

A complex of breakthrough grain production technology

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Abstract. The massive introduction of foreign machinery, seeds, and technologies not adapted to Russian conditions over the past quarter-century have led agricultural production in Russia to reduce yield and quality of manufactured products. The reasons leading to the loss-making of Russian production are manifold, namely, over-compaction of fields with heavy equipment and small processing, excluding moisture absorption and moisture accumulation, destroying floods, artificial “drought,” forced late sowing and ultra-expensive western equipment. This article is devoted to the description of a breakthrough proposal, which includes the creation of technology with a complex of domestic technology, which is cost-effective and import-leading in all environmental, energy, and economic indicators. The research work is approved by many official scientific and technical councils and is a significant legitimate contribution to the development of agricultural machinery in Russia, increasing labor productivity in agricultural production and restoring the health of the nation. On the basis of domestic tractors of traction classes of 1.5–5.0 ts, a full range of functional agricultural equipment has been created that provides an increase in productivity, yield and its quality, profitability up to 2 times with a decrease in specific metal consumption, power, fuel consumption and cost growth from 2 to 4 time.

1 Introduction

The scientifically unreasonable transition to a market economy in the Russian agro-industrial complex has led to catastrophic consequences in particular healthy livelihood of the nation: the destruction of crop rotation, crop shortages, a sharp decline in the quality of agricultural products, an increase in production costs, the elimination of domestic traction and aggregated machinery, unemployment, the destruction of villages and the country's shameful food dependence from other countries [1–4].

Instead of domestic production equipment, heavy foreign equipment poured into the fields of Russia in a mass stream without any comparative tests on the appropriateness of its use in Russian conditions. Tests of MIS equipment were attended only for compliance with the technical conditions of the manufacturer. However, this check did not take into account the permissibility of their use in our soil and climatic conditions. The incoming equipment had a huge unjustified difference in technical and economic indicators.

The scientific basis of the presented scientific and technical research work is constituted by studies on the conditions of evaporation and conservation of soil moisture according to Juren's law on capillary evaporation of soil moisture, the design of the seedbed according to the theory of T.S. Maltsev and the agrochemical basis of the teachings of D.N. Pryanishnikov that ignorance of

agricultural technology can not be compensated by the use of excess mineral fertilizers [5, 6].

The use of foreign crop cultivation technologies in a truncated version with the use of heavy tractors with tillage sowing units with pneumatic sowing of foreign seeds in many farms led to the following negative consequences:

- an exception to the technology of autumn methods of moisture absorption (dump processing, slotting, worming, plane cutting);
- failure to comply with the requirements of crop rotation and the accumulation of humus;
- re-compaction of fields with heavy equipment, which eliminates the possibility of moisture absorption in the lower horizons;
- Failure to comply with agrotechnical requirements for combing and crumbling of the soil, leading to evaporation of moisture;
- uneven seeding of seeds into the soil, which leads to uneven and weak seedlings, and their uneven maturation, and a guaranteed decrease in yield;
- the high cost of grain due to low yield, high depreciation when using foreign equipment;
- forced high costs of herbicides with minimal tillage.

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2 Research results and discussion

The research results are generalized by a mathematical model for the major groups of functional indicators.

The mathematical expression is the goal function of the factor space of production technology (general view) [7]:

$$F(\vec{x}) = \frac{\sum_{j=1}^{m_1} \sum_{i=1}^8 \alpha_{ij} \cdot \eta_{ij}}{\sum_{j=2}^{m_2} \sum_{i=1}^8 \beta_{ij} \cdot \eta_{ij}},$$

In this equation, i is the serial number of a series of indicators (1 – healthcare, 2 – environmental protection, 3 – agricultural technology, 4 – ergonomics, 5 – design, 6 – energy conservation, 7 – economy, 8 – organization); j – serial number of the corresponding indicator in the series; α_{ij} and β_{ij} are the weights of individual indicators for the numerator (maximized) and the denominator (minimized).

$$\eta_{ij} = \frac{x_{ij}^n}{x_{ij}^{ot}},$$

In this equation, η_{ij} is the relative parameter indicator for the new n and ot as the old tool; m is the number of indicators in the series.

The expression of the function of the goal of the factor space of the production technology must satisfy some conditions.

Firstly, it should be a form $F(\vec{X}_i)$, which allows minimizing or maximizing the value of F depending on the values of X_i parameters (objects of research) of the factor space of surface tillage (object of research).

Secondly, it is built in the factor space of parameters so that any change in the parameter X_i , which affects the technical indicators, would cause a change in the value of the target function, *ceteris paribus*.

Thirdly, it should reflect both positive and negative values of indicators (subjects of research) of the new machine compared to the previous one and respond to the leading indicators.

Over the 20 years of operation of heavy imported tractor units, many adverse effects on the economy and ecology of agricultural production have been identified [8, 9], and organizational and design actions have been carried out in connection with this [10-14]. Among the negative impacts on the economy and ecology of agricultural production, the following main negative consequences can be distinguished.

The use of heavy tractors in agricultural production causes soil compaction. This circumstance entails the exclusion of moisture absorption, the displacement of air from the soil, the destruction of soil flora and fauna, the elimination of humus formation and the delay in the development of plant roots, the late maturation of the soil for sowing in spring and the delay in sowing for up to a month, the underweight and weight of grain. As a result, lacking the potential of zoned varieties, the shortage of grain, crops, the purchase of foreign varieties

of grain that are not adapted to the conditions of Russia. Moreover, the quality of purchased planting material does not meet safety standards since the purchase of genetically modified planting material causes oncological, mental, and neurological diseases of the population.

Comparative tests of some heavy imported tractors with tillage and sowing units showed a big difference in productivity, compared with our complex reaching up to 4 times (Table 1, 2).

Table 1. Comparative structure of the cost of sowing by various units. Field trials of the Volga MIS in LLC Soyuz-Agro of the Almetyevsk district of the Republic of Tatarstan

brand name	rub/ha
1. MTZ-82 + SBMP-8 (<i>Tatar Agricultural Research Institute</i>)	432,6
2. MTZ-1221+ 3SZP-3,6 (<i>traditional</i>)	464,8
3. Deutz-FahrAgrotron 265 + Solitair 12	701,6
4. MTZ-1221 + Agromaster 4800	827,7
5. MTZ-1221 + Ob'-4,8	901,8
6. Fendt 936 Vario + Horsch ATD 9,35	1282,7
7. New Holland TJ 375 + Flexi-Coil 9,8	1606,4

Table 2. The performance of the seeder SPBM-16P in comparison with foreign counterparts

Indicators		Seeders	SPBM-16P	Flexi-Coil9,8	Solitair12
1	Coverage, m		16	9,8	12
2	Traction tractor brand		MT3-1221 T-150K	New-Holland TJ 375	Deutz-Fahr Agro tzon 265
3	Traction power of the unit, kW		69,7	104,0	126,1
4	Power of energy means, kW		92	283	192
5	Unit speed, km/h		11,6	9,2	12,4
6	Unit productivity in an hour of the main time, hectare / h		12,9	9,0	10,4
7	Cost of crops, RUB / ha		465	1643	702

The use of the SPBM-16P seeder is more profitable than the compared foreign units according to Flexi-Coil 9.8 and Solitair 12 in terms of required traction power by 33 and 45 %, productivity – by 43.3 and 24 %, sowing costs – by 81.7 and 33, 8 %.

The aggregation of the Smaragd foreign technological machine, as compared to our KPS-4, also exceeds fuel consumption by 4.3 times while reducing productivity by 3.1 times.

Today, the tractor manufacturing complex of Russia consists of KamTrak, RTM-160, Agromash 85TK, 150TГ, 180TK, Kirovets K-424, Kirovets K-744 R2, R3, R4 tractors. All of the aggregate the best for today's complex of domestic equipment JSC PK Yaroslavich (Fig. 1).

In the experimental fields of the Tatar Agricultural Research Institute, where KBM-4.2N cultivators cultivate almost 100 % of the fields, the average yield of grain crops was 16.3 c/ha, and in the Republic of Tatarstan without these cultivators – only 9.8 c/ha. In the fields of Vostok Zernoprodukt JSC in 2006–2019 on an area of 250 thousand ha using our technology, wheat crops of 30–35 kg/ha are obtained under any weather conditions and 85 % of the grain of class 3.

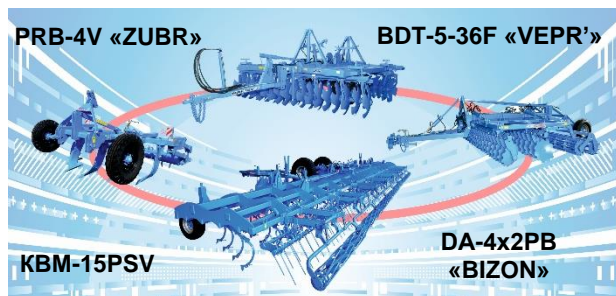


Fig. 1. Technological complex of the Flagship of the Russian agricultural engineering of the Yaroslavl modernized equipment

The cost of imported massive aggregates by the example of the Fendt-930 + Horsh 9.35 compared to the domestic one is 6.65 times higher (Table 3), which directly by depreciation deductions increases the cost of grain grown by the same amount.

Table 3. The cost of the compared units

Brand	Sowing on stubble 1. Sowing: Horsch-9.35 + Fendt-930	Processing: 1. BDM-3.2x4 2. KBM-4.2 3. Sowing: MTZ-82 + SZ-Shaidullina 4. Skating rink	Stubble sowing 1. Sowing: Victoria + MTZ-1221	Processing: 1. BDM-3.2x4 2. KBM-4.2 3. Sowing: MTZ-82 + SPU-6 4. Skating rink
Cost	10590 050	1 592 875	2 094 010	1 908 265

Further, the cost is still doubled by obtaining an ultra-low crop due to moisture loss and increased action of drought.

Based on extensive comprehensive tests from 1980 to 2019, we propose a breakthrough project to eliminate food dependence in Russia, which includes the restriction and exclusion of the use of herbicides, pesticides and insecticides due to agricultural technology, moisture accumulation and moisture conservation measures by the complex of modular equipment of JSC PC Yaroslavich, LLC Varnaagromash and the production base of agricultural machinery of the Republic of Tatarstan.

A universal resource-saving technology for tillage and sowing has been developed. This technology includes work in the autumn and spring. In autumn, the following works are carried out: post-harvest (after harvesting) surface, water-accumulating cultivation on stubble to a depth of 3–5 cm, the main autumnal dump or non-moldboard tillage to a depth of 10–30 cm, and deep

moisture-accumulating chisel cultivation (once in the rotation) depth of 35–45 cm.

In spring, the following works are carried out: moisture-closing cultivating to the depth of seed placement, and then mulching the leveled presowing treatment to the same depth with the creation of a seedbed and combing of weeds in the head stage of their development, as well as sowing with fertilizer in ordinary, narrow-row, wide-row or scatter methods.

3 Discussion

Thus, to increase the efficiency of ecological agricultural production, it is necessary:

1. To accumulate and retain moisture, eliminating the "drought" and "floods" due to the loss of moisture absorption of the soil,

2. For sowing, friendly germination, uniform stable development, ripening and harvesting of grain, fodder and fodder crops, sown even to a depth of only 2-3 cm, the field should be qualitatively aligned without ridges, a seedbed created according to T.S. Maltsev and is covered with a mulched layer that maintains a stable heat-moisture-air regime.

3. To exclude soil compaction by heavy tractors (as a rule – foreign).

4. For multiple (at least 2) reduction of depreciation deductions in the cost of crop production – feed and fodder, do not use expensive aggregates.

5. Domestic units with the same working width should be higher: in productivity, productivity, and profitability up to 2 times, lower in fuel costs, required power – up to 3 times, specific metal consumption – up to 4 times, which is achieved by our cars.

The developed set of machines for cultivating crops fulfills all the elements of technology adopted for the specific conditions of the zone and meets the functional requirements of agricultural technology, environmental protection, ergonomics, energy conservation.

At the same time, the selected technology and complicated machines ensure the production of final products:

- free of hazardous impurities for human health;
- without the use of genetically modified plant varieties;
- without additional water consumption due to the economical use of soil moisture;
- the exclusion of water, wind, and mechanical erosion, the use of progressive agricultural technology, without destroying the soil structure, dispersing it and ensuring that moisture is absorbed into the lower horizons;
- application of crop rotation and crop varieties of domestic selection appropriate for the zone;
- ensuring the fulfillment of agrotechnical requirements for soil crumbling, combing of the surface soil layer, uniformity of the depth of cultivation and sowing, sowing dates, allowing to obtain friendly seedlings and their development;

- pre-sowing soil cultivation with combing out weed root systems to exclude the use of herbicides and create conditions for organic farming;
- eliminate vibration to create the working conditions of the machine operator by high-quality leveling the field surface, by installing automatic systems for setting and monitoring the depth of processing, seeding rate and quality control of the unit;
- the creation of universal and combined machines and assemblies with replaceable working bodies and modules made of high-strength steels, equipped with fuses and vibrators, as well as performing all the elements of the technological process of operation of the unit (transportation, deepening, work, deepening, turns) and having low metal consumption;
- increasing the productivity of units by 2...4 times while reducing the required power and fuel consumption for functional operations from two to three times, reducing the metal consumption by 3...4 times due to the creation of universal and combined machines;
- reducing the cost of crop production by reducing the cost of machinery and the use of universal equipment throughout the season of fieldwork;
- the exception of the use on the fields of heavy agricultural machinery of foreign production, compacting and draining the soil;
- introduction of scientific developments of scientists of the Russian Academy of Sciences and universities to create advanced technologies and agricultural machines.

4 Conclusion

1. It is proved that imported tillage and sowing complexes are not adapted to Russian conditions and did not justify their advertising indicators; they contributed to the creation of the country's food dependence.

2. The agro engineering science of the Russian Academy of Sciences can create, and regional agricultural machine-building, to produce reliable, high-quality, highly economical, highly productive, competitive fully import-substituting and import-bearing soil cultivating and sowing machines for efficient ecological feed production.

3. An inter-regional competitive before any foreign resource-saving anti-arid technology for the production of crop production based on the use of only domestic import-substituting equipment complex according to the plan of research of the Russian Agricultural Academy and the Russian Academy of Sciences has been developed. This technology has been successfully tested in the Republic of Tatarstan, Bashkortostan and Chuvashia, Yaroslavl and Ivanovo, Kirov regions, in the zone of the Southern Urals and Krasnodar Territory.

4. It is proved that the proposed technology with a complex of domestic equipment is the most cost-effective in comparison with any foreign one in those

regions where the tests were carried out, and is convincingly import-leading in all environmental, energy and economic indicators.

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