A complex of breakthrough grain production technology

Nazib Maitzov¹, Rustem Sakhapov², Salavat Mudarisoğ³, Lenar Sharafiev¹, and Sergey Dmitriev⁴

¹Kazan State Agrarian University, 420015 Kazan, Russia
²Kazan University of Architecture and Civil Engineering, 420043 Kazan, Russia
³Bashkir State Agrarian University, 450001 Ufa, Russia
⁴Tractor Plants Concern, 428022 Cheboksary, Russia

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. Mal’tsev 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.

*Corresponding author: rusakhapov@gmail.com

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).
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]:

$$F(\bar{x}) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} \alpha_{ij} \cdot \eta_{ij}}{\sum_{i=1}^{m} \sum_{j=2}^{n} \beta_{ij} \cdot \eta_{ij}}$$

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; $a_{ij}$ and $b_{ij}$ are the weights of individual indicators for the numerator (maximized) and the denominator (minimized).

$$\eta_{ij} = \frac{x_{ij}^{n}}{x_{ij}^{o}}$$

In this equation, $n_{ij}$ is the relative parameter indicator for the new n and on 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 $F(X_i)$, 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 (Tatar Agricultural Research Institute) | 432,6 |
| 2. MTZ-1221+ 3SZP-3.6 (traditional) | 464,8 |
| 3. Deutz-FahrAgrotрон 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 | SPBM-16P | Flexi-Coil9,8 | Solitair12 |
|------------|----------|---------------|------------|
| 1 Coverage, m | 16 | 9,8 | 12 |
| 2 Traction tractor brand | MTZ-1221 T-150K | New-Holland TJ 375 | Deutz-Fahr Agrotzoon 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, 150TT, 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.

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 | Processing:                  | Stubble sowing | Processing:                  | Cost            |
|----------------|-------------------|-----------------------------|----------------|-----------------------------|-----------------|
| Fendt-930 +   | 1. Sowing:        | 1.BDM-3.2x4                 | 1. Sowing:     | 1.BDM-3.2x4                 | 10590 050       |
| Horsch-9.35    | 2. KMB-4.2        | 2.KBM-4.2                   | 2.KBM-4.2      | 10 020 040                 |
|                | 3. Sowing:        | MTZ-82 + SZ                 | MTZ-1221       | 10 020 040                 |
|                | 3.6 (openers Shaidulla) |                 |                | 10 020 040                 |
|                | 4. Skating rink   |                             | 4. Skating rink| 10 020 040                 |

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 "drought" and "floods" due to the loss of moisture absorption of the soil.

1. To accumulate and retain moisture, eliminating the use of herbicides and insecticides due to agricultural engineering, 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 use of herbicides and insecticides due to agricultural engineering, 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 use of herbicides and insecticides due to agricultural engineering, 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 use of herbicides and insecticides due to agricultural engineering, 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.
• 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 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-ard 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.

References
1. K. Babkin, Russia needs a clear industrial policy, Rostelmash Report, 2, 32–35 (2007)
2. A.A. Ezhevsky, V.I. Chernoiwanov, There is no single policy on agricultural engineering, Mach.-technol. Station, 3, 20–21 (2018)
3. Yu.F. Shack, Grain of general-purpose, Rural life, 27, (24090), 5 (12–18 July 2018)
4. I. Obolensky, 10 million hectares – sowing is canceled, “Agrarian News”, Reg. Newspap. of the Urals, Siberia, Volga Reg., 7(48), A.17 (2010)
5. N.A. Kachinsky, Soil physics, Part 2. Water-physical properties and soil conditions (Vysshaya shkola, Moscow, 1970)
6. M.A. Glukhikh, V.B. Sobyanin, O.B. Sobyanin, Terenty Semenovich Maltsev. Ideas and research, Part 2. Mound, 31–34 (FGUIPP “Zauralie”, 2005)
7. N.K. Mazitov, Improving the technology and technical means of surface tillage, 29 (Tatar Res. Instit. of Agricult., Kazan, 1988)
8. N.K. Mazitov, R.L. Sakhapov, Yu.Kh. Shogenov, L.Z. Sharafiev, Yu.S. Tsench, I.R. Rachimov, A competitive complex of equipment and technologies for the production of grain and feed, Agricult. Sci. of the Euro-North-East, 3(20), 299–308 (2019)
9. V.M. Pronin, A.I. Davydov, The results of state tests of block-modular cultivators at the Volga MIS, Niva of Tatarstan, 3, 12–13 (2002)
10. S.G. Mudarisov, I.I. Gavitov, R.S. Rakhimov et al., Reasoning of modular-type tillage and seeding machines construction diagram and parameters, J. of the Balkan Tribolog. Associat., 25(2), 481–492 (2019)
11. N.Yu. Partasova, On measures to provide agricultural producers with modern agricultural machinery, Agricult. Machi. and Technol., 2(3), 8–11 (2008)
12. I.G. Ushachev, The agro-industrial sector of Russia under the conditions of sanctions: problems and opportunities, Agricult. Mach. and Technol., 3, 3–8 (2015)
13. V.I. Chernoiwanov, Priority areas of legislative support for agriculture, Technique, and equipment for the village, 1, 2–5 (2018)
14. S.G. Mudarisov, I.I., Gavitov Y.P. Lobachevsky et al., Modeling the technological process of tillage, Soil & Tillage Res., 190(2019), 70–77 (2019)