SvedbergOpen
DISSEMINATION OF KNOWLEDGE
International Journal of Artificial Intelligence and Machine Learning
Publisher's Home Page: https://www.svedbergopen.com/
Research Paper
Open Access

Field Tests And Evaluatıon Of Economıc Effıcıency Of An Experımental Dırect Seeder

Isayev Aydin Yunis[1] , Gurbanov Gurban Yashar[2] , Mammadov Ziya Vilayat[3] , Bayramova Aysel Sarvar[4] , Jafarov Anar Telman[5] , Aliyeva Raqsana Gazanfar[6] , Mustafayev Ramil Mayil[7]

[1]Associate Professor Department of Agricultural Machinery and Technical Service Azerbaijan State Agricultural University, Azerbaijan aydin.isayev.75@mail.ru
[2]Department of Agricultural Machinery and Technical Service Azerbaijan State Agricultural University, Azerbaijan
[3]Department of Agricultural Machinery and Technical Service Azerbaijan State Agricultural University, Azerbaijan ziyamemmedov-adau@rambler.ru https://orcid.org/0009-0001-5705-8743
[4]Department of Agricultural Machinery and Technical Service Azerbaijan State Agricultural University, Azerbaijan
[5]Department of Agricultural Machinery and Technical Service Azerbaijan State Agricultural University, Azerbaijan
[6]Department of Technical Mechanics and Mechanical Engineering Azerbaijan State Agricultural University, Azerbaijan
[7]Department of Land Reclamation and Hydrotechnical Facilities Azerbaijan State Agricultural University, Azerbaijan

SUMMARY
The application of rational soil cultivation methods is of great importance in increasing the volume of crop production. Proper soil cultivation affects the retention of moisture and nutrients in the soil, the destruction of weeds, and regulates the air regime in all layers of the soil horizon. In this regard, the relevance of assessing the efficiency of pre-sowing operations in the processing of soil with combined aggregates is noted. In the article, the author evaluated the realization of the economic efficiency resource of the use of a deep loosener and a clawed coulter based on the results of field tests of the improved direct sowing aggregate. The reporting methodology for the economic assessment of the improved aggregate is reflected here.[10,11,12,13,14] Field tests of the direct sowing aggregate have shown that the annual efficiency of its application in one farm due to fuel savings alone is 735.28 manat. The payback period of the costs incurred for the development of the experimental variant is 1.6 years.[15,16,19]

Keywords: direct sowing, combined aggregate, deep loosening, seedbed, field trials, economic evaluation.

INTRODUCTION

Rich natural and climatic conditions and favorable geographical position indicate that there are wide opportunities for the development of agriculture in Azerbaijan. However, it is impossible to ensure an increase in the volume of crop production without implementing rational land cultivation methods. This means the application of energy, resource and soil conservation technologies. Such an approach to modern agricultural production is explained by the fact that the productivity of agricultural crops largely depends on the quality of operations to prepare the soil for sowing.

It is the process of tillage that affects the accumulation of moisture and nutrients in the soil, the destruction of weeds, and determines the weather regime in all layers of the soil horizon.

Many agricultural studies conducted in Azerbaijan have confirmed the effectiveness of combined tillage methods and direct seeding in preventing soil compaction due to multiple passes of aggregates [1, 2, 3, 4].

The application of these methods allows to significantly reduce the number of passes of agricultural equipment in the field, which prevents excessive soil compaction, degradation of fertile soil layers, and, in connection with this, saves energy and resource costs for technological operations of the production cycle of agricultural crops.

V.P. Goryachychkin, M.N. Letoshnev, G.Y. Listopag, A.B. Lurbe, G.N. Sineokov, G.S. Yunusov, N.N. Mammadov, and F.A. Mammadov made significant contributions to the study of the interaction of working bodies with soil in order to increase the efficiency of combined aggregates for pre-sowing operations.

Research in this area has retained its relevance today, and a number of improved ideas are constantly being published in the scientific press [5, 6, 7,20]. However, often the technological and technical options put forward and their justification in terms of economic efficiency with specific figures in changing economic conditions remain in the background.
direct seeding unit we developed was evaluated based on the results of field tests.

RESEARCH OBJECT AND METHODS

The object of the study was a combined experimental direct seeding machine based on combined operations and the results of its field tests. The special features of the object are the interaction of the improved seed drill with a deep softener . In production tests, the standard reporting method of new construction and technical means [8, 9, 10] was used to assess the efficiency of the experimental machine . This method was based on determining the difference in the costs of the existing and new variants. The tests were aimed at verifying the validity of theoretical research.

The experimental variant CZS-2.1 is assembled on a combined sowing-cultivator machine. It uses bed spreaders, vibrating deep looseners, and a claw coulter that ensures the distribution of seeds under the soil .

Figure 1 shows the change in tensile resistance in the base machine, theoretical and experimental machines as the speed increases. In all three variants, the increase in tensile resistance and the difference in these increases are clearly visible.

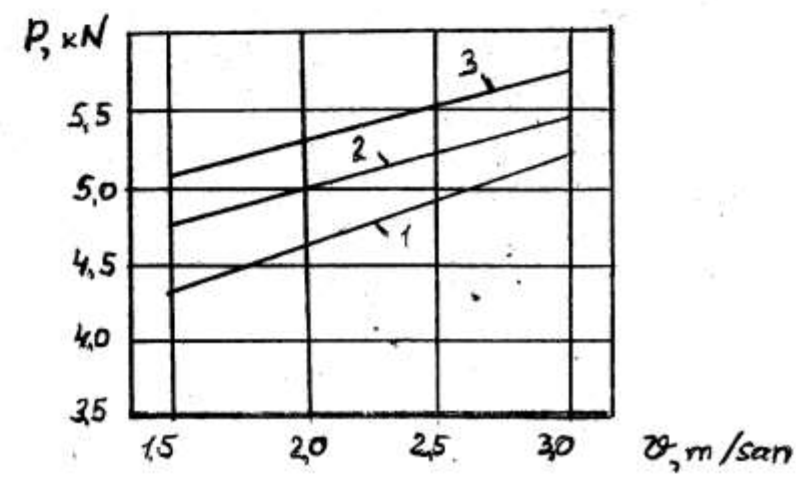

Figure 1. Thrust of the sowing units depending on the speed change in resistance.

1 - CZS -2.1, 2 - experimental, 3 - theoretical.
The experimental direct seeding machine was aggregated with the MTZ-82 tractor and carried out sowing in the fall. CZC-2.1 + MTZ-82 was taken as a control (table 1). The conditions for on-farm testing are given in table 2.

Table 1. Main indicators of the test.

Indicators	Unit of measure	Options	
		Base (soft)	Experimental
Transverse seed distribution under the seedbed	%	15.3...41.4	75.1...83.5
1 m ^{2} (if the norm is $4 \cdot 10^6$ units/ha)	number	284	356
Distribution of seeds across the width of the strip, $N_{e.or}$	%	15.6...25.4	78
Distribution in the direction of movement, M_{each}	At 1 m %	65...89	75...82
Seed spacing (when the norm is $4 \cdot 10^6$ units/ha)	mm	01...31	37...68

Table 2. On-farm testing conditions of the experimental seed drill.

No.	Indicators	Price of indicators
1	Date of holding	25.09.2016
2	Venue	Samukh district c/t

3	Composition of the aggregate	Exp SZS-2.1+MTZ-82
4	Work	Sprinkle
5	Plant	Wheat
6	Sort	Joy
7	Seed purity - %	97.6
8	Mass of 1000 seeds, g	36.25
9	Pre-sowing seed treatment	Medication
10	Mineral fertilizer	Superphosphate
11	Soil type	Gray chestnut
12	Peljev	Straight
13	Soil structure	Comal, dusty
14	Moisture content by layers, % 0 – 5 cm 5 – 10 cm 10 – 15 cm	 12.7 22.66 24.55
15	Soil density by layers, g/cm ^{3} 0 – 5 cm 5 – 10 cm 10 – 15 cm	 1.13 1.18 1.24
16		
17	Depth of softened layer, cm	5 - 7
18	Presence of plant residue	Barley root with soil, diameter not exceeding 3 mm (100 pieces per 1m ^{2})
19	Number of weeds, pcs/m ^{2}	6 - 24
20	Mass of stubble residue, g/cm ^{2}	100
21	Previous tillage	-

During production trials, the fields sown by the existing and experimental sowing units were monitored until the crop ripened, and the final results were compared (Table 3).

In the case of full maturity, the best results were achieved in the experimental variant for all indicators compared to the control variant.

Table 3. Control measurements on mature grain.

Indicators	Base	Experimental
Plant height, cm	52	56.50
Spike length, cm	4.81	5.34
Straw diameter, mm	1.68	1.77
Plant density in the field million/ha	6.12	6.61
Seeding rate, mln/ha	5	5
Turnover, times	1.23	1.33
Spike density, pcs/s	4.4	4.6
Mass of 1000 grains, g	41.71	41.80
Humidity	54.4	51.5

The improved seedbed and vibrating deep softener were significantly superior to the base variant in all indicators. The mass of one ear of grain sown with the base variant was 27.01% higher than the mass of one ear of grain sown with the base variant. Weed contamination of the field is practically the same in both variants.[17,19,9,10] The use of herbicides reduced weed contamination of the field. The yield of the day when sowing was carried out with the experimental variant was 19.8% higher than the yield in the control variant.

The costs incurred for the preparation of additional designs are calculated using the following formula:

$$C_k = C_{AH} + C_{OH} + C_{Qi} + C_{əH} + C_S, \tag{1}$$

where C $_k$ – cost of additional construction, manat;

C $_{AH}$ – price of purchased parts, manat;

C_{OH} – cost of manufacturing original parts, manat;
C_{QI} – cost of welding work, manat;
C_{XX} – the labor of the worker in the preparation and assembly of additional designs right, right;
C_S – workshop expenses, man.
The price of the purchased parts is given in Table 4.

Table 4. Prices of purchased parts.

No.	Product name	Quantity	Unit of measure	Price	Total amount
1	ECL/20-Digital amplifier plug for discrete valves	1	number	126.4	126.4
2	DSS-TA/1N-DOO-Hydro distributor	1	number	134.0	134.0
3	C22S3-D24K1/11 1903081 Socket for DS3 and DL5B = 24B	1	number	11.8	11.80
4	PMMD-A13G/20 plate for distributors and valves	1	number	49	49
5	EDCPC/10 3898301001-Connecting cable and software for ECL plug-in amplifier	1	number	52	52
6	Rigid pipeline for hydrosystem	6	m	4.6	27.6
7	Flexible hydraulic hose	4	number	4.6	18.4
8	12 x 18H9T -52mm diameter tube	10	m	20.7	207
9	Stusser	12	number	2.8	33.12
Total					**659.32**

The cost of manufacturing original parts is calculated using the following formula:

$$C_{OH} = K_{\dot{I}S} \cdot P_{ED} \cdot P_i \cdot n \cdot C_n \cdot t_{ət} + C_{\dot{I}H}, \quad (2)$$

where C_{OH} – costs of manufacturing original parts, manat;
K_{IS} – coefficient taking into account the scale of production of the product (K_{is} = 1.0);
P_{ED} – coefficient taking into account processing accuracy (P_{ED} = 1.1);
P_i – surface accuracy class coefficient (P_i = 1.4);
n – parts of the same type (n = 12);
C_n – hourly wage of the employee (C_n = 2.5 manat);
$t_{эт}$ – average labor intensity of part preparation ($t_{эт}$ = 3 hours);

$$C_{OH} = (1{,}0 \cdot 1{,}1 \cdot 1{,}4 \cdot 12 \cdot 2{,}5 \cdot 3) + 20{,}7 = 159{,}3\ man$$

The cost of welding work is calculated using the following formula:

$$C_{Q\dot{I}} = C_{nq} \cdot t_v \cdot k + C_E, \quad (3)$$

where C_{QI} – cost of welding work, man;
C_{nq} – hourly wage of the welder (Cnq = 5 man);
t_v – time spent on welding (t_v = 7 hours);
K – coefficient related to the complexity of the work (K = 1.03);
C_E – price of electrodes (C_E = 46 manat).
If we substitute the values (7, 2, 3) into the formula, we get:

$$C_{Q\dot{I}} = (5 \cdot 7 \cdot 1{,}03) + 46 = 82{,}05\ man$$

The following formula is used for the basic salary of assembly workers:

$$C_{əəн} = P \cdot P_N \cdot C_{nç} \cdot t_y \cdot P_k \quad (4)$$

where $C_{эх}$ – labor cost of workers who assemble the structure right, right;
P – additional coefficient of the basic salary (P = 1.03);
P_N – coefficient taking into account the ratio of full and operational times (P_N = 1.08);

C_{nch} – hourly wage of locksmiths (C_{nch} – 5 manats);
t_y – labor intensity of assembly work (t_y = 3 hours);
P_k – coefficient taking into account the constructive characteristics of the product (P_k = 4.0).
Thus, the basic salary of workers working in assembly work is as follows:

$$C_{əəн} = 1{,}03 \cdot 1{,}08 \cdot 5 \cdot 4{,}0 \cdot 3 = 66{,}74\ man$$

The wage fund, taking into account additional salary and social benefit deductions, is calculated using the following formula:

$$C_{əн} = C_{əəн} + C_{ələn} + A_c \qquad (5)$$

where C_X – full salary, man;
C_{Wage} – basic wage (C_{Wage} = 66.74 manat);
C_{ALAH} – additional salary (C_{ALAH} = 0.18 · 66.74 = 12 manats);
A_c – allocation to social benefits (A_c = 0.3 · 66.74 = 20 manat).
If we substitute the values in formula (5), we get:

$$C_{əн} = 66{,}74 + 12 + 20 = 98{,}74\ man.$$

The workshop costs for preparing additional designs for improvement work are determined by the following formula:

$$C_s = C_{əн} \cdot K, \qquad (6)$$

where C_{WH} – full salary (C_{WH} = 98.74 manat);
K – coefficient taking into account workshop costs (K = 2).
Here we get:

$$C_s = 98{,}74 \cdot 2 = 197{,}48\ man.$$

So, the investment for the experimental variant is as follows:

$$C_k = 659{,}32 + 159{,}3 + 82{,}05 + 98{,}74 + 197{,}48 = 1196{,}89\ man$$

To calculate the economic efficiency of the experimental direct seeding machine, the main indicators were compared with the indicators of the base variant.

The productivity of a seed drill used for direct seeding as a base option is as follows:

$$W_s = 0{,}1 B_{iş} \upsilon_{iş} \cdot t, \qquad (7)$$

where B_{work} is working engurum, m, B_{work} = 2.05 m;
υ – average working speed of the unit, υ = 2.5 m/sec = 9 km/h;
t – queue time utilization coefficient, t = 0.75.
The average working speed of the base variant, υ_b =7 km/h.
Considering the prices for the base variant

$$W_{sb} = 0{,}1 \cdot 2{,}05 \cdot 7 \cdot 0{,}75 = 1{,}07\ ha/saat,$$

For the experimental version

$$W_{s\ eks} = 0{,}1 \cdot 2{,}05 \cdot 9 \cdot 0{,}75 = 1{,}38\ ha/saat.$$

The annual (seasonal) workload is calculated as follows:

$$Q_{il} = W_s \cdot T_{il} \qquad (8)$$

where T_{year} – annual (seasonal) load of the unit,

$$T_{il} = 300\ saat.$$

Considering this, for the base option

$$Q_{il\ b} = 1{,}07 \cdot 300 = 321\ ha,$$

For the experimental version

$$Q_{il\ b} = 1{,}38 \cdot 300 = 414\ ha.$$

The direct labor input (t_y) per unit of work of the machine is determined by the following formula.

$$t_y = \frac{\Lambda}{W_s}, \tag{9}$$

Here Λ is the number of workers servicing the machine (Λ = 1 person).
Considering this, for the base option

$$t_{yb} = \frac{1}{1{,}07} = 0{,}93\ saat/ha,$$

for the experimental version

$$t_{yeks} = \frac{1}{1{,}38} = 0{,}72 \frac{saat}{ha}.$$

Labor cost savings are defined as follows:

$$Э_{work} = \left(t_{yb} - t_{yeks}\right) \cdot Q_{il} \tag{10}$$

If we substitute the values in formula (10), we get

$$Э_{work} = (0{,}93 - 0{,}72) \cdot 414 = 86{,}94\ h.$$

The increase in labor productivity is calculated using the following formula:

$$P_{əmək} = \left(\frac{t_{yb}}{t_{yeks}} - 1\right) \cdot 100 \tag{11}$$

Substituting the values in formula (11), we get:

$$P_{əmək} = \left(\frac{0{,}93}{0{,}72} - 1\right) \cdot 100 = 29\%$$

Fuel consumption per unit of work (G) is calculated using the following formula:

$$G = \frac{1}{W_s} \cdot N_e \cdot q \cdot \alpha, \tag{12}$$

where N_e – nominal power of the engine, N_e = 60 kW;
q – specific fuel consumption per unit of engine power, q = 0.220 kg/
kW · hour;
α – engine utilization factor, α = 0.8.
Considering the prices for the base variant

$$G_b = \frac{1}{1{,}07} \cdot 60 \cdot 0{,}22 \cdot 0{,}8 = 9{,}87\ kq/ha,$$

for the experimental version

$$G_{eks} = \frac{1}{1{,}38} \cdot 60 \cdot 0{,}22 \cdot 0{,}8 = 7{,}65\ kq/ha.$$

The fuel savings of the designed machine based on its annual operating volume are calculated using the following formula:

$$Э_{yanacaq} = (G_b - G_{eks}) \cdot Q_{il\ eks}\,, \tag{13}$$

If we substitute the values in formula (13), we get:

$$Э_{yanacaq} = (9{,}87 - 7{,}65) \cdot 414 = 919{,}1\ kq.$$

Considering that the price of 1 kg of diesel fuel is 0.8 manat, we can find the annual economic effect:

$$Э_{il} = 919{,}1 \cdot 0{,}8 = 735{,}28\ man.$$

The payback period of the investment is as follows:

$$T = \frac{C_k}{Э_{il}}, \tag{14}$$

$$T = \frac{1196{,}89}{735{,}28} = 1{,}6\ il$$

The annual efficiency of using an experimental direct seeding machine on a farm solely due to fuel savings is 735.28 manat, and the payback period is 1.6 years (Table 5).

Table 5. Economic efficiency indicators of direct seeding machines.

Indicators	Unit of measure	Options		Change in indicators
		Base	Experimental	
Price of improvement	man	-	1196.89	-
Aggregate productivity	ha/hour	1.07	1.38	+ 0.31
Fuel consumption	kg/ha	9.87	7.65	+ 2.22
Annual economic efficiency	man	-	735.28	-
Payback period	year	-	1.6	-

The research recommendations were discussed and approved by the Scientific and Technical Council of ASAU and recommended for publication and dissemination for the use of manufacturers (Protocol No. , 2021 Supplement).

Field tests of the combined direct seeding machine have shown that the annual efficiency of its application on a farm, due to fuel savings alone, is 735.28 manat. The payback period for the costs incurred in developing the experimental variant is 1.6 years.

Conclusion

The field tests demonstrated that the experimental combined direct seeding machine, incorporating an improved seedbed system and vibrating deep loosener, provides significant technological and economic advantages compared with the conventional seeding unit. The experimental machine improved the distribution of seeds both across the width of the seedbed and in the direction of movement, resulting in more uniform seeding conditions. The field measurements also showed improvements in plant height, spike length, plant density, spike density, and other crop-development indicators compared with the base variant. In particular, the yield obtained with the experimental variant was 19.8% higher than that of the control variant.

The experimental machine also demonstrated higher operational productivity. Aggregate productivity increased from 1.07 to 1.38 ha/hour, representing an improvement of 0.31 ha/hour. At the same time, fuel consumption decreased from 9.87 to 7.65 kg/ha, indicating a reduction of 2.22 kg/ha. These results confirm that the integration of direct seeding and soil loosening operations can reduce resource consumption while improving the efficiency of field operations.

The economic assessment further confirmed the feasibility of the proposed design. The investment required for the experimental improvement was 1,196.89 manat, while the annual economic benefit resulting from fuel savings alone was estimated at 735.28 manat. Consequently, the calculated payback period was 1.6 years. These indicators demonstrate that the experimental direct seeding machine can provide a relatively rapid return on investment under the tested operating conditions.

Overall, the results indicate that the experimental direct seeding machine is a promising resource- and energy-saving technology for grain production. Its higher field productivity, lower fuel consumption, improved seeding performance, and short payback period provide a sound basis for further testing and potential adoption in agricultural enterprises. However, additional multi-year and multi-location field trials would be valuable to confirm the stability of the observed agronomic and economic effects under different soil, climatic, and production conditions.

USED LITERATURE

1. Aduov, M., Nukusheva, S., Tulegenov, T., Volodya, K., Uteulov, K., Karwat, B., & Bembenek, M. (2023). Experimental Field Tests of the Suitability of a New Seeder for the Soils of Northern Kazakhstan. Agriculture, 13(9), 1687. https://doi.org/10.3390/agriculture13091687
2. Babu, U., Shukla, A. K., Kumar, A., & Meena, R. K. (2021). Effect of Sowing Methods and Nutrients on Growth and Yield of Wheat (Triticum aestivum L.): A Review, Curr. Rese. Agri. Far. 2(2), 18-22. doi: http://dx.doi.org/10.18782/2582-7146.135
3. Belyaev V.I. Experience of implementation of minimal and zero technologies in Altai Kras / V.I. Belyaev, T. Maynel // Herald of Altai State State Agrarian University – Barnaul: AGAU, 2008, No. 12 (50). - p. 56-61.
4. Bondarev A.V. Development of an energy-saving method of sowing grain crops with simultaneous fertilizer application: Author's Ref. dis. sugar mech. Science - Voronezh, 2008. - 20 p.
5. Gorbachev S.P. The width of the seed-pressing disk of the combined disc coulter of the seed drill / S.P.Gorbachev, N.E.Rudenko // Vestnik APK Stavropolya. – Stavropol, 2012, No. 1. - p. 42-43.
6. Gorbachiov S.P., Rudenko N.Y. A new technology of seeds plowing down // Tractors and Agricultural Machinery. - 2012. - Vol. 79. - N. 12. - P. 16-17. doi: 10.17816/0321-4443-65958
7. GOST R 53056 – 2008 Agricultural technology. Methods of economic evaluation (Electronic resource URL:http : // standard gost.ru /g/% D0%93%D0%9ED0%A1% D0%A2% D0%AO53 056 – 2008
8. Greiner, Romy. 2015. Factors Influencing Farmers' Participation in Contractual Biodiversity Conservation: A Choice Experiment with Northern Australian Pastoralists. Australian Journal of Agricultural and Resource Economics 58(1): 1-21.
9. Harrison, Glenn W. 2014. Cautionary Notes on the Use of Field Experiments to Address Policy Issues. Oxford Review of Economic Policy 30(4): 753–63
10. Holt, Charles A., Angela M. Smith, and William Shobe. 2006. An Experimental Basis for Public Policy Initiatives. In Promoting the General Welfare: New Perspectives on Government Performance, ed. E. Patashnik and A. Gerber. Washington D.C.: DC: Brookings Institution Press, 174–99.
11. Karimli, V.M., Sheydai, T.A., Simkiv, L.E. (2026). Green Economy and Sustainable Development in Azerbaijan. In: Mammadov, F.S., Kacprzyk, J., Pedrycz, W., Abbasov, A. (eds) 2nd International Conference on Smart Environment and Green Technologies—ICSEGT2025. ICSEGT 2025. Lecture Notes in Networks and Systems, vol 1817. Springer, Cham. https://doi.org/10.1007/978-3-032-16883-2_36
12. Lushnikova M. Урожаи с непаханых полей / M. Lushnikova // AgroTechnika, 2007, №1. - p. 19 - 20.
13. M. S. Manavadaria, V. Karimli Maharram, M. R. Yadav, P. Subhash Patil, G. Vijayalakshmi and H. Patil, "Innovative Detection of Human Motion Intention using a Hybrid EEGNET Framework," 2025 International Conference on Intelligent Computing and Knowledge Extraction (ICICKE), Bengaluru, India, 2025, pp. 1-6, doi: 10.1109/ICICKE65317.2025.11136200
14. Methodology for determining the effectiveness of technologies and rural farming techniques / by A.V. Shpilko. - M.: 1998. - 219 p.
15. Pisarev O.S. Justification of parameters and development of a combined coulter planter for direct sowing of grain crops: Autoref. dis. sugar mech. Science - M., 2006. - 20 p.
16. Polunin G.A. Methodological recommendations for determining the economic effect of using the results of scientific research and experimental design work in an agricultural complex/G.A. Polunin and others. – M.: РАСХН, 2007. – 12 с.
17. Shushin A.I. Quasi-stationary approximation for analyzing the geminate and bimolecular stages of singlet fission in molecular semiconductors // Himičeskaâ fizika. - 2025. - Vol. 44. - N. 1. - P. 36-43. doi: 10.31857/S0207401X25010046

18. Sorokin N.T., Tabashnikov A.T. TECHNIQUE OF THE ASSESSMENT OF AGRICULTURAL MACHINERY ECONOMIC EFFICIENCY. Agricultural Machinery and Technologies. 2015;(2):41-44. (In Russ.)
19. Vishnyakov A.S. Agrotechnical assessment of seed drills with combined vibration seeding devices / A.S.Vishnyakov, V.A.Kozlov, A.A.Vishnyakov, Ar. A. Vishnyakov // Vestnik Kras GAU. – Krasnoyarsk: Kras GAU, 2011, No. 7. - p. 175-179.
20. Zvolinsky V.N. Development of direct-seeding seed drills / V.N. Zvolinskii, N.I. Lyubushko // Tractors and agricultural machinery. – 2003, No. 7, - p. 32-36.