Opportunities and prospects of minimum soil tillage in Eastern Siberia

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Abstract. The article considers a multifaceted and universal impact on the soil machine tillage. This agrotechnical method is the most costly and environmentally dangerous with its formulaic and irrational use. Throughout the world, the annual mouldboard tillage led to a number of negative phenomena resulted in the development of erosion, dehumification and a drop in soil fertility. So the doctrine about the minimization of methods and tillage systems appeared. It has been established that both the mold board and the subsurface tillage have both positive and negative aspects. Minimalization of tillage is also not panacea, it has both promising opportunities and limitations. In this regard, at the present stage, the most appropriate combination and alternation mold board and subsurface, deep and shallow techniques up to the sowing in field crop rotations directly. It is most promising to improve the tillage based on the application of multi-operation tillage machines and mechanisms that combine tillage, sowing, fertilizing, levelling and rolling in a single pass across the field.

1. Introduction
In agrarian science, the search for modern and adaptive methods and tillage systems, taking into account the zonal conditions are constantly conducted. This is due to the fact that the effect of tillage on the surface layer of the earth's crust, i.e., the soil, is so multifaceted that there are no any universal ways of cultivating this layer as the main source of life for all plants, animals and humans on the globe.

At the same time, tillage is also the most expensive process in the agrarian economy; it accounts for about 40% of energy and 25% of the total labor costs for growing crops [1, 2]. Hence the need to minimize the process is evident.

2. Object of research
The transition to minimum tillage and search for resource-saving technologies is dictated not only by the economic state of the agriculture. Most likely, economic reasons are secondary, they are far from fundamental. The fact is that excessively systematic tilling of the soil, annual deep moldboard tillage, frequent and deep fallowing, multiproductive and intensive early spring and preplanting are accompanied by excessive mineralization of organic matter, destruction of humus, spraying of the soil, loss of soil fertility, development of erosion processes, violation of the ecological balance in farming systems, desertification of natural landscapes [3].
When "iron horses" and a plow came in life, according to the current data, 26 billion tons of fertile soils are washed and blown out annually in the world. According to the US scientists’ estimation, it is equivalent to a loss of 9.3 million hectares of arable land [3], and with it fertilizers and pesticides disappear. Everything is carried away to the bottom of rivers, seas, lakes, poisoning aquatic fauna, pollutes sources of drinking water.

At the same time fertility of the soil decreases, and consequently the yield decreases also. The area of deserts in the world is increasing annually by 6 million hectares. The sum of losses from erosion is estimated at 18-25 billion rubles [4]. The intensity of erosion phenomena is in 10 times more than the rate of natural soil-forming processes. The calculations showed that current losses from erosion processes are in 30–35 times higher than the average historical losses [5].

The minimalization (minimization) of tillage blocks, inhibits nitrification processes, prevents excessive mineralization, “preserves” the organic part from destruction, stabilizes the potential fertility of the soil, ensures its high stability to biological, wind and water erosion, prevents degradation and desertification of natural landscapes, introduces elements balance and harmony in the problem of ecology, reduces the risk of pollution of groundwater and toxicological effects [1, 3].

On the other hand, the processes of tillage minimalization require an increasing level of chemicalization due to increased nitrogen deficiency and increasing contamination of fields in all cases, on different soil types, in all countries and continents. Moreover, these processes are directly dependent on the level of chemicalization [6-8]. Nevertheless, today, the main vector in the development of soil tillage is aimed at its minimizing [6, 9]. In this regard, some researchers are in favor of a complete rejection of the plow and dump moldboard tillage in general, and accuse the plow tillage in all the troubles of farming. In fact, these troubles are not connected with the plow, but with its patterned and ubiquitous application (until recent time, there were simply no other tools with universal plow capabilities apart from the main tillage plow). In our opinion, there exist basically insoluble contradictions between the nature and the need for agricultural activity of a human. A human already a priori modifies them or stops them completely creating more favorable conditions for cultivated plants, disrupts the flow of natural processes. It makes no difference how he cultivates the soil applying moldboard, surface, deep or shallow tillage. The mechanical impact on it must be reasonable, strictly adaptive and targeted, while respecting the basic laws of agriculture and ecology (for example, the law of return in modern farming systems is not universally implemented) to smooth out these contradictions and preserve the soil as a natural type.

It is possible to formulate such a problem as: plowing or not plowing, all plows “under the fences”, the transition to “technology of preserving tillage” or “No-Till”. By itself, it leads only to new patterns and extremes. Conducted perennial studies in Eastern and Western Siberia [10-14] showed that each method of tillage (dumped or tilted, deep or shallow) has both positive and negative sides, therefore, according to many researchers the advantage of combined systems combining the alternation of depth dumping dumps, bottom-up and zero treatments in a very wide range is recognized [15-6]. The possibilities of tillage minimalization are not unlimited. Even complete minimalization, i.e. a direct seeding, cannot be annual. Moreover, the emergence of a wide range of new tillage and sowing machines significantly increases the possibilities of choosing the most adaptive machine for each particular case, especially for such a variety of natural conditions as in Russia.

The results of research by M. Krause are significant of such a case [17]. He came to the conclusion, studying various methods of tillage that water and food move from top to bottom, and in dry, vice versa, from bottom to top in a humid climate in several European countries. Therefore, in a humid climate, a turn of the reservoir is needed, and the problem is not “that we should put the plow into a corner, but the fact that so far we have plowed too much”.

The history of the development of tillage is determined, first of all, by the development of tillage machinery, and this process is endless. It is clear why T.S. Maltseva began her detailed comparative study in all regions of the country when a surface plow appeared. The development of flat cuts and related tools created by A. I. Baraev, led in general to an unprecedented surge of scientific research and the development of new revolutionary views and theories on the problem of tillage.
Today, great expectations in reducing and combining technological operations in a tillage system are associated with the transition to combined tillage sowing machines that can reduce the entire cycle of sowing to one or two technological methods.

Sowing machines of famous brands such as Concord, John Deere, Morris, Kuzbass, Ob-4 and others are already widely used in the fields of Siberia. Unfortunately, their application most often is realized without appropriate and advanced scientific support, often in conditions of free placement of crops, low levels of chemicals, and taking into account specific agrarian landscape conditions. It leads to some negative consequences such as weed infestation, spread of pests and diseases, and, consequently, a decrease in product quality.

The increased minimization is accompanied by a significant decrease in the level of accumulation of nitrate nitrogen, mainly when the culture is removed from steam; this requires higher doses of mineral fertilizers. Some researchers indicate directly that the development of minimal chemical treatment loses its perspective [18, 19].

The higher the minimization level of mechanical tillage, the higher the need to apply. It is a kind of chemical doping in the form of fertilizers and pesticides. However, some minimization disadvantages do not mean that this is a dead end in the development of tillage. On the contrary, as well as the moldboard tillage, the minimum tillage should not become another panacea that rejects all historical known methods and it is effective up to a certain time. In certain conditions, especially in arid zones, on lighter, as well as on black eroded soils, its effectiveness has already been proved.

On the basis of the research conducted in Eastern Siberia, the following main promising areas for minimizing tillage are:

- reduction of the depth and frequency of the main tillage;
- application of mixed depth systems with moldboard and surface tillage, zero tillage in combination with herbicides in crop rotations;
- combination of tillage and sowing in one mechanical unit with simultaneous fertilization, leveling and rolling in a single pass across the field;
- combination of methods of surface and minimum tillage in the preplanting period (without sowing) in one multi-operation mechanical unit;
- differentiated use of paw, anchor, disk and combined types of coulters taking into account the state of soil moisture, weather conditions, backgrounds of the main tillage;
- transition to preferential application of the band-spraying, tape, and strip sowing methods, ensuring the placement of seeds with an optimal area of nutrition.

These investigation directions, their development are of actual practical importance, as well as scientific novelty and the need to conduct comprehensive research in this field of research.

3. Conclusion

- Having increased the level of minimization of mechanical tillage, the level of weed infestation, plant damage by pests and diseases, the deficit of mobile nitrogen forms increases. And therefore the replacement of more intensive moldboard and surface tillage methods by smaller and zero ones is accompanied by the increase in the need to enhance the chemicalization of agriculture.
- At this stage of development of the agrarian and industrial complex of the country, the most effective systems are the combined ones. They are based on the alternation of deep and shallow, moldboard and surface tillage methods in combination with pesticides in a wide range depending on the agrolandscape conditions, intensification levels, crop rotations, biological features of crops, weather and other conditions and factors.
- The most promising direction for improving soil tillage is the development of systems based on the use of multi-operation machines and tools that combine tillage, planting, fertilizing, leveling and rolling in a single pass across the field.
The research on the efficiency of this system of machines should be conducted taking into account the background of different levels of chemical treatment with different cultures and varieties.

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