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The paradigm of digitalization of agriculture and tillage in the modern socio-economic conditions of the Middle Pre-Urals

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Abstract **— The study shows the problems and trends in modern agriculture, reflects foreign experience and current positions in tillage in the modern socio-economic conditions of the Middle pre-Urals. The first quarter of the new century is replete with theory and practice in the field of world and domestic agriculture. Implementing the idea of precision farming or digital agriculture in domestic conditions is extremely difficult, but it is extremely important that in the agricultural sector of the economy not be left "on the side of the high road" of world development trends. Evolutionary digital technologies are already emerging in the agro-industrial complex. At the same time, land and soil, while remaining the main means of production in the agricultural sector, require high-quality processing and extended reproduction of fertility.**

Keywords — digitalization of agricultural production, precision farming, soil fertility, agrophysical properties of the soil, soil treatment matrix, modern social and economic conditions.

I. INTRODUCTION

In the 70s of the last century, the efforts of scientists, enthusiasts, and agronomists introduced scientifically based farming systems and intensive technologies of cultivation of field crops. Together with intensive varieties, they ensured the effective use of all possible agrochemicals. This approach allows you to get 6–8 tons of grain or dry matter of feed per hectare.

In the 1990s, zonal farming systems, including the Perm Krai, were violated everywhere. Half of the area of arable land stopped processing in the fall, and in the spring they preferred direct sowing on stubble. All this became spontaneous, without scientific substantiation, in violation of the system of crop rotation and the agrotechnology of cultivation of field crops.

Along with this, the technology of precision or precision farming has been cultivated in the European Union, the People's Republic of China and the United States for several decades. The production of grain and livestock products is growing, due to the widespread introduction of digital technologies in the agricultural technology of modern agriculture.

II. RESEARCH METHODOLOGY

The core of digital technology is crop productivity management, which takes into account changes in habitat and plants. Electronic computer systems are used at digital agriculture, including geographic information systems (GIS), the global navigation tracking system GLONASS, modern samples of agricultural equipment equipped with GLONASS / GPS systems. Over 60% of agrarians in the Federal Republic of Germany use digital technology, including elements of precision farming, and in the USA this indicator exceeds 80% [1, 2]. Digitization of agricultural processes in agriculture can significantly reduce the cost of production, due to savings of agrochemicals, optimization of yield and higher quality products. A tractor with automatic GPS / GLONASS complexes - a receiver and a course controller, performs an operation according to a given program on a "chip-card" [1].

Algorithms for the introduction of elements of precision farming.

At the first stage, it is necessary to determine the actual size of the field area with their borders and create an electronic map, for which use processed satellite images, or images from UAVs (unmanned aerial vehicle Geoscan-201 or quadrocopter). The formation of a working map can be done using a ground mobile complex based on a car with a GPS / GLONASS receiver, a positional computer cartographer (PDA).

Further, the collection of information about the field begins with the mapping of the yield and moisture content of the grain. Different colors on this map distinguish zones of the levels of yield of field crops. Harvesting is carried out by combines, which are equipped with yield monitoring systems. The equipment includes: GPS receiver, on-board information system, sensors of humidity and grain mass, software mapping base. Results on the state of work in dynamics are recorded together with data from the sensors, at certain intervals [7].

In the third stage, the yield map is the rationale for the agrochemical survey. To do this they use a UAV, "Copter", or "jeep", equipped with a navigation system, an automatic sampler and a field PDA. Thus, the "jeep", following the route offered by the CCP, takes samples of the soil. The date, time of sampling and its number must be entered into the computer's memory.

At the fourth stage, information from different sources is inserted into a multi-layered electronic field map, which consists of several layers. Electronic strata display indicators of agrochemical and agrophysical surveys of the soil, its topography, harvest results, crop rotations, weather conditions and other factors of agronomy.

Further, the obtained data on the field are concentrated and form a map - a task on the "chip - card" in the on-board computer of the tractor. It moves across the field using GPS / GLONASS, determining its location and, referring to the map-task, "reads" the application rate of the agrochemical and sends a signal to the machine controllers for fertilizer application, pesticides, and a grain seeder.

The use of digital technology intensifies resource conservation, increasing crop yields by one-third. At the same time, the savings of agrochemicals (fertilizers, herbicides) reach 30–70% [6]. However, the widespread practical application of precision farming due to the high cost of machinery and equipment is significantly constrained.

III. THE RESULTS OF THE EXAMINATIONS

Agricultural science has already accumulated a large amount of data on the study of the influence of environmental and agrotechnical factors on the yield of field crops. In the era of digital agriculture and economic efficiency, it is important to use the positive beginnings of traditional technologies, matching them with elements of precision farming of economically developed enterprises.

However, in the recommended production methods, the techniques are poorly linked with each other and with the soil and climatic conditions, so they act as ready-made templates.

It is well known that agricultural techniques that increase crop yields under one condition become ineffective in others. The solution to this problem is to optimize technologies, that is, to adapt them to the evolving social and economic conditions. The technology must be dynamic, otherwise taking into account the possibility of influencing the process of the formation of yields during the growing season.

By optimizing the planting density of plants of field crops before harvesting, thinning processes in crops during the growing season, which is the basis for determining the optimal seeding rates, or modeling, designing the productivity of field crops.

The entire earth's surface is divided into homogeneous ecological systems inhabited by specific vegetation, animals, and microorganisms — biogeocenoses. Biocenosis possesses stability, self-regulation and isolation. These unique properties are supported by the diverse interactions between its organisms. Any negative impact on the plant basis of biogeocenosis is compensated by these links.

In the case of intensive use of elements of precision farming, it is necessary to create favorable agrophysical indicators of soil fertility: the density of the arable layer is 1.05–1.17 g/cm3, the content of valuable aggregates of size 0.25–10 mm is more than 50% of the mass of the arable layer, the content of dust and aggregates <0.25 mm is no more than 0–3%. [2,7,10,11,12,14,15,16].

Tillage was and remains the most widespread and widely available method of dealing with harmful objects. It performs a sanitary role, preventing the development of harmful insects and pathogens that are concentrated in the surface layer of the soil and plant residues. The most important task of tillage is to prevent soil erosion. In modern agriculture, tillage should contribute to the creation and preservation of water-resistant soil structure and fulfill the soil-protective role.

Tillage creates the conditions for enhancing microbiological activity and contributes to the decomposition of all post-harvest residues and fertilizers of the treated soil layer. This can be achieved only by a clever approach to tillage, significantly changing the composition of the arable soil layer (Table 1).

TABLE 1. PARAMETERS OF AGROPHYSICAL AND WATER-PHYSICAL PROPERTIES OF SOD-PODZOLIC SOIL WITH VARIOUS METHODS OF PRIMARY TREATMENT (ZUBAREV YU.N., FOMIN D.S., 2011)

Tillage techniques	**Agronomic valuable water aggregate (0.25–10 mm) before sowing, %**	**The density of the soil, g/m^2**		**Reserves of productive soil moisture (0–100 cm), mm**	
Dump cultural plowing	76	1.17	1.43	136	72
Dump Leveled Plowing	55	1.11	1.37	138	127
Flat cut	73	1.16	1.32	142	129
Chisel	61	1.15	1.41	154	143
Combined	61	1.12	1.38	160	148
Minimum	73	1.12	1.38	128	114
Zero	57	1.38	1.44	50	38

All the concepts of "soil treatment systems" can be illustrated by a formalized model (Fig. 1)

Tillage system in crop rotation				
Dump	Flat cut	Combined	Special Land Reclamation	On irrigated land
				On drained soils
				On the slopes
Soil treatment technology under				
Poisonous different and late	Winter crops	Rowing	Perennial	Other
After cereal	Clean pairs			Vegetable
After tilled	According to different pairs			Fruit
After years of	No couples			Berry
Seasonal complex tillage				
The main	Presowing	Summer plant care	Under a lot of grass	Under intermediate cultures
Processing techniques				
By the main technological operation			By depth	Special
With turn over	Without turn over	Ameliorative	Zero (without processing) 0-0,5 cm	Plantation plowing
Dump plowing	Chisel processing	Holeing	Surface 1-6 cm	Storey plowing
Rotary processing	Undump plowing	Chipping	Small 6-16 cm	
Milling	Cultivation	Wandering	Middle (normal) 18-24 cm	
Grinding		Combing	Deep 24-35 cm and more	
Technological operations				
Loosening	Crumbling	Mixing	Lining	Compaction
Turning over	Cropping			

Fig. 1. Formalized model of tillage and classification of concepts for tillage (cited by Yu.N. Zubarev, S.L. Eliseev, E.A. Renev et al., 2012)

To prepare the field for sowing crops It requires a series of tillage techniques for the accumulation of moisture, the control of harmful objects and weeds, and the creation of optimal conditions for the development of crops.

IV. Discussion of Results

It should be noted that in practice, agricultural technologies that save resources, often ignore the systematic processing of fields, which in the Middle Urals, with its soddy-podzolic soils of heavy grain size distribution, violates the long-term traditions of agronomy. Simplification in tillage leads first to indirect costs, and over the years it incurs direct losses from loss of soil quality and fertility.

In the Ural agriculture, the main tillage systems are used for spring early and late field crops, which, depending on the predecessor, are allocated to the processing subsystems for spring crops and for winter crops. Academician D.N. Pryanishnikov noted that "the culture of the field always follows hand in hand with the culture of man" [5]. That is why the issues of high-quality, rational and resource-saving tillage remain urgent and important. In the task of tillage in modern economic conditions, the main algorithm is to create an optimal set of soil properties. This, perhaps, is the whole point of the innovative attitude to tillage.

The tasks of agrophysics are the creation of an optimal structure of the arable layer and the formation of a small-clove soil structure. This will provide the best water and air conditions, form agrochemical and agrobiological properties of the soil, ensure the incorporation of organic (root-rod residues of stubble, weeds, straw, green manure or manure), mineral fertilizers and other agrochemicals.

It is very important, although technologically and financially difficult, to connect to digital agriculture now. At the same time, inevitably, precision farming technologies are already emerging in the agro-industrial complex of the Middle Urals.

So, in a number of advanced agrarian enterprises — LLC Agroholding Rus, Perm, LLC Agrofirm Rus Russia of Kungursky Region and LLC Klyuchi of the Chusovsky Region.

Processing systems for individual crops are combined in a rotation. Only crop rotation makes it possible to combine them most rationally and foresee the end results. All possible tillage techniques had tested according to the method of basic processing under individual cultures by the scientists of Perm GATU in the period 1968–2018. When erosion occurs, soil protection techniques are used in farms of various forms of ownership and regardless of the socio-economic conditions and the economic status of agricultural enterprises [8,10,13,1].

Most attention is paid to the main tillage - the first treatment after harvesting the previous crop, which significantly changes the composition of the arable layer of the soil [7,8,9].

The agrotechnical significance of primary or autumn processing is to improve the main factors of soil fertility. Timely autumn processing contributes to the accumulation of nutrients in the soil, enhancing aerobic processes and decomposition of plant residues, reduces the desiccation of the soil in the summer-autumn post-harvest period, while maintaining an effective effect on weed control. Stubble, plant debris and weeds left on the field after harvesting serve as a habitat and overwintering of many pests and pathogens. Conducting of stubble with the subsequent autumn plowing is an effective method of destroying harmful objects.

Conducting energy-intensive, requiring a large amount of equipment main processing in the summer-autumn period is very important in organizational terms. If the main treatment is not carried out in the autumn, then it is carried out in the spring before sowing. This dramatically increases the amount of spring field work, the quality of processing deteriorates, the time of sowing of spring crops is delayed, and their productivity is reduced. Therefore, high-quality carried out in optimal time, autumn processing is the key to future harvest. It is carried out by various methods and tools depending on the soil and climatic conditions of each specific region, nature.

Variants of saving technologies of tillage can be different: from carrying out surface treatments with flat-cutters, APK 1.8 “Leader”, KST, Diskator BDM-3 to direct sowing using SKP-2,1 seeders, or combined units such as “John Deere”, “Horsh”, “Amazon” or "Gaspardo" with elements of precision farming.

The evolution of farming systems and priorities of agricultural technology should be gradual, reasonable and intelligible for farmers, that is, systemic, without separation from the agro-industrial complex and the worker.

Thus, to minimize the main and pre-sowing tillage (mini-till) in the Middle Urals, a number of mandatory conditions must be taken into account. First, select suitable fields for fields with light soils of light particle size, structure, density, and fertility (about 20–25% of such soils in the Perm Territory), the least littered with weeds.

Second, as far as possible, keep plant residues on the field (chopped straw and stubble) as the arrival of organic matter. True, this practice in agriculture of the Perm Territory does not yet exist, and the straw in rare cases is removed “vrastil” and crushed on the surface of the field.

Thirdly, the minimization of field processing is highly expedient and recommended when there are erosion and soil deflation.

Fourthly, the minimum processing system requires mandatory development, implementation, and development of crop rotation with a set, alternation, and vegetation of crops in the regime of constant soil cover and the acquisition of seeds, zoned in this soil-climatic zone, responsive to saving technologies.

When developing and introducing into the LLC “Agrofirm Trud”, modern innovative principles of tillage cannot be a template. With saving technologies for the production of grain and fodder, not only are the methods of tillage and seeding changed, but other elements of the farming system must also be adjusted (crop rotations, fertilizers, plant protection, etc.).

V. Conclusion

1. Research by Professor M.N. Gurenyov and associate professor V.N. Mosin (1988–1989), scientists of the Department of General Agriculture and Plant Protection of Perm GATU, confirm the obligatory basic dumping or sowing-down deep processing once every two or three years, for softening the soil and destroying the “plow sole”. The effectiveness of such a processing system is economically and technologically justified in the Middle Urals.

2. Depending on the time of treatment and the method of impact on the soil, seasonal processing complexes are distinguished:

- main or autumn tillage;
- pre-sowing tillage;
- post-sowing tillage.

3. Specialists and agronomists who gradually and methodically master digital agriculture use elements of precision farming, point out a higher level of farming culture of their fields. Only 12 economically stable farms from the 43 agricultural enterprises of the Middle Urals, or 26%, began using digitalization systems for agriculture.

References

[1] Adamchuk, V.V. Precision Farming: essentiality and technical problems / V.V. Adamchuk, V.V. Moiseenko // Tractors and agricultural machines. - 2003. - No. 8. - Pp. 15-18.

[2] Adaptive farming in the Middle Urals: state, problems, and ways to solve them // Ural Research Institute of Agriculture. / Under the general editorship of N.N. Zezina, A.N. Semina. - Yekaterinburg, 2010. - 338 p.

[3] Bautin V.S. Center for Precision Agriculture / V.S. Bautin // Resource-saving Farming.- 2009.- No. 2. - Pp. 49-50.

[4] Belenkov A.I. Precision farming is a model of modern farming systems: Farming and plant protection technologies: intellectual and innovative resources / Mat. Scientific and Practical Conference dedicated to the 85th anniversary of the Department of General Agriculture and Plant Protection, Perm, 2010. - Pp. 132–135.

[5] Zubarev Yu.N., Eliseev S.L., Vasilyev A.A., Mosin V.N. and etc. Scientific and methodological foundations of the pre-Ural system of agriculture .- Perm, 2002.- 103 p.

[6] Zubarev Yu. Precision farming systems: textbook / Ministry of Agriculture. RF, FSBEI HPE Perm State Agricultural Academy. - Perm: 2012. - 121 p.

[7] Zubarev, Yu.N., Eliseev S.L., Renyov E.A, etc. Innovative technologies in agribusiness: textbook / E.D. Akmanaev [and others] under total. ed. Yu.N. Zubareva, S.L. Eliseeva, E. A. Renyov; Ministry of Agriculture. RF, FSBEI HPE Perm State Agricultural Academy. - Perm: 2012. - 335 p.

[8] Kashtanov A.S. Scientific farming of Russia for 75 years / A.N. Kashtanov, I.P. Makarov, A.V. Zakharenko // Bulletin of the Russian Academy of Agricultural Sciences. - 2004. - No. 3. - Pp. 7–9.

[9] Kiryushin V.I. Ecological basis of agriculture .- M.: Kolos, 1996. - 365 p.

[10] Kochetov I.S. Agrolandscape agriculture and soil erosion in the Central Non-Black Earth Region / I.S. Kochetov. - M.: Kolos, 1999. - 224 p.

[11] Makarov I.P. Resource-saving tillage systems / I.P. Makarov; by ed. Acad. VASKHNIL I.P. Makarova. - M.: Agropromizdat, 1990. - 242 p.

[12] Mingalev S.K. Resource-saving technologies of tillage: monograph. - Yekaterinburg. - 2006. - 322 p.

[13] Scientific basis of the system of agriculture of the Perm region for 1981-1985. / Under total. ed. V.V. Kazantsev, L.G. Sorokin, A.V. Korotaev, B.G. Levin et al. - Perm: Prince publishing house, 1982.- 258 p.

[14] Parahin N.V. Ecological sustainability and efficiency of crop production: theoretical foundations and practical experience. M.: KolosS, 2002. - 199 p.

[15] Rassadin A.Ya. development of a system for conservation of soil and resource-saving tillage for haymakings of landscape greenery. - M.: Publishing house of the Moscow Agricultural Academy, 1996. - 35 p.

[16] Safonov, A. F. Farming systems / A. F. Safonov, A. M. Gataulin, I. G. Platonov and others - M.: KolosS, 2006. - 443 p.