8,4
Mean-square deviation of depth, ±cm	0,71	0,89	0,89
Depth variation coefficient, %	7,86	10,40	10,65

Table 2. Results of the study of motion stability of a standard V-shaped sweep at a tillage depth of 8 cm

Таблица 2. Результаты исследования устойчивости хода стандартной стрельчатой лапы при глубине обработки почвы 8 см

Indicator	Indicator value, % at driving speed, km/h		
	8,0	10,5	13,0
Average depth, cm	8,8	9,2	9,0
Mean-square deviation of depth, ±cm	0,84	2,0	2,10
Depth variation coefficient, %	9,55	15,21	23,30

Table 3. The results of comparison of motion stability of a new asymmetric working body of a fallow cultivator and the standard V-shaped sweep at a tillage depth of 8 cm

Таблица 3. Результаты сравнения устойчивости хода нового асимметричного рабочего органа парового культиватора и стандартной стрельчатой лапы при глубине обработки почвы 8 см

Working body	Mean-square deviation of depth, ±cm	Depth variation coefficient, %
New asymmetric working body of the fallow cultivator	0,71–0,89	7,96–10,65
Standard V-shaped sweep	0,84–2,10	9,55–23,30

Table 4. Results of the study of ridgeness of field surface after tillage by working bodies to a depth of 8 cm

Таблица 4. Результаты исследования гребнистости поверхности поля после обработки почвы рабочими органами на глубину 8 см

Working body	Indicator value, cm, at driving speed, km/h		
	8,0	10,5	13,0
New asymmetric working body of the fallow cultivator	2,3	2,2	2,4
	2,3	2,4	2,2
	2,6	2,5	2,3
	2,1	2,7	2,6
Average	2,3	2,5	2,4
Standard V-shaped sweep	3,6	3,4	3,9
	3,5	3,4	4,1
	3,5	3,3	4,3
	3,2	3,6	4,2
Average	3,5	3,4	4,1

speed of movement (10.5 km/h); this value subsequently decreases to 2.4 cm when the movement speed increases to 13.0 km/h.

The uneven depth of tillage due to the stroke depth instability of the standard V-shaped sweep at a movement speed of 13.0 km/h caused increased ridgeness (3.9–4.2 cm), that does not meet the agrotechnical requirements for this indicator (up to 4 cm).

At a movement speed of 8.0 km/h and 10.5 km/h, the ridgeness value obtained after the passing of a standard V-shaped sweep was 3.2–3.6 cm and 3.3–3.6 cm, respectively, which is on average 1.4–1.5 times higher than that of the new working body of a fallow cultivator; however, this does not contradict the standardized agrotechnical requirements in terms of leveling the field surface.

The results of the study regarding the quality of soil crumbling and the background after the soil tillage with working bodies are presented in Table 5 and in Fig. 4.

Analysis of the obtained data (Table 5) reveals that both working bodies fulfill the agrotechnical requirements for the quality of crumbling of soil at a cultivation depth of 8 cm, since after passing through the treated soil

Table 5. Results of study of quality of soil crumbling by a new asymmetric working body of a fallow cultivator (depth 8 cm)

Таблица 5. Результаты исследования качества крошения почвы новым асимметричным рабочим органом парового культиватора (глубина 8 см)

Working body	Indicator value Lumps less than 25 mm in size, %			
	Actual movement speed, km/h			Acceptable according to agrotechnical requirements
	8,0	10,5	13,0	
New asymmetric working body of the fallow cultivator	88,9	91,3	93,2	Not less than 80%
	89,3	92,1	92,5	
	89,5	91,8	92,9	
	88,7	92,0	93,4	
Average	89,1	91,8	93,0	
Standard V-shaped sweep	86,0	87,4	85,9	
	86,8	86,5	85,7	
	86,7	87,7	86,6	
		86,7	87,0	
Average	86,6	87,1	86,3	

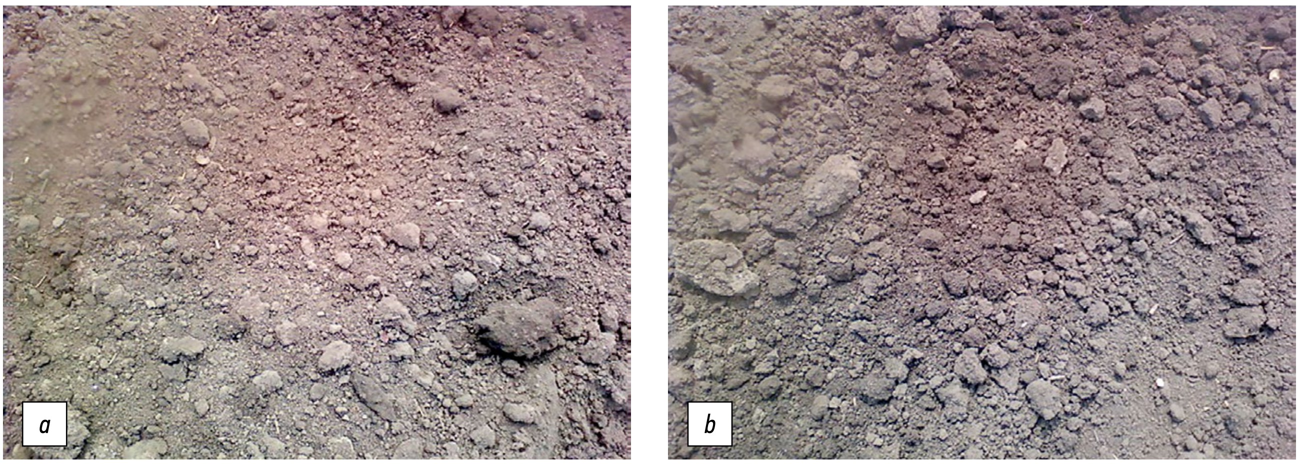

Fig. 4. Ground after tillage by working bodies: *a* — the new asymmetric working body of a fallow cultivator; *b* —the standard V-shaped sweep.

Рис. 4. Фон после обработки почвы рабочими органами: *a* — новый асимметричный рабочий орган парового культиватора; *b* — стандартная стрельчатая лапа.

layer, approximately 85.7–93.4% of lumps are less than 25 mm in size.

The new asymmetric working body of the fallow cultivator with an increase in movement speed from 8.0 km/h to 13.0 km/h ensures an increase in the quality of soil crumbling from 88.7% to 93.4%, respectively.

When a standard V-shaped sweep operates, the quality of soil crumbling is at the same level as that obtained by the new asymmetric working body of the fallow cultivator, with 85.7–87.7% of lumps less than 25 mm in size in the treated layer.

It is noteworthy that in the most effective operating mode from the standpoint of increasing productivity (at a movement speed of 13.0 km/h), the standard V-shaped sweep provides the worst quality of soil crumbling (on average 86.3%); in contrast, the new working body of the fallow cultivator provides the best quality of soil crumbling (on average 93.0%).

In general, the new asymmetric working body of the fallow cultivator provides an improvement of 2.2–7.3% on average in the quality of soil crumbling in terms of the presence of lumps of sizes less than 25 mm in the treated soil layer as compared to that of the standard V-shaped sweep.

The improvement in the quality of soil crumbling by the new working body of the fallow cultivator is due to the following: with an increase in the speed of movement, an impact interaction between the formation and the chisel forms an advanced crack in the longitudinal direction (Fig. 5), and flat sweep rippers cut the separated soil mass in the transverse direction (Fig. 6), resulting in better quality of soil crumbling.

Simultaneously, the higher the movement speed, the further the crack front propagates, which is accompanied by a greater intensity of soil crumbling by the new asymmetric working body of the fallow cultivator.

This is due to the close relationship between the amount of energy required to crumble the soil and the energy of the resulting crack, that is directly proportional to the surface tension of the lump.

The process of soil crumbling is caused by the presence of trapped air inside the layer, which is released when the balance of external forces is disturbed from the support from the untreated massif and from the influence of the working body. Simultaneously, at a shallow tillage depth, external forces from the working body acting on the formation cannot be balanced and turn into compression, tension, and shear deformations, which is accompanied by crumbling into separate lumps when the connection between them is lost.

The soil crumbling by the new asymmetrical working body of the fallow cultivator is accompanied by an increase in soil volume, that occurs when deformation occurs normal to the surfaces of destructive shear deformations. The increase in soil volume is due to a looser arrangement of the resulting lumps.

The standard V-shaped sweep does not contain a chisel; thus, impact interaction with the formation does not occur when it operates at an increased speed.

Additionally, the soil mass, under the influence of compression and shear deformations arising due to the working surface configuration of a standard V-shaped sweep, is subject to crumbling for some time, which is determined by the duration of interaction with the soil, that decreases with the increase in the movement speed.

Therefore, the higher the speed of the movement of a standard V-shaped sweep, the less time the soil is subject to crumbling, which is accompanied by a decrease in its crumbling quality.

Fig. 5. Formation of a leading crack with a chisel of the new asymmetric working body of a fallow cultivator.
Рис. 5. Формирование опережающей трещины долотом нового рабочего органа парового культиватора.

Fig. 6. Soil crumbling with flat-cut rippers of the new asymmetric working body of a fallow cultivator.
Рис. 6. Крошение почвы плоскорезными рыхлителями нового асимметричного рабочего органа парового культиватора.

DOI: https://doi.org/10.17816/0321-4443-568649

CONCLUSIONS

The operational process of the new asymmetrical working body of the fallow cultivator meets the agrotechnical requirements regarding the stability of the stroke depth throughout the entire speed range, since the mean-square deviation of this indicator is ±0.71–0.89 cm, that does not exceed the permissible value (±2 cm). The standard V-shaped sweep meets the agrotechnical requirements regarding the stability of stroke depth only at movement speeds up to 10.5 km/h inclusive (mean-square deviation ±0.84–2.0 cm); additionally, at 13.0 km/h, it does not comply with the abovementioned agrotechnical requirements, since the obtained indicator value (±2.1 cm) exceeds the permissible value (±2 cm).

The coefficients of variation of 15.21% and 23.30% when cultivating the soil with a standard V-shaped sweep at movement speeds of 10.5 km/h and 13.0 km/h, respectively, indicates an excessive spread relative to the average depth value at given 8 cm. The latter circumstance confirms the instability of the stroke depth of the standard V-shaped sweep when operating in these modes and the unsuitability of this working body for high-speed tillage equipment.

The uneven depth of tillage due to the instability of the stroke depth of the standard V-shaped sweep at a movement speed of 13.0 km/h caused an increase in the ridgeness value (3.9–4.2 cm), that does not meet the agrotechnical requirements for this indicator (up to 4 cm). At speeds of 8.0 km/h and 10.5 km/h, the ridgeness value obtained after the passing of the standard V-shaped sweep was 3.2–3.6 cm and 3.3–3.6 cm, respectively, which is on average 1.4–1.5 times higher than that obtained by the new working body of a fallow cultivator; however, these values do not contradict agrotechnical requirements in terms of leveling the field surface.

The new asymmetric working body of the fallow cultivator, with an increase in the movement speed from 8.0 km/h to 13.0 km/h, ensures an increase in the quality of soil crumbling from 88.7% to 93.4%, respectively. When the standard V-shaped sweep operates, the quality of soil crumbling is at the same level, with 85.7–87.7% of lumps with sizes less than 25 mm in the treated layer. From the standpoint of increasing productivity, in the most effective operating mode (at a speed of 13.0 km/h), the standard V-shaped sweep provides the worst quality of soil crumbling (86.3% on average); on the contrary, the new asymmetric working body of the fallow cultivator provides the best quality of soil crumbling (on average 93.0%). Thus, the new asymmetrical working body of the fallow cultivator provides an improvement in the quality of soil crumbling by 2.2–7.3% on average in terms of the presence of lumps of sizes less than 25 mm in the treated soil layer as compared to that obtained by the standard V-shaped sweep.

ADDITIONAL INFORMATION

Authors' contribution. S.I. Kambulov — research management, conceptualization, methodology, project administration; G.G. Parkhomenko — formal analysis, conducting research, writing the draft of the manuscript, visualization; D.S. Podlesny — formal analysis, conducting research, writing the draft of the manuscript, visualization; I.V. Bozhko — conducting research, writing the draft of the manuscript; S.V. Belousov — formal analysis, conducting research, writing the draft of the manuscript, writing and editing the final version of the manuscript. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

Competing interests. The authors declare that they have no competing interests.

Funding source. This study was not supported by any external sources of funding.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. С.И. Камбулов — руководство исследованием, концептуализация, методология, администрирование проекта; Г.Г. Пархоменко — формальный анализ, проведение исследования, создание черновика рукописи, визуализации; Д.С. Подлесный — формальный анализ, проведение исследования, создание черновика рукописи, визуализация; И.В. Божко — проведение исследования, создание черновика рукописи; С.В. Белоусов — формальный анализ, проведение исследования, создание черновика рукописи, создание окончательной версии (доработка) рукописи и ее редактирование. Авторы подтверждают соответствие своего авторства международным критериям *ICMJE* (все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией).

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с проведенным исследованием и публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования и подготовке публикации.

REFERENCES

1. Sándor Zs, Tállai M, Kincses I, et al. Effect of various soil cultivation methods on some microbial soil properties. *DRC Sustainable Future.* 2020;1(1):14–20. doi: 10.37281/DRCSF/1.1.3

2. Parkhomenko GG, Parkhomenko SG. Environmentally safe operation of technical means in conditions of physical soil degradation. *Tekhnicheskiy servis mashin.* 2019;2(135):40–46. (In Russ). EDN: WSZBHC

3. Couvreur V, Vanderborght J, Draye X, et al. Dynamic aspects of soil water availability for isohydric plants: Focus on root hydraulic resistances. *Water Resources Research.* 2014;50(11):8891–8906. doi: 10.1002/2014WR015608

4. Parkhomenko SG, Parkhomenko GG. Method for structural modeling of systems for automatic regulation of operating modes of soil-cultivating units. *Trudy GOSNITI.* 2017;126:55–61. (In Russ). EDN: YLPRPR

5. Bluett C, Tullberg JN, McPhee JE, et al. Soil and Tillage Research: Why still focus on soil compaction? *Journal of CO_2 Utilization.* 2019;33:201–214. doi: 10.1016/j.still.2019.05.028

6. Parkhomenko GG, Parkhomenko SG. Reduced soil compaction during grain production. *Khranenie i pererabotka zerna.* 2017;2(210):20–24. (In Russ). EDN: QZWYWZ

7. Colombiabc T, Torresd LC, Walterc A, et al. Feedbacks between soil penetration resistance, root architecture and water uptake limit water accessibility and crop growth — a vicious circle. *Science of The Total Environment.* 2018;626(1):1026–1035. doi: 10.1016/j.scitotenv.2018.01.129

8. Geng Niu, Longtan Shao, De'an Sun, et al. A simplified directly determination of soil-water retention curve from pore size distribution. *Geomechanics and Engineering.* 2020;20(5):411–420 doi: 10.12989/gae.2020.20.5.411

9. Parkhomenko GG, Parkhomenko SG. Theoretical study of the mechanisms of movement of working bodies for tillage. In: *Intelligent machine technologies and equipment for the implementation of the state program for the development of agriculture Collection of scientific reports of the International Scientific and Technical Conference. Part 1.* Moscow: FNATS VIM; 2015:210–214. (In Russ). EDN: UFOINT

10. Chappell A, Webb NP. Using albedo to reform wind erosion modelling, mapping and Monitoring. *Aeolian Research.* 2016;23:63–78. doi: 10.1016/j.aeolia.2016.09.006

11. Belousov SV, Pomelyayko SA, Novikov VV. Design of the universal agricultural working body and study of its parameters. *MATEC Web of Conferences.* 2018;224:05006. EDN FZUDHT doi: 10.1051/matecconf/201822405006

12. Rykov VB, Kambulov SI, Shevchenko NV, et al. *Methodological approaches to substantiating the basic parameters of promising machine-technological units.* Krasnodar: KubGAU im IT Trubilina; 2022. (In Russ). EDN KUZKJL

СПИСОК ЛИТЕРАТУРЫ

1. Sándor Zs., Tállai M., Kincses I., et al. Effect of various soil cultivation methods on some microbial soil properties // DRC Sustainable Future. 2020. Vol. 1, N. 1. P. 14–20. doi: 10.37281/DRCSF/1.1.3

2. Пархоменко Г.Г., Пархоменко С.Г. Экологически безопасная эксплуатация технических средств в условиях физической деградации почвы // Технический сервис машин. 2019. № 2(135). С. 40–46. EDN: WSZBHC

3. Couvreur V., Vanderborght J., Draye X., et al. Dynamic aspects of soil water availability for isohydric plants: Focus on root hydraulic resistances // Water Resources Research. 2014. Vol. 50, N. 11. P. 8891–8906. doi: 10.1002/2014WR015608

4. Пархоменко С.Г., Пархоменко Г.Г. Метод структурного моделирования систем автоматического регулирования эксплуатационных режимов работы почвообрабатывающих агрегатов // Труды ГОСНИТИ. 2017. Т. 126. С. 55–61. EDN: YLPRPR

5. Bluett C., Tullberg J.N., McPhee J.E., et al. Soil and Tillage Research: Why still focus on soil compaction? // Journal of CO_2 Utilization. 2019. Vol. 33. P. 201–214. doi: 10.1016/j.still.2019.05.028

6. Пархоменко Г.Г., Пархоменко С.Г. Снижение уплотнения почвы при производстве зерна // Хранение и переработка зерна. 2017. № 2(210). P. 20–24. EDN: QZWYWZ

7. Colombiabc T., Torresd L.C., Walterc A., et al. Feedbacks between soil penetration resistance, root architecture and water uptake limit water accessibility and crop growth – a vicious circle // Science of The Total Environment. 2018. Vol. 626, N. 1. P. 1026–1035. doi: 10.1016/j.scitotenv.2018.01.129

8. Geng Niu, Longtan Shao, De'an Sun, et al. A simplified directly determination of soil-water retention curve from pore size distribution // Geomechanics and Engineering. 2020. Vol. 20, N. 5. P. 411–420 doi: 10.12989/gae.2020.20.5.411

9. Пархоменко Г.Г., Пархоменко С.Г. Теоретическое исследование механизмов перемещения рабочих органов для обработки почвы // В сборнике: Интеллектуальные машинные технологии и техника для реализации государственной программы развития сельского хозяйства Сборник научных докладов Международной научно-технической конференции. Ч. 1. М.: ФНАЦ ВИМ, 2015. С. 210-214. EDN: UFOINT

10. Chappell A., Webb N.P. Using albedo to reform wind erosion modelling, mapping and Monitoring // Aeolian Research. 2016. Vol. 23. P. 63–78. doi: 10.1016/j.aeolia.2016.09.006

11. Belousov S.V., Pomelyayko S.A., Novikov V.V. Design of the universal agricultural working body and study of its parameters // MATEC Web of Conferences. 2018. Vol. 224. P. 05006. EDN FZUDHT doi: 10.1051/matecconf/201822405006

12. Рыков В.Б., Камбулов С.И., Шевченко Н.В., и др. Методические подходы к обоснованию базовых параметров перспективных машинно-технологических агрегатов. Краснодар: КубГАУ им. И.Т. Трубилина, 2022. EDN KUZKJL

AUTHORS' INFO

*** Sergey V. Belousov,**
Cand. Sci. (Engineering),
Associate Professor of the of Processes and Machines in Agribusiness Department, Junior Researcher of the Mechanization of Crop Production Department;
address: 3 Nauchny Gorodok street, 347740 Zernograd, Russian Federation;
ORCID: 0000-0002-8874-9862;
eLibrary SPIN: 6847-7933;
e-mail: sergey_belousov_87@mail.ru

Galina G. Parkhomenko,
Cand. Sci. (Engineering),
Leading Researcher of the Mechanization of Crop Production Department;
ORCID: 0000-0003-1944-216X;
eLibrary SPIN: 6048-2834;
e-mail: parkhomenko.galya@yandex.ru

Sergey I. Kambulov,
Associate Professor, Dr. Sci. (Engineering),
Chief Researcher of the Mechanization of Crop Production Department;
ORCID: 0000-0001-8712-1478;
eLibrary SPIN 3854-2942;
e-mail: kambulov.s@mail.ru

Igor V. Bozhko,
Cand. Sci. (Engineering),
Researcher of the Mechanization of Crop Production Department;
ORCID: 0000-0002-8423-4079;
eLibrary SPIN: 8506-5144;
e-mail: i.v.bozhko@mail.ru

Dmitry S. Podlesny,
Cand. Sci. (Engineering),
Junior Researcher of the Mechanization of Crop Production Department;
ORCID: 0000-0002-6069-138X;
eLibrary SPIN: 5168-1664;
e-mail: podlesniy.dmitri@yandex.ru

* Corresponding author / Автор, ответственный за переписку

ОБ АВТОРАХ

*** Белоусов Сергей Витальевич,**
канд. техн. наук,
доцент кафедры «Процессы и машины в агробизнесе», младший научный сотрудник отдела механизации растениеводства;
адрес: Российская Федерация, 347740, Зерноград, ул. Научный городок, д. 3;
ORCID: 0000-0002-8874-9862;
eLibrary SPIN: 6847-7933;
e-mail: sergey_belousov_87@mail.ru

Пархоменко Галина Геннадьевна,
канд. техн. наук,
ведущий научный сотрудник отдела механизации растениеводства;
ORCID: 0000-0003-1944-216X;
eLibrary SPIN: 6048-2834;
e-mail: parkhomenko.galya@yandex.ru

Камбулов Сергей Иванович,
доцент, д-р техн. наук,
главный научный сотрудник, заведующий отделом механизации растениеводства;
ORCID: 0000-0001-8712-1478;
eLibrary SPIN 3854-2942;
e-mail: kambulov.s@mail.ru

Божко Игорь Владимирович,
канд. техн. наук,
научный сотрудник отдела механизации растениеводства;
ORCID: 0000-0002-8423-4079;
eLibrary SPIN: 8506-5144;
e-mail: i.v.bozhko@mail.ru

Подлесный Дмитрий Сергеевич,
канд. техн. наук,
младший научный сотрудник отдела механизации растениеводства;
ORCID: 0000-0002-6069-138X;
eLibrary SPIN: 5168-1664;
e-mail: podlesniy.dmitri@yandex.ru

DOI: https://doi.org/10.17816/0321-4443-568649