С.Сейфуллин атындағы Қазақ агротехникалық университетінің **Ғылым жаршысы (пәнаралық)** = **Вестник науки** Казахского агротехнического университета им. С.Сейфуллина (**междисциплинарный**). - 2018. - №3 (98). - С.166-178

INFLUENCE OF FOUR-ROW DISK WORKERS BODIES ON THE QUALITY OF SOIL CULTIVATION PROCESSING

V.V.Blednykh [1] – Academician, the Russian Academy of Sciences, Doctor of Technical Sciences
P.G.[1]Svechnikov, Professor, Doctor of Technical Sciences
V.N.[1]Voinov– Candidate of Technical Sciences
A.N.[2]Grishin Associate Professor, Candidate of Technical Sciences
R.F.[2] Galimova– Assistant, Master of Engineering and Technological Support in Mechanical Engineering
[1]- South Ural State Agrarian University,
[2] – S.Seifullin Kazakh Agro Technical University ,

Annotation

The article presents data on the effect of disk header installation on the cultivation quality. Influence of speed of aggregate movement, impinging angle of disk and depth cultivation on agrotechnical indicators is shown. It is established that as the speed of the aggregate increases, the degree of soil crumbling increases at all impinging angle of disk. There is an improvement in plant residues up to 68% with an increase in the speed of the aggregate movementwhile increasing the indicators at leveling of the field surface. The obtained theoretical dependences are confirmed by the results of experimental studies.

Key words: depth cultivation, *ridgeness of furrow bottom*, ridgeness *of field surface, disk header, motion speed of aggregate, impinging angle of disk.*

Relevance

When performing minimal tillage with disking single-row harrows MDH-7, MDH-10, which performs multiple passes through the field in order to receive loosing and weed-free soil are used[1].

To reduce the number of passes across the field, completely new multi-row disk tools of the MDH series were developed with disks located on separate racks and regulating the impinging angle of disk and the width of the disk's grip by a parallelogram mechanism with a depth of processing from 10 to 16 cm.

The scheme of the technological process of cultivating the soil with a four-row disk header is shown in Fig.1

taking into account a technical characteristic and agrotechnical indicators

Materials and research methodology

The distance between the centers of the disks in each row L, the displacement of the disks of each row M, the formation of the furrow bottom profile with a disk of diameter D, on the processing depth *a*, and the angle of the disk position to the direction of motion a, the height of the ridgeness of furrow bottom*h* (Figure 2), affecting on the quality of soil cultivation [3, 4, 5].

Let us determine the displacement axes of disks for a four-row disk header.

$m = L/n$, (1)

when

n=4 – number of rows of a disk header.

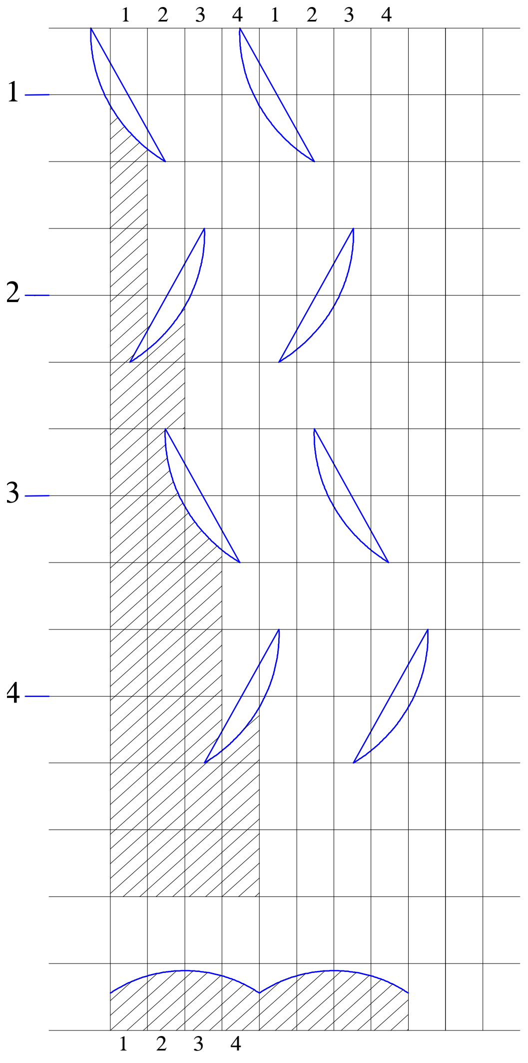


Figure 1 - Scheme of the technological process of tillage with disks in the horizontal plane

We determine the height of the surface irregularity *h* from the following assumptions (Figure 3), the centers of two disks of the first and second rows, with radius R = R1 = R2 located at a distance of *m* from each other, and the point C is the intersection point of two circles with these radii. The coordinates of the point C correspond to coordinates of the height of the surface irregularity furrow bottom *h*. We find the coordinates of the point C from ratios

$R_1^2 = x_1^2 + y_1^2$; (2)

$$R_2^2 = (x_2 - m)^2 + y_2^2; \quad (3)$$

where

$y = y_1 = y_2$, since the depth of the disk motion (depth of cultivation) is constant

$x_1 = x_2 - m$, (4)

where

m –distance between the centers of traces of the neighboring disks

Then we will receive the equation

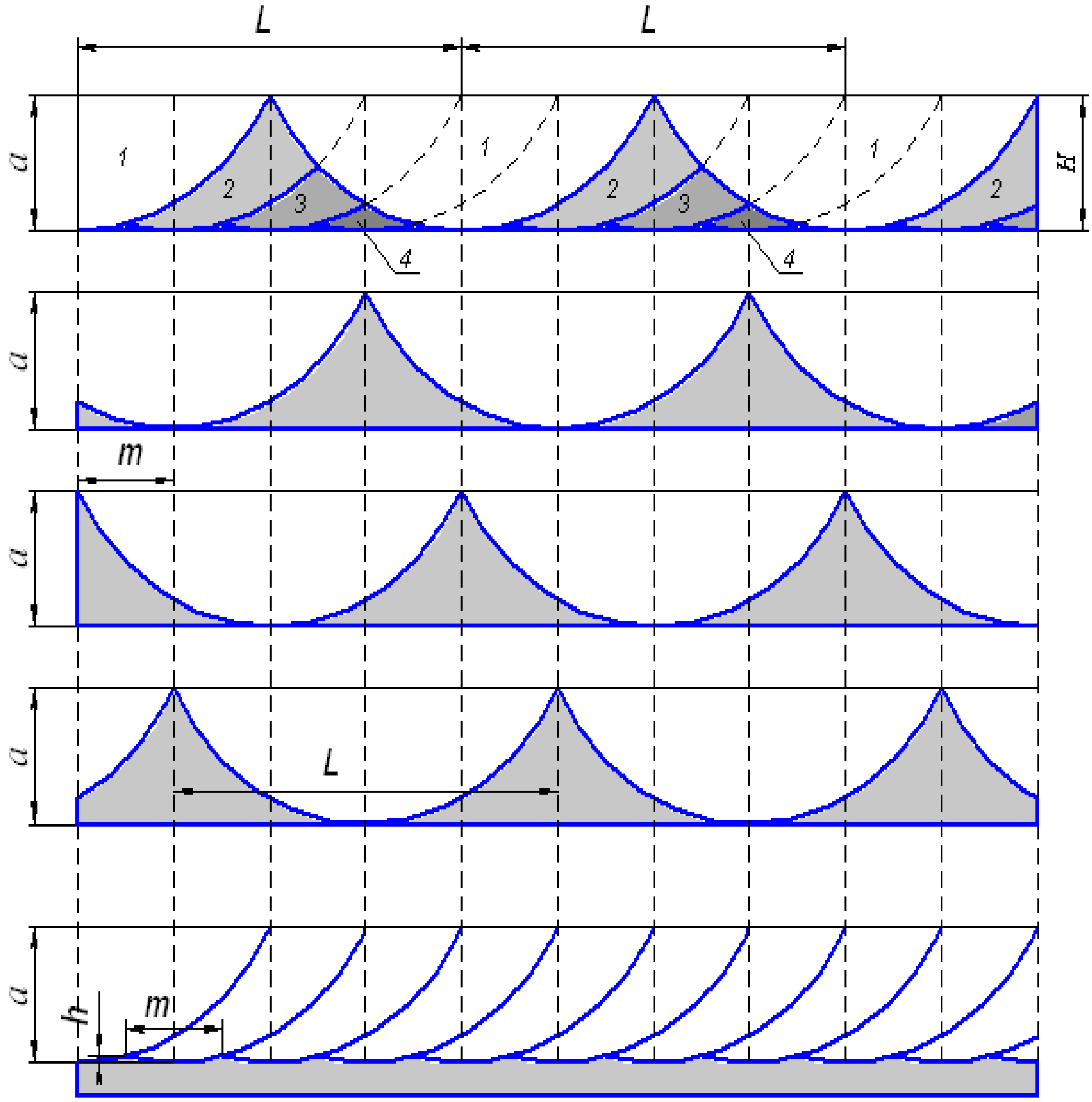


Figure 2 - Formation of the furrow bottom during cultivation with a disc header:

L –distance between the disks in the row; *m* – distance between traces of the neighboring disks; *a* –depth of cultivation; *h* – height of ridgeness of furrow bottom after passage of four rows of disks; *H* – height of ridgeness of furrow bottom after passage of the first row of disks.

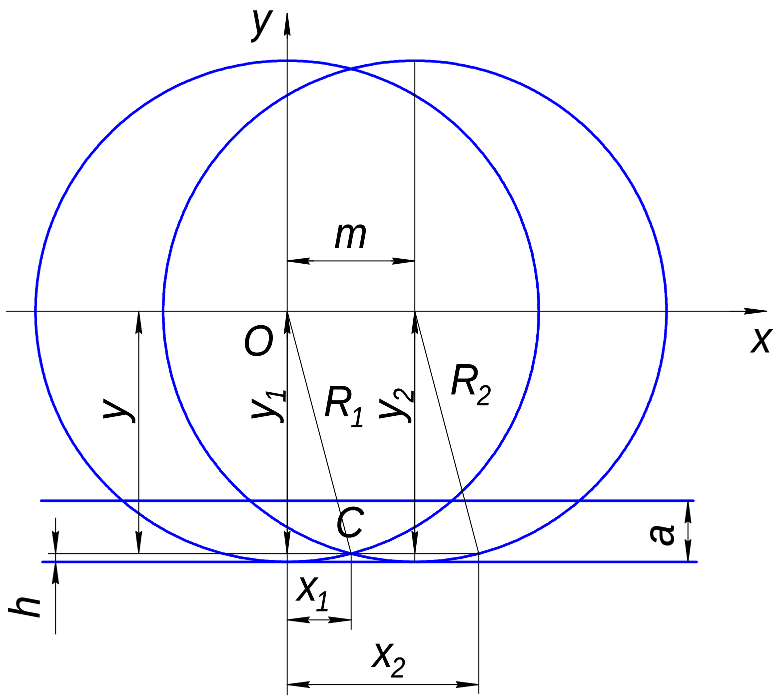


Figure 3 - Scheme for determination of the ridgeness height of furrow bottom after the passage of disk header

$$x_1^2 + y_1^2 = (x_2 - m)^2 + y_2^2; \qquad (5)$$

Figure 3 shows that the coordinates x and y, x1 and y can be determined

$x = x_1 = \frac{m}{2};$ (6)

$x_1^2 = (x_2 - m)^2;$ (7)

$y_1^2 = R^2 - x_1^2;$ (8)

after transformation we will receive

$$y = \sqrt{R^2 - \left(\frac{m}{2}\right)^2} = \frac{1}{2}\sqrt{D^2 - m^2}; \quad (9)$$

Knowing the coordinates of the point C, we find the height of the ridgeness of furrow bottom

$$h = R - y = \frac{1}{2}\left(D - \sqrt{D^2 - m^2}\right)(10)$$

Research results

Based on the results of the calculation of equation (1), the graphics dependence of the height of the irregularities on the diameter of the disk D were obtained for different distances between the centers of the traces of neighboring disks m (Fig. 4).

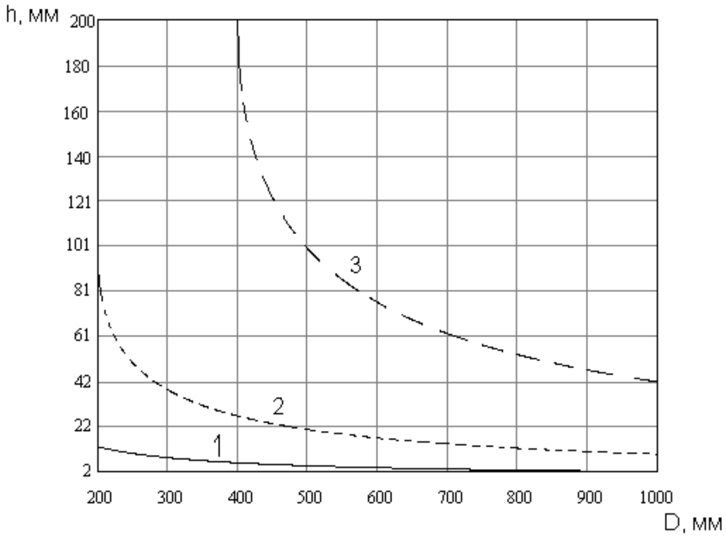


Figure 4 - Changes of height of the ridgeness of furrow bottom depending on diameter of a disk D at various distances between traces of disks *m*
1 – *m*=100 mm; 2 – *m*=200 mm; 3 – *m*=400 mm

From the graph it can be seen that the optimal distance between the traces of the neighboring disks in the row.

For the further solution of a task of optimum arrangement working bodies of a disk header on a frame of the tool we will determine coverage of a disk at the level of the field surface (Figure 5):

$$R^2 = \left(\frac{1}{2}b\right)^2 + (R-a)^2; \quad (11)$$

$$\left(\frac{1}{2}b\right)^2 = R^2 - (R-a)^2; \quad (12)$$

after ransformation and calculation

$$\frac{b^2}{4} = R^2 - (R^2 - 2\mathrm{Ra} + a^2) = 4(\mathrm{Da} - a^2); \quad (13)$$

from where we will receive the equation for determination of disks width

$$b = 2\sqrt{a(D-a)}. \quad (14)$$

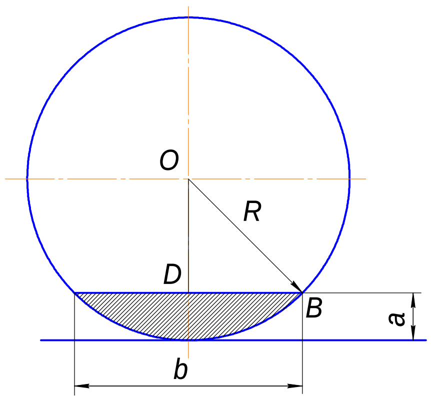


Figure 5 - Width of disk at the level of the field surface
with a depth of cultivation *a*

Figure 6 shows graphs of the dependence of disk width on cultivation in a section perpendicular to the plane of the disk, obtained from equation (14).

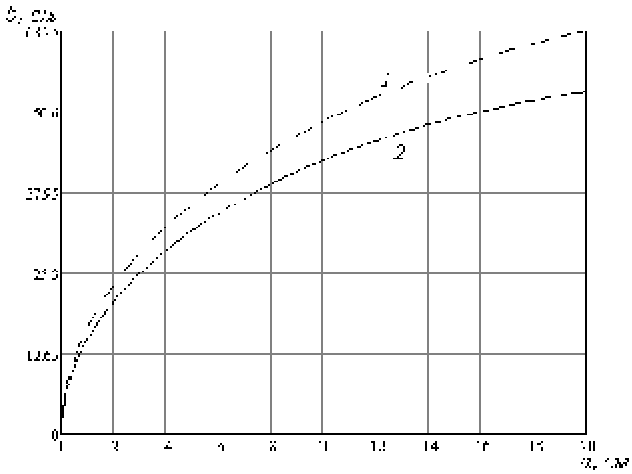


Figure 6 - Width of disk in section, perpendicularto
the disk planes, depending on the depth of the motion of disks*a*
with diameters of disks of D:
1 – *D*=0,7 м; 2 – *D*=0,56 m

Analysis of graphical dependencies allows us to conclude that the width of disk in the section perpendicular to the disk plane increases with increasing depth of cultivation.

When installing the disc at an angle a to the direction of movement (a - impinging angle), it is necessary to reduce all the equations obtained above to the direction perpendicular to the movement of the tool – *V*(Figure 7).

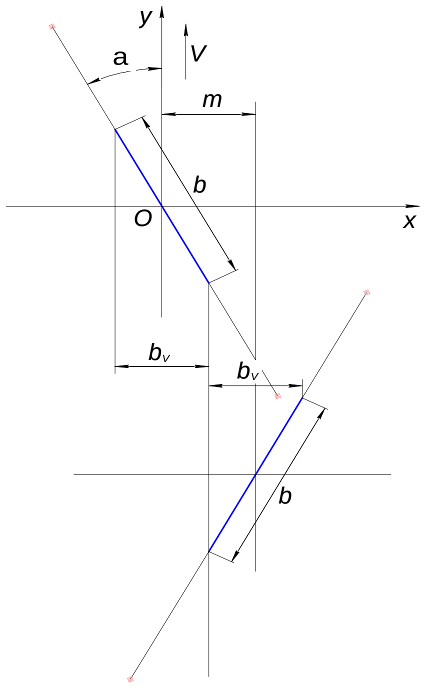


Figure 7 - Scheme for determining the width of disk with impinging angle of disk α

The width of disk at the level of the field surface

$$b_v = b\sin\alpha = 2\sin\alpha\sqrt{a(D-a)}, \tag{15}$$

where

b_v –width of disk in a direction perpendicular to the movement of the tool, m.

Figure 8 shows the graphs of the dependence width of disk on the impinging angle.

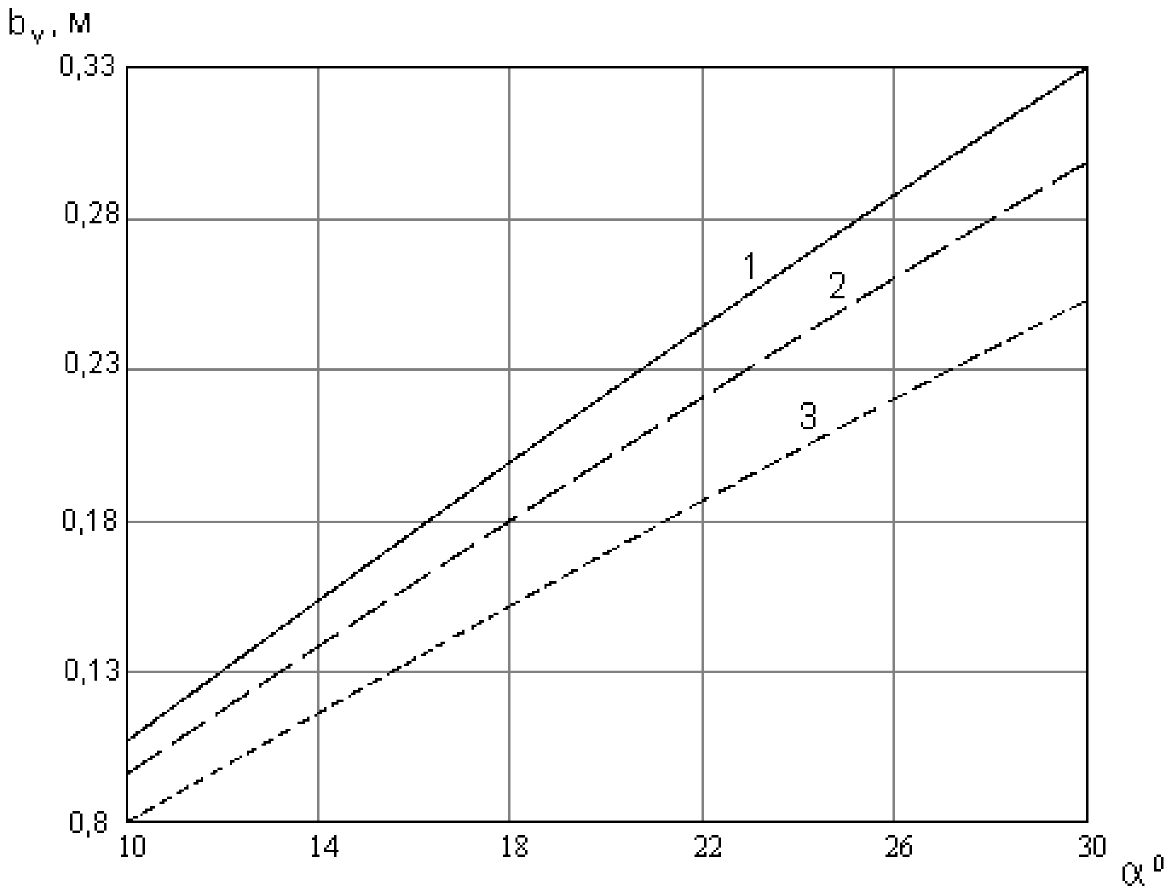


Figure 8 - Changes of the disk width
depending on an impinging angle α °
at various meanings for a depth of disk motion at *D*=0,7 m:
1 – *a*=0,20 m; 2 – *a*=0,15 мm; 3 – *a*=0,10 m

Thus, the impinging angle of disk α ° has the same effect on the width of disk b_v at different depth of cultivation *a*.

If the angle α = 0°, then b_v = 0. That is, the disk forms a furrow with a width of disks equal to the width of the spherical disk *b* (Figure 10b), and the gap between the traces of the disks remains untreated.

Low-quality soil cultivation (galls) is possible if the distance between the traces of adjacent disks is incorrectly chosen, when $m>b_v$(Figure 9).

At $m = b_v$, the point of the joint of traces of disks is on the surface of the field (Figures 9b, 10b). In this case, the height of the irregularities is equal to the depth of cultivation, that is, $h = a$.

For m $<b_v$, the traces of two neighboring discs overlap (Figures 9c, 10a) at some distance from the field surface.

The size of overlap $\Delta = b_v - m$.

The larger size Δ, the smaller height of unevenness of a field surface after the passage of the tool (Figure 9), determined by equation (1). The actual height of the unevenness of the furrow bottom after the passage of the disc header is within the range $0 \le h \le a$.

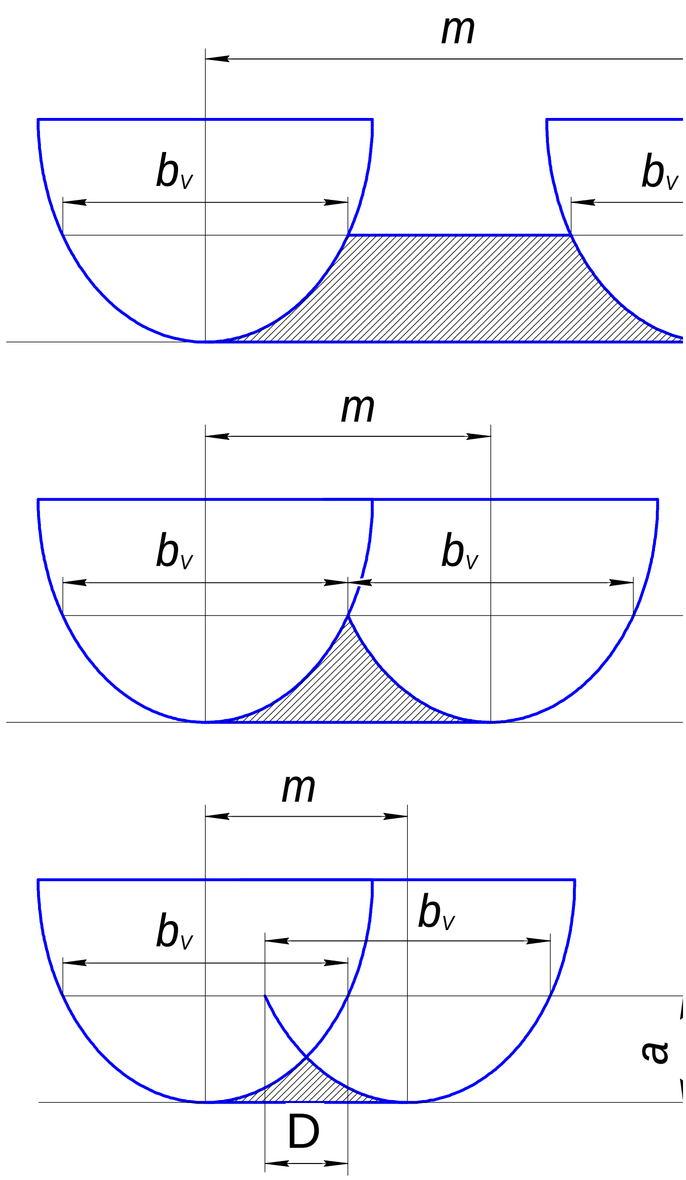
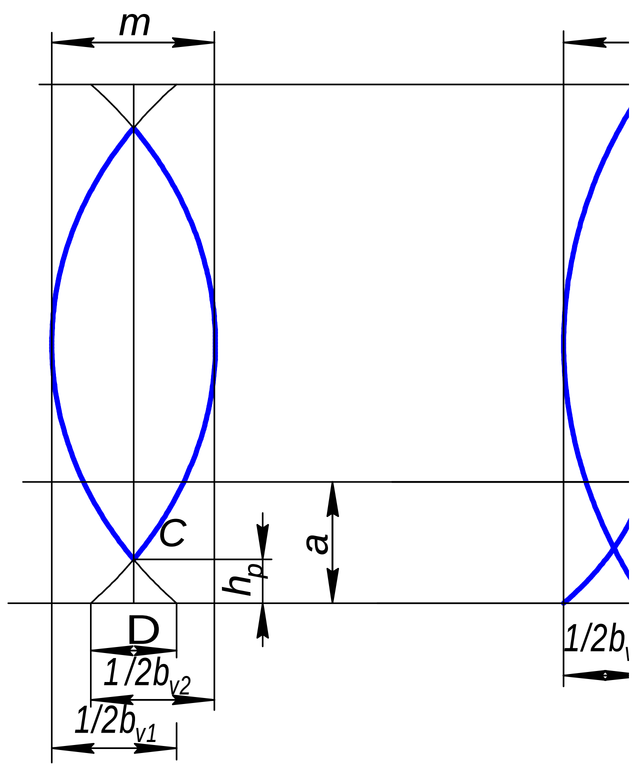


Figure 9 - Matching the disk width b_v and with the distance between the axes of the traces of neighboring disks *m*



abc

a) $m<½\, b_{v1} +½\, b_{v2}<b_v\Delta=b_v-m$;
b) $m=½\, b_{v1} +½\, b_{v2}= b_v\Delta=0$;
c) width of disk at $\alpha=0^{o}$;

Figure 10 - Operating position of disks of neighboring traces:
b_{v1} – working width of disk 1;
b_{v2} – working width of disk 2 (at a given impinging angle);
m – distance between axes of neighboring traces;
Δ – size of overlap at the furrow bottom

Spherical discs of disc headers wrap the soil layer like a dump body of a plow, and therefore the impinging angle of each row of the discs is equal and opposite in the direction of a disc header. In this case, when the disc header passes, the soil layer falls off by the disks of each row into the furrow of the previous row.

Theoretical studies found that the obtained parameters of the construction of the disc header provide high-quality soil cultivation. Recommended design parameters: the distance between the disks in the row is not more than 0.425 m, the distance from the frame to the disk axis is 0.55 m, the distance between the rows is not more than 0.7 m [7, 8].

Figure 1 shows the scheme of soil movement in the horizontal plane. Good quality of soil layer rotation, ridgeness of field surface is achieved when all discs are equal in height and the specified distance between the axes of the disc traces is maintained.

Thus, the relation of constructive and technological parameters of a disk header with indicators of technological process is established that allows to choose the best option by criterion a quality of operation [9, 10, 11].

The received theoretical dependences have been experimentally confirmed.

The results of experimental studies of the effect a impinging angle on agrotechnical indicators and tractive resistance are presented in Tables 1, 2, and 3.

When processing a dense, dry deposit, the depth of cultivation decreases with the same setting parameters of the disk header.

Table 1 - Agrotechnical indicators of work a disk header MDH 6 × 4 in the aggregate with a tractor K-700A at a different impinging angle

Indicators	Impinging angle of disk, α°		
	15	25	30
Depth of cultivation, cm	8	12	16
Mean square deviation of a depth of cultivation, cm	1,2-1,8	1,6-1,8	1,5-1,9
Ridgeness of field surface, cm	3,2-5,0	1,8-2,5	2,7-4,8
Trash burial, %	12-23	42-48	52-68
The number of soil fractions after the passage of the disc header, %:			
- less than 10 mm in size	12-19	9,7-16,8	16,5-19
- the size of 10-25 mm	30-59	76,4-78	50-64
- the size of 25-50 mm	10-28	7,4-8,2	9,2-15,5
- larger than 50 mm	12-23	4,6	7,7-18,3

It is established that with increasing plowing speed, the degree of crumbling of the soil increases at all impinging angles of disks. At thespeed of more than 10 km / h, good soil pulverization was noted at all impinging angles of disks examined (bolster of soil less than 25 mm in size are more than 70%). Disc headers in all modes of operation provide up to 96% cutting of weeds .

Table 2 - Agrotechnical indicators of MDH 4 × 4 disk header’s work in the aggregate with the tractor RTM-160 at different impinging angle and different speeds of movement

depth of cultivation cm		0-5		5-10		10-15		15-20
humidity, %		19,3		19,5		20,4		20,1
hardness, MPa		0,716		2,43		3,623		4,52

Impinging angle α,grade	Transmission	Working speed V, km / h	depth of cultivation, см			ridgeness of field surface, cm		ridgeness of furrow bottom, cm	
			established	measured					
			a	*aav*	*σ*	*average*	*σ*	*average*	*σ*
Without packing wheel									
10	I-II	5,24	6	5,22	1,726	9,6	1,252	14,915	1,469
	I-III	9,04	6	6,25	2,013	9,0	1,420	15,731	1,723
	I-IV	14,7	6	7,25	2,189	8,8	1,550	16,0951	1,977
20	I-II	5,02	6	7,27	3,363	7,3	2,297	14,322	1,48
		4,84	10	8,41	3,195	7,6	2,569	16,02	2,42
		3,87	12	10,93	3,412	6,9	2,55	18,92	2,32
		4,5	18	13,19	3,51	6,9	2,648	20,16	2,05
	I-III	7,64	6	6,95	3,112	6,9	2,391	14,536	2,13
		6,3	10	9,45	3,056	7,4	2,415	15,23	2,01

		7,46	12	15,37	3,22	7,5	2,153	22,878	2,18
30	I-II	4,6	12	13,68	2,893	7,5	2,746	21,158	1,1
	I-III	8,53	8	10,2	2,967	7,4	1,884	18,83	1,25

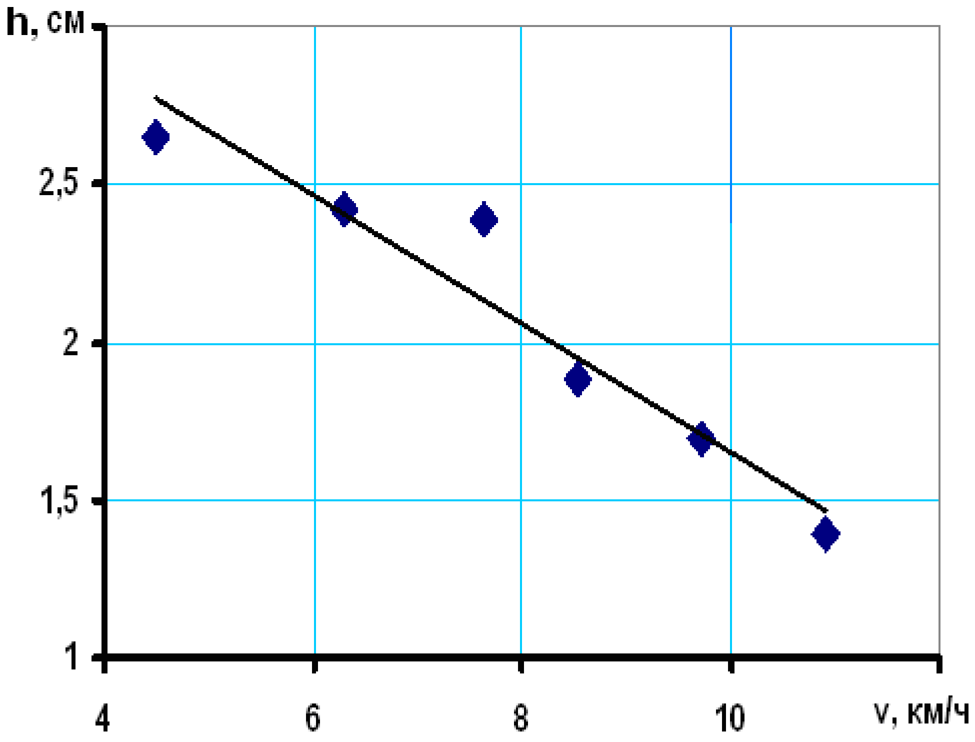


Figure 11 - Change of the ridgeness of field surface (h_{ridg}) from the working speed of RTM-160 + MDH-4 × 4 aggregate (α = 30º, a = 0.10 m)

The speed of movement of the aggregate significantly influences the plowing of the arable land: at a plowing speed of 8 km / h the ridgeness was 2.1 cm, and at the speed of 11 km / h - 1.5 cm (Figure 11). As the speed increases, plant residues are improved (at the indicated speeds of 52 and 68%, respectively). Simultaneously, the leveling of the field surface is improved (Fig. 12, 13).

Figure 12 – Ridgeness of field surface after passing the disc header at the speed of 6.2 km / h

Figure 13 – Ridgeness of field surface after passing the disc header at the speed of 8,7 km / h

Conclusion

As a result of testing and processing of experimental data, it has been established that agrotechnical indicators of quality of a disk header work in all operating conditions satisfy agrotechnical requirements:

- ensures the stability of the disk header motion along the depth and width of disk;

- good soil pulverization is ensured with a very low content of dust particles (≤5%);
- satisfactory sealing of plant residues is ensured (up to 68%);
- a small ridgeness of field surface is achieved (1.5-2.0 cm depending on the speed of movement).

References

1. Blednykh V.V. Vzaimodeystviye plasta pochvy s poverkhnost'yu klina // Sovershenstvovaniye metodov ispol'zovaniya i obsluzhivaniya sel'skokhozyaystvennoy tekhniki: Sb. nauch. tr. / CHIMESKH. – Chelyabinsk, 1984, p.36-40.

2. Blednykh V.V. Sovershenstvovaniye rabochikh organov pochvoobrabatyvayushchikh mashin na osnove matematicheskogo modelirovaniya tekhnologicheskikh protsessov: Avtoref. dis. … dokt. tekhn. nauk. – L., 1989. – 40 p.

3. Blednykh V.V., Svechnikov P.G. Tillage machines (theory, design and calculation): [Text]: monograph / Blednykh VV, Svechnikov PG - Chelyabinsk: ChGAA, 2015. - 292 p.

4. Blednykh V.V., Svechnikov P.G. Teoreticheskiye osnovy obrabotki pochvy, pochvoobrabatyvayushchikh orudiy i agregatov: [Tekst]: monografiya / Blednykh V.V., Svechnikov P.G. - Chelyabinsk: CHGAA, 2014 – 192 p.

5. Blednykh V.V., Svechnikov P.G. Teoriya pochvoobrabatyvayushchego klina i yeyo prilozheniya: [Tekst]: monografiya / Blednykh V.V., Svechnikov P.G. - Chelyabinsk: CHGAA, 2013 – 92 p.

6. Voynov V.N. Diskatory: obespecheniye kachestvennoy obrabotki pochvy // Traktory i sel'skokhozyaystvennyye mashiny, 2006, № 7, s. 34-35.

7. Voynov V.N. Opredeleniye chisla diskov diskatora // Vestnik CHGAA. T.62. –Chelyabinsk, 2012, p. 23-25.

8. Svechnikov P.G. Modernizatsiya pochvoobrabatyvayushchikh rabochikh organov na osnove issledovaniya protsessa ikh vzaimodeystviya s pochvoy: Dis. …dokt. tekhn. nauk. – Chelyabinsk, 2013. – 284p.

9. V. Blednykh, P. Svechnikov. Theoretical Foundations of Tillage, Tillers and Aggregates. – 2014 by Nova Science Publishers, Inc, New York. – P. 174.

10. V. Blednykh, P. Svechnikov. Economic reasons of tillage quality / European science review. - # 7-8, 2014. – p. 103-105.

11. V. Blednykh, P. Svechnikov. Theory of a Tillage Wedge and its Applications. – 2013 Logos Berlin GmbH, Berlin. – p. 94.

Төрт қатарлы дисклі органдарының топырақты сапалы өңдеуге әсер етуі

В.В. Бледных [1] – РҒА академигі, т.ғ.д., профессор,
П.Г. Свечников [1] – т.ғ.д., профессор,
В.Н. Войнов[1]– т.ғ.к., профессор,
А.Н. Гришин [2] – т.ғ.к., доцент,
Галимова Р.Ф. [2] – магистр
[1] Орал оңтүстік мемлекеттік аграрлық университеті
[2] С.Сейфуллин атындағы қазақ агротехникалық университеті

Түйін

Төртқарлы дискатор дискілері өсінің ауытқу шамасына, дискілердің диаметріне және дискілер еніне байланысты жыртылған топырақ түбі тегіссіздердің биіктігі теория жүзінде анықталып, эксперимент түрінде расталған.

Топырақты өңдеудің сапасы мен арамшөпті жоюға әсер етеді: дискілер орталықтарының ара қашықтығы, әр қатардың ығысуы, дискінің диаметрі мен топырақты өңдеу кезінде 10-16 см қалындықтағы дискілердің орналасуы.

Төртқатарлы дискілермен топырақты өңдеуде дискілер мен көрші дискілер іздерінің ара қашықтығы және жыртылған жер түбі тегіссіздігінің түбі теория жүзінде негізделіп әрі анықталған.

Теориялық зерттеулер нәтижесінде жыртылған топырақ түбі тегіссіздігі биіктігінің дискілер диаметрінің әр түрлі қашықтығында дискілердің диаметріне тәуелдәігінің графигі жасалған.

Дискілердің диаметрлері мен орналасу бұрышы қарай жерді жырту қалындығына байланысты дискілердің өңдеу ені анықталған. Дискілердің өңдеу еніне және көрші дискілер іздерінің өс аралық қашықтығына байланысты көрші дискілердің орналасуы негізделген.

Топырақты ұсақтау және арамшөкті кесу сапасына әсер ететін дискілердің орналасу бұрышы, ара қашықтығы және диаметріне байланысты теориялық және эксперименттік зерттеулер негізінде төртқатарлы дискатордың оңтайлы параметрлері тағайындалған.

Кілттік сөздер: өңдеу тереңдігі, жүйек түбінің әркелкілігі, егістік бетінің әркелкілігі, дискатор, агрегаттың қозғалу жылдамдығы, табақшалардың ену бұрышы.

Влияние четырехрядных дисковых рабочих органов на качество обработки почвы

В.В. Бледных [1] – академик РАН, д.т.н., профессор,
П.Г. Свечников [1] – д.т.н, профессор,

В.Н. Войнов[1] [1]– к.т.н., профессор,
Галимова Р.Ф. [2] . [2] – к.т.н., доцент,
Галимова Р.Ф. [2] – магистр
[1] Южно-Уральский государственный аграрный университет
[2] Казахский агротехнический университет им.С.Сейфуллина

Резюме

Теоретически определены и экспериментально подтверждены высота неровностей дна борозды, зависящие от величины смещения осей дисков четырехрядного дискатора, диаметра дисков и ширины захвата диска на уровне поверхности поля.

На качество обработки почвы и уничтожение сорняков влияют: расстояние между центрами дисков, смещение каждого ряда, диаметр диска и угол атаки при выполнении обработки на глубину от 10 до 16 сантиметров.

В технологическом процессе обработки почвы четырехрядными дисками горизонтальной плоскости теоретически обоснованы и определены расстояния между дисками в ряду и между следами соседних дисков, высота неровностей дна борозды первого и последующих рядов дисковой бороны.

В результате теоретических исследований получены графики зависимости высоты неровностей дна борозды от диаметра дисков бороны при различных расстояниях между центрами следов соседних дисков. Определена ширина захвата диска в зависимости от глубины обработки при разных диаметрах диска и установки диска под углом атаки к направлению движения бороны. Обосновано положение соседних дисков в зависимости от ширины захвата диска и расстояния между осями следов соседних дисков.

На основании теоретических и экспериментальных исследований установлены оптимальные параметры четырехрядного дискатора в зависимости от угла атаки, расстояния между рядами и диаметрами дисков, влияющих на качество крошения почвы и подрезания сорняков.

Ключевые слова: глубина обработки, гребнистость дна борозды, гребнистость поверхности поля, дискатор, скорость движения агрегата, угол атаки дисков.