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Modern problems of ploughing as special method of soil cultivation

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The purpose. To formulate on the basis of consideration of different systems of soil cultivation their basic criteria of reasonable and effective use in modern conditions of management of hi-tech agriculture and to determine in them the place and role of ploughing. **Methods.** The methodical approaches of analytical probe based on consideration, comparison and analysis of the basic agrophysical and mechanical methods and techniques of soil cultivation which are used in the field of pedology and farm mechanization. At deriving experimental data modern methods of strain-gauging and subsequent statistical analysis on PC are used. **Results.** Modern definitions of such concepts, as system, methods and techniques of soil cultivation are considered. The exclusive role of plowing during restructuration of soil as one of the major factors of preserving its fertility is underlined. Condition at which it is expedient to use moldboard soil cultivation is offered. **Conclusions.** Systems of soil cultivation known nowadays which require clarification of their definitions can be realized using 3 methods: moldboard, moldboardless and combined. One of the important methods of moldboard soil cultivation is ploughing, to realize which it is necessary with the use of skim-coulters or two-deck plows and not annually but when the structural quotient of top layer (8-10 cm) of soil will be less than 0,76.

Key words: *soil, system of cultivation, method, technique, ploughing, plow, skim-coulter, structural quotient.*

In the beginning, a difficult peasant's life has always been associated with the difficult labor of the plowman. Despite the fact that in the long and saturated chain of the process of obtaining agricultural products there are other, no less important components, such as seed, cropping, harvesting, but neither the sowman nor the collector are so suited to determine the gravity of this complex The process, called the "feeding of people" in the world, is actually the basis of their lives.

And why is this so? It is obvious that as if the first step, or the initial stage of the birth of something new, the meaning of all man-made arable land, without which everything is still impossible, when it is still allegedly untouched by this virgin, is watered by abundant sweat and hard work is preparing for further use as a fertile field, as nurse as hope for life.

The main cultivation of the soil, or as it was said before, is very simple - plowing, has always been and is one of the main factors in obtaining the appropriate conditions for the further cultivation and harvesting of crops. In the long evolutionary way of developing agriculture in the world in accordance with various natural and climatic conditions, there was a continuous transformation of the principles of mechanical action on the upper fertile layer of soil, which, from different techniques and methods, have been

transformed and compiled now into the whole system, provided by the various tools created accordingly , which are constantly being modified and refined.

We will observe to what degree the modern system of cultivating soil in the world and in Ukraine, due to the long-term, tireless work of scientists and farmers-practitioners in the fields of soil science, agriculture, mechanization, etc., has now reached the level of soil cultivation in the world and in Ukraine. As concepts and definitions in this area, which now have the status of official state application and implementation, help modern agricultural producers not only intensively and technologically manage the land, but also protect nature and the environment, preserve and enhance the soil fertility and actually provide the next generation with such same hope for life.

Recently, a new classification of soil tillage systems, which is offered for general use, has become popular in domestic agrarian science. At present, the following are proposed: traditional, multicultural, canning and "no-till" [1]. Each of them not only formulated its definition, but even specified the relevant rules of execution.

At the same time, the authors of the aforementioned work [1] refer to the traditional system of soil cultivation. Among them, they provide for the loosening of the soil at a depth of 20...32 cm with full wrapping of plant remains, but for some reason at a depth of only 8...12 cm. Moreover, all the proposed systems of soil cultivation for some reason include a technological operation such as wrapping seeds of agricultural crops at a given depth - that is, sowing.

However, completely different names of soil tillage systems are established by the current DSTU 4691: 2006 "Agriculture. Terms and Definitions ", which has been functioning in our country for many years and has not been canceled by anyone. It states that such systems have only three: differentiated, minimal and soil protection. According to the essence of these aforementioned concepts, plowing can, in our opinion, be an integral part of a differentiated system, which, as emphasized by this standard, "provides for different ways of cultivating the soil under separate crops."

Before we carry out a further analysis of the state of affairs and existing problems, we will define some key concepts. First of all, it concerns the very concept of "soil cultivation system". According to the already mentioned DSTU 4691: 2006, it is understood as "a complex of methods and methods for cultivating soil under crop rotation crops".

Further in this standard it is determined that soil cultivation is a mechanical action on it by the working bodies of soil cultivating machines and implements in order to optimize the soil conditions for growing crops. With this in mind, wrapping seeds of different crops at a given depth is already an integral part of non-cultivating of the soil, and of a technological process like seeding. Therefore, the definitions given in [1] in terms of legality and elemental logic do not quite correspond to those that characterize exclusively the soil cultivation system.

The main cultivation of the soil, according to DSTU 4691: 2006, is "the deepest cultivation of soil under a certain crop rotation crop", and deep soil cultivation - "cultivating soil to a depth of more than 24 cm".

By themselves, these definitions of this DSTU as a simple translation into Ukrainian widely known, existing before GOST 16265-89 " Agriculture. Terms and Definitions ", are, in our opinion, not only imperfect, but in some cases also not quite accurate.

First, it is necessary to understand in detail the main wording of this State Standard and analyze them. Yes, it is completely unclear how to understand the term "deep soil cultivation?"

Second, what determines the depth of soil cultivation in 24 cm? After all, taking into account the effect of these concepts, plowing on a depth of 25 cm is a deep cultivation of soil, and if the depth of 22 ... 24 cm (which is very common in conventional agricultural production) - then no.

Thirdly, if in autumn only the discs of the stubble of the collected culture are carried out to a depth of 10 ... 12 cm, and in the spring to limit the harrowing of the hay and soil cultivation to the same 10 ... 12 cm, then should these technological operations be attributed to the main cultivation of the soil?

And will it be lawful, in such a case, that the statement, even made in the title of labor [2], that the gravity of the soil is one of the main methods of its cultivation? Of course not!

From this there is an urgent need to thoroughly study and logically identify all these concepts, important for the purpose of streamlining and accurate and accurate their further use.

According to DSTU 4691: 2006, the main methods of soil cultivation, in large measure, are only two: shelf and bezpolitsey. The latter, as is known, is carried out without rotation of the arable layer. The state standard referred to it also involves the cultivation of soil with disk implements (for example, a disk plow), emphasizing that this method provides for collapse, partial mixing of the soil and the destruction of weeds.

In reality, even the work of a pewter, not to mention a disk harrow, and even more so - a disk plow, is characterized, albeit incomplete, but nevertheless, the rotation of the cultivated layer of soil. In view of this, it turns out that the disk cultivation of the soil should also be classified as a back-up method.

And if so, then it's difficult not to agree that there is actually a third way of cultivating the soil - a combination which, just not, is included in the mentioned DSTU. In practice, it is implemented by widely-spreading tools, which, in one pass, carry out a disk (ie, politsevyy) cultivation of the upper layer of the ground and bezpolitsey - the lower one. Thus, we can make the following preliminary conclusion that the technological content of this method is to some extent consistent with the one specified in [1] only a conservation system for soil cultivation.

Now, as far as the "no-till" system is concerned. From English "no" is not, and "till" - soil cultivation. It turns out that by its very nature, it can not in principle be called a system of soil cultivation. On the contrary, it is quite understandable and logical that it is a technology of growing crops precisely without the use of the latter, and no system of cultivating soil.

If further guided by the notions of DSTU 4691: 2006 on the definition of soil cultivation system, plowing is one of its methods (such as harrowing, milling, cultivation, etc.). At the same time, the standard in another place for some reason classifies it as a landfill way of cultivating soil.

There is a completely understandable question, and what is the reason for this state of affairs. The situation is complicated by the fact that today, in addition to conceptual uncertainty, we also have the duality of views on the application of plowing. According to the first one, scientists and well-known producers systematically argue about technical and economic impracticability and agro-technical harmfulness of this soil tillage [2-5]. Especially in terms of an unceasing drop in its fertility. So, the well-known farmer-practitioner Ovsinsky I.E. even at the beginning of the last century considered this technological operation generally harmful and offered to carry out only once: "deep plowing - it's a spoilage of soil or an unproductive waste of fertilizers; only in exceptional cases it can be made once as a reclamation (improving) means. This occurs when the upper layer of soil differs in bad qualities, and it is possible to improve it with the earth extracted from the soil "[6]..

One of the first founders of organic farming, the American farmer Faulkner E., was practically the same position, who published on this subject work [7], which for many years was considered fundamental.

What kind of reliable answer is there for this very important question?

We will continue to follow more thoroughly the views of authoritative scientists in the plow from the positions of general soil science. Turning to the views on plowing expressed by the world-renowned soil scientist Academician Williams, VR, we will see that he followed a completely different view, which is difficult now to disagree with. Let's start with the basic of his postulates. Thus, in his writings, he, on the basis of many years of solid research, emphasized that the crop of any agricultural crop depends on the presence of many vital factors, among which the dominant place is moist and nutrients [8]. Moreover, their influence on the development of plants is not directly, but through the intermediary - the soil. As a result, no grams of water or organic compounds can penetrate into the body of any plant other than through its root system, which is located in the middle of the soil environment.

Hence the scientist formulates a logical conclusion that the soil fertility is its ability to provide a vital need of plants in the simultaneous and common presence of two main factors of their existence - moisture and nutrients [8].

He further notes that the soil structure can be located in at least two opposite states: lumpy (structural) and partially (unstructured). The first one is a more or less loose layer of lumps in diameter from 1 to 10 mm, which are formed with the help of such a special "cement", which is humus.

In the second, unstructured state, the individual particles of soil, between which there is no relationship, lie solid mass throughout the depth of the arable horizon. And there is practically no humus here. And if he is, then, as a rule, is in the so-called "inactive" state.

Williams V.R. puts forward a very important thesis, the essence of which is that in unstructured soil water and nutrients are antagonists, and in structural - no. For a partially grounded state, the space between its particles can be filled either with air or with moisture. In the first case, it is intensively undergoing an aerobic process, but in the absence of water, cultivated plants are not able to fully utilize existing nutrient minerals. It is known from ancient times that good crop yields are always the result of frequent, but not severe rains.

On the contrary, in the presence of unstructured soils only moisture, the decomposition of organic remains may not occur at all.

Consequently, since only the lumpy soil structure can simultaneously provide plants with moisture and nutrients, it should be maintained at all times in proper condition. It is this, the assertion of the scientist, that it is the first task of productive cultivation.Тепер докладно прослідкуємо, до чого може призвести не усвідомлення важливості цього завдання?

Suppose that the soil is structural. To destroy this structure by appropriate sealing (by the engines of modern power tools and agricultural machines / tools, for example) is quite easy, but getting it back in the old state is quite problematic. Unfortunately, it is unfortunately not solved this problem, which is used in practice to dissolve the surface layer of soil after the passage of the power tool propulsion. The fact is that substantially reduced compaction due to soil compaction (less than 50%) can be restored only due to the vital activity of soil microorganisms. But for this, you need the right conditions and time.

Moreover, even with a sufficient amount of humus, when re-thickening of the soil, it will necessarily lose its fertility. Just in this case, a significant part of the "active" humus will turn into a state of "inactive". And the method of making the conversion of the second state to the first scientist, unfortunately, does not yet possess. That is why the problem of preventing the overpopulation of the soil environment is and should be their constant concern. But, unfortunately, the technology that is now used in the fields is getting harder!

However, as if the lumpy soil structure was not supported, over time, under the influence of precipitation and atmospheric air, its upper layer (approximately 8 ... 10 cm deep) tends to gradually move into a partially-shaped state [8]. This is because humus, as a product of the synthesis of anaerobic bacteria, gradually breaks down under aerobic conditions, and any interconnections disappear between soil particles. To a large extent, this is facilitated by the replacement of calcium cation (Ca2 +) with ammonia cation (NH4 +) in humus, as well as by mechanical cultivation of the soil medium, when, together with the restoration of its lumpy structure, partial dissolution and dispersion of lumps to a separate partition is observed.

In the end, the upper layer of the soil, unfortunately, gradually loses its cultural properties, that is, fertility. And this process can only slow down, but not stop, with which, by the way, strongly disagree (obviously, unreasonably) adherents of the "no-till" system.

Let's return to the classics of the field of soil science again. As Williams V.R. notes, there is also a second task of cultivation, which consists in periodically restoring the strength of the structure of the soil. It is periodic, but not constant, since the strength (ie, the ability of the soil lumps to resist the erosion of their water) is lost, and is restored gradually over several vegetation periods.

In our opinion, the frequency of application of plowing should be determined by the farmers, based on the analysis of the soil condition in each individual case, since in the 1 ... 2 years the soil medium of the lower layer (deeper than 10 ... 12 cm) is far from always able to recover its structure.

The fact is that for a year, dead organic residues, wrapped in soil, can often not be completely decomposed by anaerobic bacteria. This is hindered, as Williams VR emphasizes, the accumulation of the product of their activity - ulmic acid in the soil. The periodic extension of mineralization of organic residues is possible only if it is denaturated - the transition to the substance of the gumin. And this process occurs only in winter at low soil temperatures. That is why quite often after the manure or wrapping of not completely crushed remains of rhosseblivyh cultures in the soil during the plowing next year, the plank shells bring to the surface not fully decomposed organic remains. Most likely, this requires a longer period of time.

To restore the strength of the structure of the upper soil layer, it must be isolated from the influence of drip-like atmospheric water and air by moving it to the bottom of the structural layer.

The task of changing the places of two layers of soil without any mixing (which is fundamentally unacceptable!) Is now capable of solving so far only a plow, but it is necessarily equipped with pre-plows.

Thus, we have consistently come to the problems directly associated with plowing from the standpoint of general soil science, in no way violating their basic classical postulates.

As you know, the plow rotates a layer of soil for two tricks. Initially, the pre-bowl discharges the bottom of the furrow fractured on the surfaces of the least resistance to the depth of the unstructured soil, and then the main plow housing falls over from the top with a lumpy (pre-arranged) mass underneath. Does not it remind me of this very "meliorative (improving) means", as pointed out by Ovsinsky I.E. in my statement, which was given above?

Subsequently, the process of restoring the strength of the soil structure begins in the lower layer under anaerobic conditions. And it is much more effective than the one that under certain conditions occurs in the lumps of the upper layer. Therefore, one can not agree with modern domestic researchers, who argue that "... the very idea of aerobic conditions in the upper part of the arable layer and anaerobic in the lower served as the justification of the theory of crop cultivation of soil ..." [9]. In our opinion, this principlely important postulate is not based on imagination, but on the sufficient factual scientific material of such well-known soil scientists as Williams V.R. and other.

Since the loss of the structure of the soil to the upper layer and its recovery by the lower layer does not occur in a year, there is virtually no need for annual implementation of plowing. We risk to assert that the arable horizon of the soil can be exploited without rotation until its upper layer, 8 ... 10 cm deep, reaches the extreme structural value.

In practice, it is accepted to estimate the coefficient of soil texture, that is, the relative number of agronomically valuable aggregates, which include lumps of soil with a diameter of 0.25 to 10.0 mm [10]:

$$K_C = \frac{\sum M_a}{\sum M_o},$$

where M_a – mass of soil particles in diameter 0,25…10,0 mm; M_o – the mass of soil particles, the diameter of which is less than 0.25 mm and greater than 10,0 mm.

The method of determining the indicator K_C is very simple, and the process of obtaining its value is not laborious. The decision on the need for plowing is taken when the value of the coefficient of soil structure is less than 0.67. The use of this important indicator must be considered obligatory for all producers of agricultural products now operating on the ground.

Separately, it should be noted the use of plowing preliminaries. Labor [11] considers the widespread reasons for their removal by producers. However, it should be remembered that the use of a plow without pre-cuttings is technically feasible only in the case of the accumulation of organic fertilizers (manure) or lime in the soil.

In other conditions, even in the absence of weeds in the field, the removal of the preliminator leads to a simple mixing of the upper (unstructured) and lower (not yet sufficiently structured) layers of soil with the gradual loss of its structure throughout the arable horizon. Due to this, the latter turns into a

homogeneous environment, while in the plow with the preliminary he (the arable horizon) is always heterogeneous.

According to the authors of the paper [12], the width of the capture of the preliminaries is 2/3 of the width of the capture of the main plow body. There is a completely understandable question, and what is the reason for this? Similarly, in [12] it is indicated that this is necessary in order for the first to dump a piece of soil into a furrow the first one had the opportunity to lie to the bottom of the second, rather than jamming between the furrow's wall and the upper limit of the pre-inverse chute.

The answer to this question is found in the same Williams V.R. [8]. According to his explanations, the decrease in the width of the capture of the preliminaries is due to the traction ability of the propeller of that time - that is, a horse. For the same value of the width of the capture of the main body of the plow and the pre-plowman, a single-hull awning gun for the traction resistance was too heavy for one horse and too light for two.

Obviously, it is precisely in this circumstance that the German peasant designer of the plow Rudolf Sakk, in 1863, reduced the width of the capture of the preliminary by one third in relation to the capture of the main body. As a result, the cutting of the upper part of the soil to the prefluid was replaced by its shredding (or separation). And this process is known to require less energy for its implementation and is accompanied by a minimum amount of spray lumps.

It should also be emphasized that in many modern foreign and domestic plows the width of the capture of the pre-flood does not equal third, and that most half the width of the capture of the main body. And the preliminator is often declared not as a mandatory working body, but as an option (!).

However, it is quite clear that, with the use of modern energy vehicles (tractors), there is no need to reduce the breadth of capture of the pre-mixer. Instead, it is possible (and preferably, in our opinion) to use the same equivalent working body, that is, the plow body. In practice, the design of such an instrument has long been known - a two-tier plow.

Conducted in the NSC "Institute of Mechanization and Electrification of Agriculture" of the National Academy of Agrarian Sciences of Ukraine and the Tavria State Agrotechnological University, many years of experimental research on the work of these arable guns revealed a number of technological advantages. First of all, it concerns the completeness of the wrapping of plant remains of the agronomic background. In a two-tier plow, it is almost 100%. The use of these arachnids enables the tractor to be assembled with the wheels of the right-hand side of the semi-detachment, which results in a decrease in the specific consumption of fuel by the machine-tractor tractor unit.

The results of our experimental studies also show that following plots with standard plows with minimum energy costs, the following recommendations should be followed. So, until recently, it was believed that the smallest traction resistance of the plow is provided with its symmetric aggregation with the power tool (tractor) [12]. In fact, this is not true. According to the data of many years of field research, the least energy-consuming is the scheme of joining an arable gun to a tractor, after which the "center of resistance" of the first (when viewed from the rear) is shifted to the left with respect to the longitudinal axis of symmetry of the second [13]. Moreover, the wheels of the right side of the power tool during the working of the awn machine and tractor unit should be located outside the furrow, and the constructive width of the plow capture must be at least 1,15 times the wheel track of the wheeled tractor. Due to the significant unloading of the plow board, all but the latter can be removed. Ultimately, such a constructive solution also results in an additional reduction in the tractional resistance of the plow and the specific consumption of fuel by the machine-tractor tractor unit.

Since the above-mentioned requirements can sometimes be implemented quite problematically, in practice most often two other schemes of arable machine-tractor unit should be used. According to the first (most widespread of them) tractor, the width of which propulsion does not exceed the width of the capture of the plow case, moves the wheels of the right side of the furrow. The ornament of the instrument is then aggregated with the power tool symmetrically or even with a left-sided lateral displacement.

If the width of the plow is greater than the width of the tires of the wheeled tractor, then the movement of the latter is carried out outside the furrow. The tractor's circumference at the same time, as a rule, is larger than the structural width of the plow capture. In this regard, the aeration device joins the power tool not from the left, but with the right-hand transverse displacement, which is undesirable. After all, the larger the value of such a displacement of the plow, the greater its traction resistance. And this unequivocally leads to greater tractor hitching and the increase in specific consumption of fuel by the awn machine and tractor unit [15].

To minimize these negative results, a two-point system for adjusting the rear hinged mechanism of an aggregate tractor should be used. In this case, the right-hand transverse displacement of the aeration instrument, in the first place, should be carried out by moving the lower tines of the rear hinged mechanism of the power tool (tractor). And only when this displacement is not enough, then it is necessary to further move the frame of the plow relative to its own connecting bugles [13-15].

When using plows with cultural shelves, the speed of the arable aggregate should be not less than 2.2 m / s (7.9 km / h). Otherwise there will be insufficient rotation of the arable layer. In practice, this disadvantage is visually observed in the form of sharply delimited soil bands after the passage of each shell of the plow. As a result of this spring, such an agronomic background requires considerable time and energy to equalize it.

When plowing with a speed less than 2.2 m / s it is necessary to use plows with half-screw shelves. But at the same time such spike implements rotate the soil layer better, but less (sometimes insufficient) it is crushed.

Provided plowing sticky soil it is advisable to use plows with currently distributed strips. Compared to the cultural shelves, their traction resistance is much smaller, and when servicing is replaced, each of the bands separately.

It should also be emphasized that one of the problems with the use of standard plows is the presence after their use of flexural and / or accelerated furrows. In order to eliminate this disadvantage, in practice, reversible plows must be used. The most suitable for this, in our opinion, are long-term plows of the brands PNE-4-42, PNI-5-42, which are manufactured by the famous Ukrainian company "Voskhod".

As for the timing of direct plowing, the summer / autumn period is most desirable for this purpose. In conditions of sufficient moisture plowing, as a rule, it is desirable to carry out immediately after harvesting agricultural crops. In this case, the anaerobic process, during which humus is formed, will be completely provided with organic residues. In the opposite case, that is, with the delay of the start of plowing to late autumn, these remains will be decomposed in the aerobic conditions of the upper layer of the soil, which is undesirable.

In the dry conditions of the south of Ukraine, plowing should also be carried out in the autumn, but the stubble of the predecessor should be twisted twice: the first time immediately after harvesting, and the second after the appearance of weeds and / or fallow stands.

And the last. In the presence of an aggregate tractor with a front hinged mechanism it is expedient to use such an airstream unit under the "push-pull" scheme, that is, "push-pull". According to solid studies [16], the use of a power tool with front and rear axle plows is accompanied by an increase in labor productivity (up to 40%) and a decrease in specific fuel consumption of up to 20% compared to the traditional awning unit..

Conclusions

Widely known in the world today soil cultivation systems that need to refine their definitions, can be implemented in three ways: shelf, bezpolcovym and combined.

One of the important methods of the landfill method is plowing, which should be carried out not annually, but only when the structural factor of the upper (8 ... 10 cm) layer of the soil is less than 0.76.

A prerequisite for plowing is the use of preplants or the use of bunk plows. Only in this case, it acts as one of the means of restoration of the structure of the soil, as one of the most important factors in preserving its fertility.

Bibliography

1. Kravchuk V. Technological and technological systems of soil cultivation in Ukraine. Condition and prospects (advices to the time) / V. Kravchuk, V. Pogorily, O. Rozhansky, O. Bodnar // Technology and technology of agrarian and industrial complex, 2011, №4. - P. 6 - 9.

2. Stepchenko S. Torting as one of the ways of basic soil cultivation / S. Stepchenko // Engineering and Technology of Agroindustrial Complex, 2010, No. 5. - P. 15-19.

3. Morgun F.T. Peasant - World Soul / F.T. Winker. - Poltava: Poltava writer, 2001. - 312 p.

4. Shikula M.K. Soil protection system of agriculture / M.K. Skeleton - Kharkiv: Flag, 1987. - 200 p.

5. Organic farming: from the experience of PE "Agroecology" of Shishatsky district of the Poltava region. Practical recommendations / Antonets SS, Antonets AS, Pisarenko V.M. VI and others. - Poltava: RVB PDAA, 2010. - 200 p.

6. Ovsinsky I.E. The new system of agriculture / I.E. Ovsinsky. - M., 1909. - 103 p.

7. Faulkner E. The Madness of the Plowman / E. Faulkner. - M .: Publishing house s.-. Literature, 1959. - 302 p.

8. Williams V.R. Soil science. Agriculture with the fundamentals of soil science / V.R. Williams. - M .: The State Council. ed. agricultural literature. - 1951. - 576 p.

9. Strelchuk O.Ya. Minimalization of soil cultivation - a way to save energy and maintain soil fertility / O.Ya. Strelchuk, O.V. Arsenyuk - Scientific bulletin of NUBiPU. - K., 2010. - Vip. 144, part 2. - P. 271-279.

10. Shein E.V. Agrophysics / E.V. Shein, V.M. Goncharov. - Rostov-on-Don: Phoenix, 2006. - 400 p.

11. Nadtikot VT Mechanic-technological fundamentals of plowing / VT Superman - Bulletin of Agrarian Science, 2012, No. 4. - S. 28 - 30.

12. Klenin N.I. Agricultural and meliorative machines / N.I. Klenin, V.A. Sakoon. - Moscow: Kolos, 1994. - 751 p.

13. Bulgakov V.M. Aggregate plows (monograph) / V.M. Bulgakov, VI Kravchuk, V.T. Superman - K .: Agrarian science. - 2008 - 152 p.

14. Bulgakov V.M. Self-organization of soil structures (monograph) / V.M. Bulgakov, B.A. Sheludchenko - K .: Publishing house of NAU. - 1998. - 58 p.

15. Adamchuk V.V. Aggregate plows / VV Adamchuk, VM Bulgakov, V.T. Nadtiko VM Kierchev // Agrarian Week, 2014, №15. - S. 42-44.

16. Kyrchev VM Mechanic-technological bases of aggregation of ornamental-propagating tractors: author's abstract. dis ... to gain a degree in science. degree doc. tech Sciences: special 05/05/11 / VM Kyurchev - Glevakha: NSC "IMESG" NAAS of Ukraine, 2015 - 44 p.

17. Tanchik S.P. Agriculture - Food, Energy and Ecological Safety of Ukraine // S.P. Tanker - Bioresources and nature management. - 2009. - T.1, No. 1-2 - p.81-94.