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COMPARATIVE ANALYSIS OF TECHNICAL AND OPERATIONAL CHARACTERISTICS OF CHISEL PLOWS AND SUBSOILERS FOR ANTI-EROSION SOIL TILLAGE

Annotation: *The paper presents a comparative analysis of technical and operational characteristics of modern chisel plows and subsoilers used for non-inversion anti-erosion soil tillage. The relevance is determined by the high level of wind erosion in Northern Kazakhstan, where over 52 million hectares are subject to erosion. The aim of work is to conduct a comparative analysis of the technical and operational characteristics of modern chisel plows and sweep subsoilers for anti-erosion tillage. For comparative analysis, nine implements were selected, divided into two groups: chisel plows (PChM-4, PCh-4-5, PCh-4.5PM, KAMA TIGER 3, Dondi 813) and sweep subsoilers (RSP-5.4, Cultiplow Platinum SR Agrisem, STAVR PG-5, STAVR PG-7). The official test protocols of accredited MTS for 2014-2025 served as the information base. The comparison methodology was based on the requirements of GOST 20915-2011, GOST 33736-2016, GOST 52777-2007 and GOST 24088-88. The analysis was carried out according to qualitative and technical and operational indicators. Chisel plows provided soil crumbling of 90.6-98.6%, while for sweep subsoilers this indicator was 49.9-94.9% (RSP-5.4 – 62.3-68.4%). The best stubble retention was achieved by STAVR PG-5 (89.0%); chisel plows meet the standard of ≥60% but are inferior to sweep subsoilers, which is critical for anti-erosion technologies. Among chisel plows, PCh-4.5PM showed the highest working capacity (5.14-5.22 ha/h); among subsoilers, Dondi 813 led (5.43 ha/h). The lowest specific fuel consumption was recorded for PChM-4 (14.62 kg/ha), the highest for RSP-5.4 (21.36 kg/ha). Based on the overall set of indicators, PCh-4.5PM and PChM-4 are recommended for the conditions of Northern Kazakhstan; under the threat of wind erosion, STAVR PG-5 is preferable, and for compacted soils, RSP-5.4.*

Key words: *chisel plow, subsoiler, sweep subsoiler, non-inversion soil tillage, anti-erosion tillage, technical-operational characteristics, stubble retention.*

Introduction

Soil cover of Northern Kazakhstan is subjected to systematic wind erosion. According to the Institute of Soil Science of the National Academy of Sciences of the Republic of Kazakhstan, over 52 million hectares of land in the republic are affected by wind erosion, with chernozem soils occupying 25.5 million hectares of the main grain-producing belt being among the most vulnerable [1]. The use of non-inversion soil tillage with stubble retention is a key agrotechnical method for soil protection, substantiated within the soil-protective farming system developed by A.I. Barayev [2].

International studies confirm the effectiveness of this approach. Soane et al. established that non-inversion soil tillage combined with crop residue retention reduces humus loss by 15-30% in arid climates [3]. Munkholm et al. showed that subsoiling without soil inversion reduces bulk density in the 20-40 cm layer by 10-18% [4]. According to Siddique et al., stubble retention on the surface

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reduces the rate of wind-driven soil particle transport by a factor of 2.5-3.7 [5]. Based on long-term observations, Kertész and Madarász found that no-till technologies reduce soil loss due to water erosion by 25-55% [6]. Ogbeche et al. investigated the influence of the design parameters of chisel tillage tools on draft resistance and determined optimal chisel attack angles for soils with a hardness exceeding 2.0 MPa [7]. V.V. Blednykh with co-authors developed tillage tools with a variable cutting angle, providing a reduction in draft resistance by 12-18% [8].

In Kazakhstan, both domestic and foreign implements for non-inversion soil tillage are widely used; however, an objective comparison based on official test data is practically absent in the scientific literature [9]. Some publications are promotional in nature and are not based on standardized protocols. This complicates the informed choice of machinery for specific soil and climatic conditions.

The aim of this work is to conduct a comparative analysis of the technical and operational characteristics of modern chisel plows and subsoilers with sweep tillage tools.

Objectives: 1) to systematize the studied implements by the type of tillage tools; 2) to compare the qualitative performances of the technological process; 3) to compare the energy and operational and technological performances; 4) to develop recommendations for the selection of implements for the conditions of Northern Kazakhstan.

Materials and Methods

For the research analysis, nine implements for non-inversion deep soil tillage were selected, classified into two groups [10].

Group 1 – chisel plows with chisel-type tillage tools: PChM-4 (JSC KOMZ-Export, Russia), PCh-4-5 (JSC Rubtsovsk Plant of Spare Parts, Russia), PCh-4.5PM (BDM-Agro LLC, Russia), KAMA TIGER 3 (Tekhnika-Agro LLC, Russia), Dondi 813 (Dondi S.p.A., Italy).

Group 2 – subsoilers with sweep tillage tools: RSP-5.4 (Kostanay branch of «SPC of agricultural engineering» LLP, Kazakhstan), Cultiplow Platinum SR Agrisem (Agrisem International, France), STAVR PG-5 and STAVR PG-7 (JSC Rubtsovsk Plant of Spare Parts, Russia).

PChM-4 chisel plow is a mounted implement designed for primary non-inversion soil tillage for grain and industrial crops to a depth of up to 45 cm. The frame carries symmetrically arranged chisel tillage tools (right and left legs with chisels) and a packer roller system for breaking and leveling the top layer. It is used with tractors of the 5th traction class such as K-701, K-744R3, New Holland T8040, etc.

PCh-4-5 chisel plow is a mounted implement with 11 chisel tillage tools arranged in a staggered pattern in two rows. Each tillage tool consists of a leg, a flow deflector, a chisel, and side wings. It is equipped with two toothed rollers 540 mm in diameter. Depth adjustment is carried out by means of support wheels with a fine-tuning mechanism. It is used with tractors of 300-400 hp such as the K-701.

PCh-4.5PM chisel plow is a mounted implement for tractors of traction classes 5-6. The design features an increased working speed (up to 12.0 km/h) and reinforced tillage tools for soils with a specific resistance of up to 0.1 MPa. It is equipped with rollers for surface leveling.

KAMA TIGER 3 subsoiler is a mounted subsoiler with chisel and sweep tillage tools. It is intended for loosening on moldboard and non-inverted backgrounds with deepening of the plow layer as a substitute for fallow and spring plowing, post-harvest loosening, and pre-sowing tillage on stubble backgrounds. Working width is 3.0 m, tillage depth is up to 45 cm. It is used with tractors of 110-180 hp.

Dondi 813 subsoiler is an Italian-made trailed subsoiler with 13 chisel tillage tools arranged in several rows. It is equipped with 4 toothed rollers 410 mm in diameter for breaking clods and leveling the surface. Tillage depth is up to 60 cm, working width is 6.0 m. It requires a tractor of traction classes 7-8 (Challenger MT 865C). It is hitched via a special CTR 800 mounting trolley.

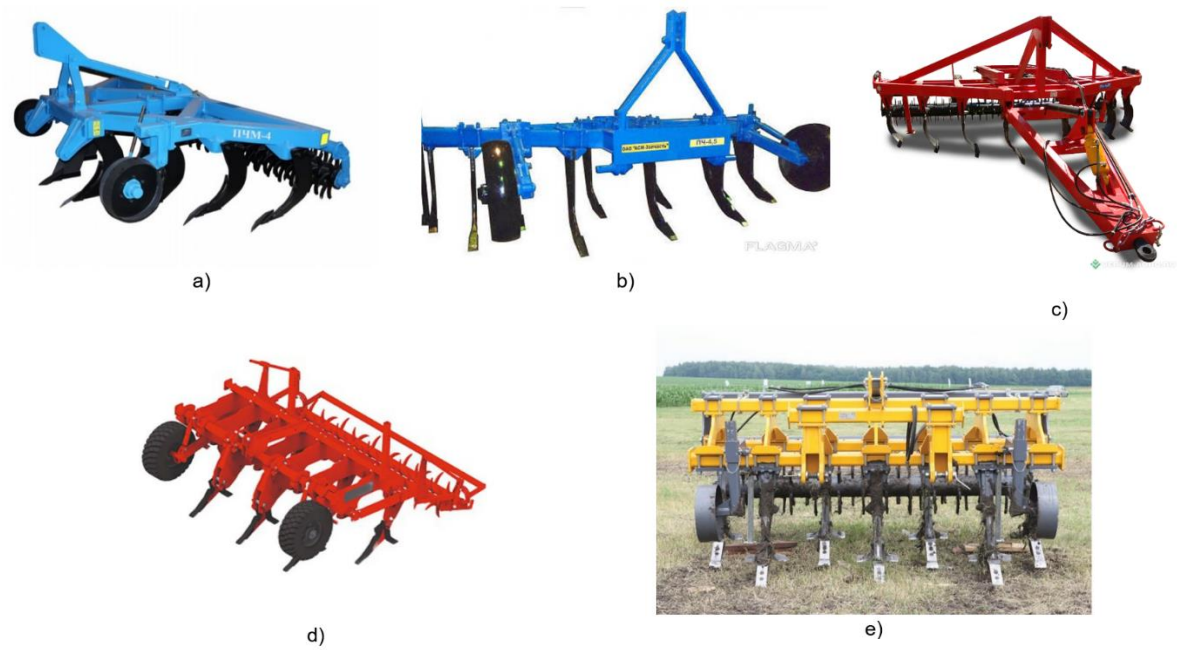
RSP-5.4 sweep subsoiler is designed for non-inversion primary tillage of fallow and stubble fields under conditions of low moisture, high hardness, and density of the plow layer. It is hitched to tractors with an engine power of 320-380 hp. The implement comprises sweep tillage tools with a working width of 0.5-0.6 m each, a central frame, folding side wings operated by a hydraulic cylinder, and bar rollers (optional).

Cultiplow Platinum SR Agrisem subsoiler is a French-made mounted subsoiler with 6 tillage tools on TCS750-Platinum stands with offset cutting elements. It is fitted with a tubular roller and a

spring protection mechanism. Tillage depth is 15-45 cm, working width is 4.0 m. It is used with tractors of at least 250 hp (Versatile 2375).

STAVR PG-5 sweep subsoiler is intended for primary fallow tillage and autumn tillage with maximum stubble retention to protect against wind erosion. The tillage tools are sweep-type tools. Specific resistance is up to 0.09 MPa. It is used with tractors of 250-350 hp.

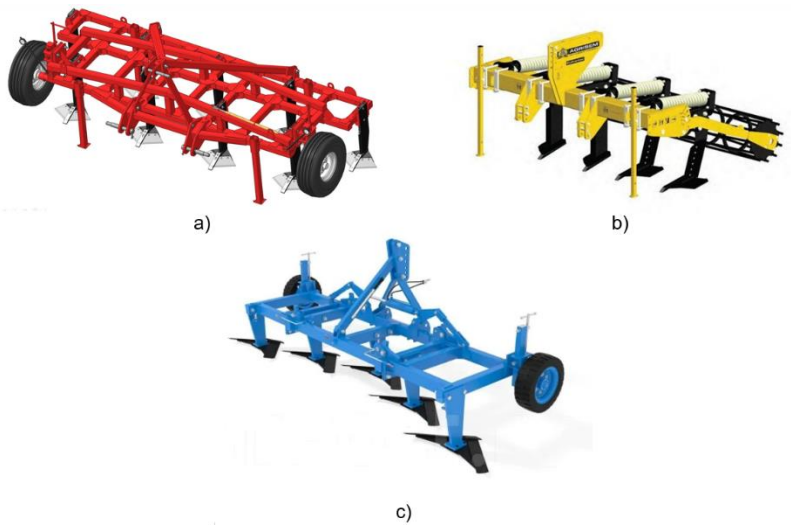
STAVR PG-7 sweep subsoiler is a semi-mounted version with an increased working width for farms with large areas. It is structurally similar to the PG-5 but designed for more powerful tractors (380-450 hp). It is intended for pre-sowing and autumn tillage (Figure 1, 2).



a) b) c) d) e)

a – PChM-4; b – PCh-4-5; c – PCh-4.5PM; d – KAMA TIGER 3; e– Dondi 813

Figure 1 – Chisel plows with vertical carriers and chisel-shaped tillage tools



a) b) c)

a – RSP-5.4; b – Cultiplow Platinum SR Agrisem; c – STAVR PG-5

Figure 2 – Subsoilers with sweep tillage tools

The data sources were official test reports of the specified implements from the accredited state zonal machine testing stations of Kostanay branch of «SPC of agricultural engineering» LLP, Kuban, Siberia, North Caucasus, and Altai for the years 2014-2025 [7; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20].

The performances were determined according to GOST 20915-2011, GOST 33736-2016, GOST 52777-2007, and GOST 24088-88. The comparison was carried out according to two groups:

(1) quality of the technological process (tillage depth, soil crumbling, stubble retention, surface ridging); (2) energy and operational-technological indicators (working capacity, working speed, working width, specific fuel consumption, shift time utilization coefficient).

The technical characteristics of the studied implements are presented in Tables 1 and 2.

Table 1 – Technical characteristics of chisel plows

Indicator	PChM-4	PCh-4-5	PCh-4.5PM	KAMA TIGER 3	Dondi 813
Type of aggregation	Mounted	Mounted	Mounted	Mounted	Trailed
Working width, m	4.0	4.0	4.5	3.0	6.0
Tillage depth, cm	up to 45	up to 45	up to 45	up to 45	up to 60
Working speed, km/h	7-10	7.0-8.0	up to 12.0	up to 12	9.3–9.5
Number of tillage tools, pcs.	8	11	–	–	–
Tractor traction class	5	5	5-6	110-180	450-500

Table 2 – Technical characteristics of subsoilers with sweep tillage tools

Indicator	RSP-5.4	Cultiplow Platinum SR	STAVR PG-5	STAVR PG-7
Type of aggregation	Mounted / trailed	Mounted	Mounted	Semi-mounted
Working width, m	5.4	4.0	5.0	7.4
Tillage depth, cm	20-35	15–45	15–30	15–30
Working speed, km/h	6.0-9.0	7.9–8.0	–	–
Tractor power, hp	320-380	≥ 250	250–350	380–450

Research results

The qualitative tillage performances for the two groups of implements are presented in Table 3.

Table 3 – Qualitative performances of the soil tillage

Indicator	AR	PChM-4	PCh-4-5	PCh-4.5PM	RSP-5.4	KAMA TIGER 3	Dondi 813	Cultiplow Platinum SR	STAVR PG-5	STAVR PG-7
Soil moisture, %	≤20.0	28.0	–	12.9	18.1	19.5	21.4	41.0	22.0	22.0
Soil hardness, MPa	≤4.0	2.8	–	3.9	6.5	3.2	2.56	4.41	3.5	3.5
Tillage depth, cm	≥45	43.1–43.4	18.7*	45.4	30.0	45.1-45.5	35.1	37.0	15–30	29.5
Soil crumbling (≤50 mm), %	≥40	98.5–98.6	–	90.6–95.2	62.3-68.4	49.9-66.2	75.0	94.9	82.0	85.4
Surface ridging, cm	≤5	2.8–3.0	4.0	–	–	–	2.2	4.4	6.5**	3.8
Stubble retention, %	≥60 / ≥80***	62.3–63.7	–	65.1	46.1-62.4	65.5	–	100****	89.0	–

*Note – * PCh-4-5 has been tested for treatment after row crops;*
*** Exceeding the standard is associated with the use of large-width sweep tillage tools;*
**** Standard ≥80% – for implements with sweep tillage tools;*
***** Cultiplow Platinum SR ensures complete incorporation of plant residues, which is unacceptable in conditions of wind erosion*

The chisel plows PChM-4 and PCh-4.5PM provide the best soil crumbling: 98.5-98.6% and 90.6-95.2%, respectively. This is explained by intensive fragmentation of the soil layer by vertical chisel stands. Among the subsoilers with sweep tillage tools, the highest soil crumbling is achieved by the Cultiplow Platinum SR (94.9%) and STAVR PG-7 (85.4%). The RSP-5.4 shows soil crumbling of 62.3-68.4% at soil hardness of 6,5 MPa, which meets the agrotechnical standard (≥40%). The Dondi 813 provides a tillage depth of 35.1 cm instead of the stated 45 cm – a significant deviation from the standard. The STAVR PG-5 shows a ridging height of 6.5 cm, exceeding the standard of 5 cm. In terms of stubble retention, the STAVR PG-5 leads (89.0%), which is its main advantage in anti-erosion technologies. All chisel plows meet the standard of ≥60%, although they are inferior to the subsoilers with sweep tillage tools in this indicator.

The energy and operational and technological performances of the implements are presented in Table 4.

Table 4 – The energy and operational and technological performances

Indicator	PChM-4	PCh-4-5	PCh 4.5PM	RSP-5.4	KAMA TIGER 3	Dondi 813	Cultiplow Platinum SR	STAVR PG-5	STAVR PG-7
Working speed, km/h	9.5	7.06	11.4-11.6	6.0-9.0	10.0-11.8	9.4	7.87-7.97	–	–
Working width, m	4.05	4.4	4.5	5.4	3.0	5.8	4.0	5.0	7.4
Working capacity per 1 hour of basic time, ha	3.85	3.11	5.14–5.22	3.30-5.00	–	5.43	3.19	–	–
Working capacity per 1 hour of shift time, ha	3.05	2.43	–	2.80-4.23	–	4.01	2.56	–	–
Specific fuel consumption per shift, kg/ha	14.62	19.2	–	21.36	–	18.8	21.3	–	–
Shift time utilization coefficient	0.79	0.78	–	0.85	–	0.74	0.80	–	–
The reliability coefficient of the technological process	1.0	1.0	–	–	–	1.0	1.0	–	–
Note – "–" – this indicator was not defined in the MTS protocol									

Discussion

From Table 4, it follows that the PCh-4.5PM provides a productivity of 5.14-5.22 ha/h, exceeding that of the PCh-4-5 (3.11 ha/h) by 33-68% due to its greater working width (4.5 m) and higher working speed (11.4-11.6 km/h). The RSP-5.4 shows a working capacity of 3.3-5.0 ha/h and 2.8-4.23 ha/h for main and shift times, respectively. The Dondi 813, with a working width of 5.8 m, achieves 5.43 ha/h; however, it requires a tractor of traction classes 7-8 (450-500 hp), which is atypical for the machinery fleet of farms in Northern Kazakhstan. The STAVR PG-7 with a working width of 7.4 m potentially provides the highest area capacity provided a suitable tractor (380-450 hp) is available. In terms of specific fuel consumption, the lowest consumption is shown by the PChM-4 (14.62 kg/ha), and the highest by the RSP-5.4 (21.36 kg/ha) and Cultiplow Platinum SR (21.3 kg/ha), probably due to the high value of soil hardness. The shift time utilization coefficient for all implements for which data are available meets the standard (0.74-0.80). The technological process reliability coefficient for the PChM-4, PCh-4-5, and Dondi 813 is 1.0, with the standard being ≥0.98-0.99.

The obtained results are generally consistent with international data. The high soil crumbling achieved by chisel plows with chisel-type tillage tools (98.5–98.6%) corresponds to the findings of Ogbeche et al. [7], who established that chisel-type tillage tools with an optimal chisel attack angle provide better soil layer fragmentation compared to sweep-type analogues. The RSP-5.4 shows soil crumbling of 62.3-68.4%, which also meets the standard. The results confirm the conclusions of Munkholm et al. [4] regarding the importance of decompaction of the subsoil layer: implements with a tillage depth of 43-45 cm (PChM-4, PCh-4.5PM) meet this requirement to a greater extent than the STAVR PG-5 and PG-7 with a working depth of 15-30 cm.

The observed superiority of the STAVR PG-5 in stubble retention (89.0%) is consistent with the data of Siddique et al. [5]: it is precisely the preservation of the mulching layer that determines the effectiveness of protection against wind erosion. At the same time, the limited tillage depth of these implements (up to 30 cm) does not allow for the disruption of the plow pan. Kertész and Madarász [6] similarly point to the need to combine surface mulching with periodic deep subsoiling.

For compacted soils, the most suitable subsoiler is the RSP-5.4. The comparatively low performance of the Dondi 813 in terms of depth (35.1 cm against a standard of ≥45 cm) and the necessity of a tractor of traction classes 7-8 significantly limit its applicability under the conditions of

Northern Kazakhstan. These data agree well with the position of Malyukov S.V. et al. [10], who emphasized the need to consider tractor traction class requirements when selecting subsoilers.

The practical significance of the results lies in the fact that the presented data are derived from official state test reports of accredited machine testing stations, which ensures the objectivity of the conclusions given the scarcity of independent research in Kazakhstan [9].

Conclusion

Based on a comparative analysis of nine implements for non-inversion soil tillage, the following conclusions are formulated.

1. Chisel plows PChM-4 and PCh-4.5PM provide the best soil crumbling (90.6-98.6%) and optimal tillage depth (43-45 cm), which meets the requirements for decompaction of the plow layer. The RSP-5.4 shows soil crumbling of 62.3-68.4%, also meeting the standard.

2. In terms of stubble retention, the STAVR PG-5 leads (89.0%), making it the preferred implements when there is a risk of wind erosion. Chisel plows meet the standard of ≥60% but are inferior to sweep-type implements. For deep decompaction, it is recommended to alternate the use of STAVR PG-5 with periodic chisel tillage.

3. The chisel plow PCh-4.5PM demonstrates the highest working capacity within its class (5.14-5.22 ha/h) with tractor requirements of traction classes 5–6, which corresponds to the structure of the machine and tractor fleet of farms in Northern Kazakhstan.

4. The use of Cultiplow Platinum SR Agrisem for anti-erosion tillage is inadvisable due to the complete incorporation of plant residues. The Dondi 813 is limited in application by the need for a tractor of traction classes 7-8 (450-500 hp). The RSP-5.4 shows the highest specific fuel consumption (21.36 kg/ha) when tilling soil with a soil hardness exceeding 6.0 MPa.

5. For the conditions of Northern Kazakhstan, the use of the PCh-4.5PM and PChM-4 is recommended, as they provide an optimal balance of tillage quality, working capacity, and specific energy consumption. Under the threat of wind erosion, it is advisable to use STAVR PG-5, followed by periodic chisel tillage once every 3-4 years to disrupt the plow pan. For compacted soils, the most suitable subsoiler is the RSP-5.4.

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ЭРОЗИЯҒА ҚАРСЫ ТОПЫРАҚТЫ ӨҢДЕУГЕ АРНАЛҒАН ЧИЗЕЛЬДІ СОҚАЛАР МЕН ТЕРЕҢ ҚОПСЫТҚЫШТАРДЫҢ ТЕХНИКАЛЫҚ-ПАЙДАЛАНУ КӨРСЕТКІШТЕРІНІҢ САЛЫСТЫРМАЛЫ ТАЛДАУЫ

Мақалада топырақты аударусыз эрозияға қарсы өңдеуге арналған заманауи чизельді соқалар мен терең қопсытқыштардың техникалық-пайдалану көрсеткіштерін салыстырмалы талдау нәтижелері ұсынылады. Зерттеудің өзектілігі Солтүстік Қазақстандағы жел эрозиясының жоғары деңгейімен айқындалады: 52 млн га-дан астам алқап эрозияға ұшыраған. Жұмыстың мақсаты – топырақты эрозияға қарсы өңдеуге арналған заманауи чизель соқалары мен жалпақ тілгіш терең қопсытқыштардың техникалық-пайдалану көрсеткіштеріне салыстырмалы талдау жүргізу. Салыстырмалы талдау үшін екі топқа бөлінген тоғыз құрал таңдалды: чизель соқалары (ПЧМ-4, ПЧ-4-5, ПЧ-4,5ПМ, KAMA TIGER 3, Dondi 813) және жалпақ тілгіш терең қопсытқыштар (РСП-5,4, Cultiplow Platinum SR Agrisem, STAVR PG-5, STAVR PG-7). Ақпараттық база ретінде аккредиттелген МИС-дың 2014-2025 жылдардағы ресми сынақ хаттамалары алынды. Салыстыру әдістемесі ГОСТ 20915-2011, ГОСТ 33736-2016, ГОСТ 52777-2007 және ГОСТ 24088-88 талаптарына негізделген. Талдау сапалық және техникалық-пайдалану көрсеткіштері бойынша жүргізілді. Чизельді соқалар топырақтың ұсақталуын 90,6–98,6% қамтамасыз етеді, ал жалпақ тілгіш терең қопсытқыштарда бұл көрсеткіш 49,9–94,9% құрайды (РСП-5,4 – 62,3-68,4%). Сабан сақтаудың ең жақсы көрсеткіші STAVR ПГ-5 үшін (89,0%) қол жеткізілді; чизельді соқалар нормативке ≥60% сәйкес келеді, бірақ жалпақ тілгіштерден кем түседі. ПЧ-4,5ПМ чизельді соқалар арасында ең жоғары өнімділікті көрсетті (5,14-5,22 га/сағ.), терең қопсытқыштар арасында – Dondi 813 (5,43 га/сағ). Ең төменгі меншікті отын шығыны ПЧМ-4 үшін тіркелді (14,62 кг/га), ең жоғарғы – РСП-5,4 (21,36 кг/га). Көрсеткіштер жиынтығы бойынша Солтүстік Қазақстан жағдайында ПЧ-4,5ПМ және ПЧМ-4 ұсынылады, жел эрозиясы қаупі кезінде – STAVR PG-5, тығыздалған топырақтар үшін – РСП-5,4.

***Түйін сөздер*:** *чизельді соқа, терең қопсытқыш, топырақты аударусыз өңдеу, эрозияға қарсы өңдеу, техникалық-пайдалану көрсеткіштері, сабан сақтау.*

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ ТЕХНИКО-ЭКСПЛУАТАЦИОННЫХ ПОКАЗАТЕЛЕЙ ЧИЗЕЛЬНЫХ ПЛУГОВ И ГЛУБОКОРЫХЛИТЕЛЕЙ ДЛЯ ПРОТИВОЭРОЗИОННОЙ ОБРАБОТКИ ПОЧВЫ

В статье представлены результаты сравнительного анализа технико-эксплуатационных показателей современных чизельных плугов и глубокорыхлителей для безотвальной противоэрозионной обработки почвы. Актуальность исследования обусловлена высоким уровнем ветровой эрозии на территории Северного Казахстана, где свыше 52 млн га подвержены эрозии. Цель работы – провести сравнительный анализ технико-эксплуатационных показателей современных чизельных плугов и плоскорезных глубокорыхлителей для противоэрозионной обработки почвы. Для сравнительного анализа выбраны девять орудий, разделённых на две группы: чизельные плуги (ПЧМ-4, ПЧ-4-5, ПЧ-4,5ПМ, KAMA TIGER 3, Dondi 813) и плоскорезные глубокорыхлители (РСП-5,4, Cultiplow Platinum SR Agrisem, STAVR ПГ-5, STAVR ПГ-7). Информационной базой послужили официальные протоколы испытаний аккредитованных МИС за 2014–2025 годы. Методика сравнения строилась на требованиях ГОСТ 20915-2011, ГОСТ 33736-2016, ГОСТ 52777-2007 и ГОСТ 24088-88. Анализ проводился по качественным и технико-эксплуатационным показателям. Установлено, что чизельные плуги обеспечивают крошение почвы 90,6-98,6%, тогда как у плоскорезных глубокорыхлителей этот показатель составляет 49,9-94,9% (РСП-5,4 – 62,3-68,4%). Наилучшее сохранение стерни достигается у STAVR ПГ-5 (89,0%), чизельные плуги соответствуют нормативу ≥60%, но уступают плоскорезным, что критично для противоэрозионных технологий. Наибольшую производительность среди чизельных плугов показал ПЧ-4,5ПМ (5,14-5,22 га/ч), среди глубокорыхлителей – Dondi 813 (5,43 га/ч). Наименьший удельный расход топлива зафиксирован у ПЧМ-4 (14,62 кг/га), наибольший – у РСП-5,4 (21,36 кг/га). По совокупности показателей для условий Северного Казахстана рекомендованы ПЧ-4,5ПМ и ПЧМ-4, при угрозе ветровой эрозии – STAVR ПГ-5, для переуплотненных почв – РСП-5,4.

Ключевые слова: *чизельный плуг, глубокорыхлитель, плоскорез, безотвальная обработка почвы, противоэрозионная обработка, технико-эксплуатационные показатели, сохранение стерни.*

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THE EFFECT OF ELECTROLYTE-PLASMA HARDENING PARAMETERS ON THE MICROSTRUCTURE, PHASE COMPOSITION, AND MECHANICAL AND TRIBOLOGICAL PROPERTIES OF 20X STEEL

Abstract: *This article investigates the effect of electrolytic-plasma treatment (EPT) parameters–voltage (260-320 V) and dwell time (2-5 s) – on the microstructure, phase composition, microhardness, elastic modulus, and tribological properties of 20X steel. Treatment was performed in a 12 wt.% Na_2CO_3 aqueous solution. X-ray diffraction and scanning electron microscopy showed the formation of α'-martensite with a body-centered cubic (BCC) lattice without residual austenite or carbide phases. The threshold treatment mode was 260 V for 2 s, at which complete austenitization was not achieved. Increasing the dwell time to 5 s at 300 V nearly doubled the microhardness to 441.66 HV, while increasing voltage at 2 s primarily affected carbon*

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