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## WHY PLOUGHING REMAINS ACTUAL

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### Abstract

The article examines the techniques of ploughing as a component of differentiated tillage, which remains competitive in comparison with the method of sowing in mulch. The essence of the classical tillage method that guarantees obtaining a stable harvest is outlined. The advantages and problem aspects of ploughing as the main method of classical tillage technology are analyzed. It has been proved that in order to restore the structure of the top layer of soil, ploughing is mandatory, though not annually, but once every few years. It is noted that ploughing best covers crop residues and organic solid fertilizers and enables to successfully control weeds that are resistant to modern herbicides. Emphasis is made on applying cultural ploughing, which ensures higher soil fertility. The issue of control of soil compaction that arises under mechanical tillage methods is clarified. It is established that economic preconditions for crop losses affect the reasons why farmers neglect the methods of preventing soil compaction.

**Keywords:** ploughing, plough, pre-plough, soil, structure, technique, method.

**Formulation of the problem.** Yield indicators in the agricultural sector largely depend on the ability to work with the soil. The key technique, in this case, is plowing. With its help, the soil becomes looser, better permeable to moisture and air. Thus, optimal conditions

for crop growth are created. There are several different approaches to preparing the soil for sowing, each of which has its effect on its condition. The technique of plowing for almost a thousand years is considered one of the main methods of soil preparation: rolling lumps

allows you to return the soil to its original structure and begin preparing the seedbed. Plowing has undeniable benefits and environmental control of weeds, plant diseases, and pests. She is a major stumbling block in disputes over various tillage technologies. The plowed field is vulnerable to wind and water erosion. It is not possible to carry it out during a drought, but it is definitely not worth considering it as a boon or a "fertility killer".

**Analysis of researches and publications.** A number of works by scientists are devoted to studying the issue of basic tillage as the most important method, such as Williams, P.M. Василенко, B.B. Dokuchaev, VP Goryachkin, TS Мальцев, B.T. Nadikto and others. Dokuchaev's scientific research was closely connected with the urgent problems of practice. He became an innovator in the organization of special complex expeditions "for land valuation". V.R. Williams emphasized that shallow tillage is agronomic and industrial nonsense, and any deep plowing, especially fallow, should be carried out with plows to a depth of at least 20 cm [1, p. 224]. Almost until the 1950s, the literature was dominated by the theoretical justifications of V.R. Williams on the feasibility of annual plowing to improve the structural condition of the soil and L.M. Barsukov on the need to eliminate differentiation by the fertility of different parts of the arable soil layer by plowing. In the last 10-15 years, minimal tillage and direct sowing have been intensively promoted, but the practice has shown that to restore the structure of the topsoil, plowing must be carried out, but not annually, but once every few years [2, 5]. Analyzing modern scientific and practical publications, as well as responses of farmers-practitioners regarding plowing, it is possible to conclude that this, practically the oldest technological method of tillage, is currently the least studied. Therefore, the study of such issues was and remains relevant in the future, requires further study, and deserves the attention of the scientific community.

**Formulation of aims of the article.** The purpose of the study is to substantiate the factors of relevance and competitiveness of plowing.

**Exposition of basic material of research.** Plowing - the traditional method of cultivation land before sowing, which in ancient times was carried out by plowing, and since the times of Kievan Rus began to do so with a plow.

Plowing is a measure of tillage with shelf plows, during which the plowed slice is rotated, crushed and loosened. During the operation of the plow, weeds are also pruned and crop residues, fertilizers, weed seeds, pests and, pathogens are wrapped.

Traditional plowing has a number of significant consequences that make it competitive among a whole range of modern systems and methods of tillage. Arable land has a loose lumpy structure, which perfectly absorbs and accumulates moisture. Rotation of a slice provides reliable wrapping of crop residues, destroys weeds in a mechanical way to which it is impossible to develop resistance. Provides purity of arable land and gives the chance to sow with the minimum expenses and even manually.

In the nineteenth century, scientists and practitioners recommended deep plowing but did not specify the maximum depth for a particular soil and crop. In the 1920s, considerable experimental material on the depth of cultivation was already accumulated. This material allowed most researchers to conclude that even under the most demanding to deep cultivation of culture the optimum depth of plowing of chernozems makes 18-22 and only in some cases 27 cm. Further deepening, as a rule, did not increase the yield or its gains were very small. For cereals, shallow tillage was sufficient [3; p. 62].

The depth of plowing is set depending on the thickness of the arable horizon, biological characteristics of cultivated plants, tillage for previous crops, the degree and nature of field contamination, the presence of pests, and diseases of agriculture plants.

Depending on the depth, there are *shallow* (depth up to 20 cm), *ordinary* (20-22 cm), *deep* (over 22 cm) and *plantation* plowing (over 40 cm).

With shallow plowing, the weeds of the fields increase and the soil gradually depletes. Deep and ordinary plowing help to improve the condition of the soil and its fertile properties.

The alternate combination of all the above species is considered ideal for the territory of Ukraine.

Unfortunately, arable land has a significant vulnerability because the open ground is a purely anthropogenic product not inherent in nature, even nonsense, which in the presence of moisture is eliminated in a very short period with the onset of spring with weeds and crops. In one season the soil hardens again, the field is covered with plant remains, so plowing must be done again.

Arable land has a final moisture content, so it suffers from water erosion, especially on the slopes. The arable land dries quickly, the cohesion of small lumps is lost and therefore blown away by strong winds. It is impossible to raise arable land in strong drought.

But humanity continues to plow. After the transition from the plow to the plow, the yield of cereals has increased many times. And growing sugar beets and potatoes are problematic without plowing.

Plowing as a measure of soil preparation for sowing has not lost its position in the introduction of other methods of tillage caused by drought.

Foreign experts note that "for a long time, until the advent of chemical pesticides, the plow remained the only effective tool for primary tillage. The debate over the usefulness of plowing arose at a time when factors such as labor economics, technological costs, and the increased risk of soil erosion "spoke" against this type of basic tillage. Effective herbicides helped keep competing for plants under control. That is why the technology of sowing in mulch has become so popular. There is a growing interest in tillage by strip technology. But both of these methods are difficult to apply without effective chemistry. If we now compare the weaknesses and strengths of plowing and plowless technologies, plowing tillage for many may again be attractive" [4].

The tool used for plowing is called a plow. It is pulled by a tractor (usually with a lot of horsepowers).

All plows intended for the basic preparation of the soil are classified on the following signs:

- *by a purpose*: plows of general-purpose (agricultural) and special;
- *by type of working bodies*: plowshare, disk, screw, rotary, chisel, roller and combined;
- *by type of traction*: horse and tractor;
- *by the method of connection with the tractor*: trailed, hinged, semi-hinged;
- *by tillage speed*: conventional (tillage speed up to 1.4 m/s) and high-speed (tillage speed from 1.4 to 2.2 m / s and above).

Automated plows with GPS navigation are also now available.

The modern plow is a result of the centuries-old activity of many people, the harvest always depended on

its level of perfection. The improvement of plows has always kept pace with the development of technology. The last 10-15 years have seen a certain leap after the mass entry into the markets of energy-intensive and computerized tractors and updated reversible plows (Fig. 1).

The main working body of the plow is the body, the modern structure of which was finally established in the second half of the nineteenth century.

The peculiarity of the plow's impact on the soil is determined by the shape of the shelf. It is best to turn a piece of soil with a plow with a screw shelf, but it is not enough to crush it. Therefore, they are used mainly for the cultivation of very turfed heavy clay soils. Such plows are unsuitable for the cultivation of light soils by the granulometric composition of soils.



*Fig. 1. Plowing with a reversible plow*

Source: [6]

Plows with a cylindrical shelf loosen well and mix the soil, but do not rotate enough. They are suitable for the cultivation of cultivated and light untamed soils.

Plows with a semi-screw shelf rotate all types well and satisfactorily crush only untamed light soils, they are used for the cultivation of drained peat and swamp mineral soils and for the cultivation of fallow lands.

The most widespread in modern agriculture during plowing were plows with the cultural and combined forms of shelves. Plows with cultivated shelves rotate the soil and loosen and crush it better than plows with semi-screw shelves. However, they treat turf soils worse than plows with screw and semi-screw shelves.

Combined shelves by their design and impact on the soil occupy an intermediate place between the cultural and semi-screw shelves. Plowing, when the slices are lifted and successively stacked at an angle of about

135°, is called conventional plowing. During such plowing, the remains of weeds or rhizomes of weeds or perennial grasses, which either grow in the presence of sufficient moisture or their remnants form additional lumps due to lack of water, remain unwrapped at the joints of the slices on the field surface. For better wrapping of plant remains, plows with cultivated and combined forms of shelves equipped with plowshares are used. Shelf plowing with plows with plowshares is called cultivated.

The pre-plow is a reduced and simplified body in terms of structure and mounting, installed in front of each main body. When moving, the plow cuts rotates and dumps towards the furrow part of the upper layer of the chip, which should be cut off by each main body (Fig. 2) [6].

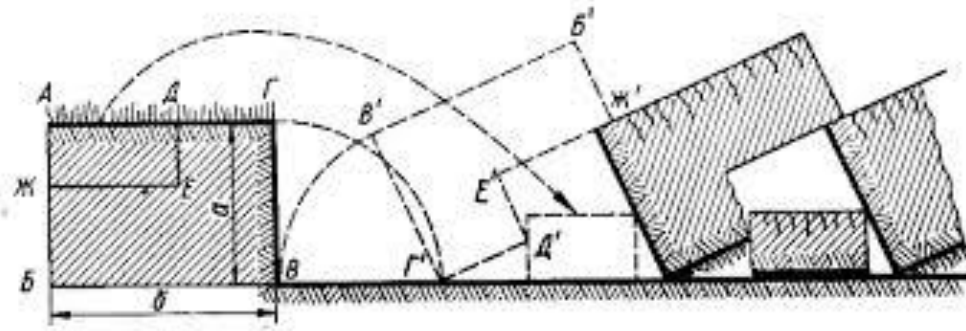


Fig. 2. The scheme of rotation of a slice at work of a plow with before plows

Source: [6]

A strip of soil up to 12 cm thick with crop residues, weed seeds, pests, and pathogens, taken from the unploughed field, enters the furrow. This ensures cleanliness from the stubble of the joint of the raised slice with the surface of the slice from the passage of the front body, and all the organic matter is guaranteed to be covered by a layer of soil.

The width of the pre-plow is smaller and is two-thirds of the width of the main body. This position ensures good laying of the top layer of soil on the bottom of the furrow. However, since the width of the plow is less than the width of the main body, it is impossible to achieve high-quality plowing with such a plow at high speeds and in fields with a significant amount of crop residues (after corn and sunflower). In this case, a plow with a pre-plow works better, the width of which is equal to the width of the main body. In practice, the design of such a tool is called a two-tier plow.

The main body cuts the lower part of the soil slice, which is less connected by the roots, rotates it, grinds it well into lumps, and fills it with a layer of soil that has been dropped into the furrow by a plow. The quality of plowing with a plow is improved due to the reduction of bouldering and combing, greater porosity, and a better ratio between capillary and non-capillary porosity. In the case of cultivation due to better wrapping of crop residues, it is possible to reduce the number of treatments when bringing the arable land to the sowing state. Cultivation significantly increases the efficiency of applied organic and mineral fertilizers, because they are wrapped in a more moist lower part of the arable layer. However, plowing with plowshares is possible only at the depth of the arable layer not less than 20 cm. On podzolic and other soils, where the depth of the arable layer is less than 20 cm, it is necessary to apply measures aimed at its deepening, and only then to introduce plowing with plows with plowshares.

Machine operators often avoid the use of plows due to the mass of left and unevenly distributed on the surface of crop residues, and hence the clogging of the plow. To eliminate clogging of plows, the stubble must be pre-treated with mulchers or disc harrows [12].

Plowing without plowshares does not lead to the replacement of one layer of soil with spent fertility and partially destroyed structure to a structured and more

fertile, but to simple mixing of soil layers and the formation of a homogeneous soil layer to break the structure to the full depth of plowing [7].

Plowing is divided into:

- technique of execution on smooth, bending, and seamlessly circular or figured;
- the direction of movement of the unit - on rectilinear and contour;
- the condition of the arable surface - on the confluence, with depressions and ridge;
- profile of the bottom of the furrow - with the same depth of all plow bodies and stepped;
- moving individual layers - two- and three-tiered;
- depth - shallow, medium, deep, and very deep.

Smooth plowing - shelf plowing without dumping ridges and overlocking furrows. The absence of furrows and ridges improves the quality of plowing and improves the working conditions of drills and other machines operating at high speeds.

Band plowing - plowing the field in separate bands. It is practiced in the fields of a rectangular or close shape. For such plowing the field is divided into straight lines (so that there are no flaws), the length of which depends on the size of the field, and the width varies from 40 - 100 to 100 - 140 m. First, the odd-numbered detachments plow, and then the even-numbered detachments plow, which reduces the number of furrows and ridges by half, as a result of which they achieve better field alignment. During plowing, the unit moves from the middle to the edges of the fold. Thus on the edges of a fold, there are open furrows, and in the middle - a dump ridge. Accelerated plowing is plow plowing, during which the unit moves from the sides to the middle of the plow. At the same time, ridges are formed along the edges from the discarding of the slice (along the course of the plow to the right) on the unploughed area, and in the middle - an overlocking furrow [8].

Figured plowing - flawless plowing without transferring the plow to the transport position on turns. Due to the low quality due to a large number of defects on turns, such plowing is practiced infrequently, only on small arrays of non-rectangular configuration, which remain after the division of the field into folds.

Contour plowing - plowing of complex slopes along lines close to the horizontals of the terrain. Used to combat water erosion in the contour and reclamation

organization of the territory. In the case of such plowing, the slice should always be tilted up the slope. To do this, the slope is plowed from top to bottom with balancing or reversible plows, and in their absence - conventional plows in one direction.

Merge plowing - shelf plowing, in which the surface of the plowed field is characterized by a well-aligned condition (in the complete absence of furrows and ridges). Such plowing reduces the cost of bringing arable land to the sowing state, but at the same time can cause flooding of the surface during the autumn-winter period on soils that are sprayed or have a low water resistance of structural units [8].

Hollow plowing is shelf plowing, in which furrows are left on the surface of the arable land after each pass of the unit or each plow body. It is only appropriate on slopes to prevent water erosion. Thus simple unisexual slopes plow across, and difficult - on horizontals.

Comb plowing - shelf plowing with a plow with one (or on multi-hull - two) elongated shelf, by means of which a ridge is formed on the surface of the arable land to retain meltwater. Spend it across the slope.

Step plowing - plowing, which provides a stepped profile of the bottom of the furrow. Performed with conventional plows, in which a body with an elongated riser is installed through one body, as a result of which it cultivates the soil to a greater depth. The stepped bottom during such plowing reduces the groundwater runoff. Step plowing is practiced only on slopes, and on lands with a flat surface, plowing with the same depth of all buildings is used, which ensures a uniform furrow bottom.

Tiered plowing is shelf plowing, in which individual soil layers change places. It can be two-tiered in the case of moving the upper and lower layers and three-tiered, in which different schemes can change places of the upper, middle, and lower layers. It should be introduced in the case of deepening of the arable layer and deep plowing to wrap the remains of crops, organic fertilizers, or clogged topsoil.

Reclamation plowing - deep plowing with special plows to improve the physical and chemical properties of the soil. Carried out by plantation plows mainly on salt marshes for their salting.

Plantation plowing - shelf plowing with special plows to a depth of more than 40 cm. It is used before laying gardens and vineyards, as well as for self-reclamation of saline soils with shallow gypsum or carbonates. Depending on the degree of cultivation of the soil, biological characteristics of the culture, and weather conditions [8].

Plowing in the fall is called fallow - this is one of the types of soil preparation for spring sowing of spring crops. It is held immediately after harvest and lasts until late autumn. Experts advise carrying out this measure as early as possible because it improves the structure of the arable soil layer. Under conditions of acceptable moisture, it is desirable to plow immediately after harvesting the predecessor. In this case, the anaerobic process, under which humus is formed, will be fully provided with organic residues. Otherwise, by delaying the plowing of the remains in late autumn, they will be disrupted by anaerobic bacteria and valuable components of organic

matter will evaporate or be washed away into deeper soil horizons.

If it is not possible to plow the stubble at once, it should be peeled twice. The first time immediately after harvest, and the second after the emergence of provoked weeds.

Observations over the last 5-6 years show that the stem mass of cereals leaves enough moisture in the arable layer obtained from June precipitation. Combined with the circumstances of shredding and scattering straw with combine harvesters, farmers had at least another 7-8 days to plow successfully. Procrastination with plowing led to the postponement of this event to November-December. As for the predecessors of winter wheat - soybeans, sunflowers, and corn in 2019, plowing was impossible until November due to the catastrophic drying of the soil to a considerable depth. The decision was to dispose of the stubble with two-track disc harrows and sow on dry land. Small precipitations in November were provided by saplings. Then came a warm and snowless winter, dry cold with May frosts. Small June rains give a winter harvest of 15-32 kg/ha. At the same time, arable land grown in July and sown in early October harvested more than 60 centners per hectare.

The soil, plowed in autumn, accumulates as much moisture as possible in the autumn-winter period, which provides more preservation for spring sowing. In the warm period, the soil is faster biological processes for the accumulation of nutrients, which makes it more fertile. The earlier the plowing is carried out, the sooner the anaerobic soil bacteria will begin to process the crop residues, turning them into plant food. However, with the treatment of soils of light particle size distribution is not necessary to hurry, because early plowing in them accelerates the decomposition of humus and, when precipitation falls, nutrients will be leached into deeper soil layers outside the root system of plants.

The depth of furrow plowing is of great importance. Before sowing grain, it is necessary to plow to a depth of 18-20 cm, industrial crops - 24-27 cm. But in Ukraine, there are many areas where the arable layer is very small (Transcarpathia, Polissya, and other western regions). In these areas, it is necessary to plow to a depth of less than 18 cm. It is necessary to increase the depth by no more than 1-2 cm with each autumn plowing. With the obligatory application of fertilizers (phosphorus fertilizers, peat, manure, and in areas with sandy soil - potassium fertilizers). Before increasing the arable layer, it is necessary to check the soil for acidity, if it is high, it is necessary to fertilize it with lime. Increasing the fertile soil layer can be done in two ways. In the first method, the arable layer is plowed, and the lower layer is simply loosened with soil deepeners. The second method is the simultaneous plowing of the arable layer and part of the subsoil. The soil is mixed and, with the addition of fertilizer, cultivated. The second method is considered more effective, as it quickly forms a full, deep depth of the arable layer. It is important to remember that each time it is necessary to change the depth of furrow plowing by a few centimeters to avoid the formation of a plow sole, which helps prevent the penetration of nutrients, moisture and air to the roots of



plants. Following all the above rules, autumn plowing provides: to avoid the formation of a plow sole, which helps prevent the penetration of nutrients, moisture, and air to the roots of plants. Following all the above rules, autumn plowing provides: to avoid the formation of a plow sole, which helps prevent the penetration of nutrients, moisture, and air to the roots of plants. Following all the above rules, autumn plowing provides:

- increasing crop yields to 50%;
- the ability to sow in the spring at the earliest possible time;
- increases soil fertility (accumulation of moisture and nutrients);
- clearing the field of weeds, pathogens, and pests.

Today, the plowing system is constantly studied and compared with the minimum tillage systems, but despite global warming and declining rainfall in the right-bank forest-steppe of Ukraine, plowing is the only system that provides the projected yield. Systems with direct sowing and strip tillage for a number of reasons did not take root. However, this changed the approaches to plowing and made it a component of differentiated tillage [6].

When choosing one or another cultivation, first analyze the features of the culture that was grown last season and the culture that will grow next season. It is necessary to consider the soil-climatic zone and type of soil and then make the final decision.

Plants respond differently to deep basic tillage. It is needed for plants that form a crop in the soil, have a taproot or a strong root system.

Today, a large part of the land in Ukraine and in the leading European countries is subject to plowing. And this trend will continue for a long time. In the near future, the final abandonment of plowing is not expected. In particular, on heavy loamy chernozems plowing remains an unalterable measure of basic tillage. And in terms of earning in the soil of crop residues of the predecessor, green manure or solid organic fertilizers, plowing outperforms all other types of basic tillage.

As practice shows, the plow must be used in the same field at least once every three to five years. Plowing to a standard depth of 20-22 cm is a good preventive measure in the fight against diseases and pests in the cultivation of monocultures and short crop rotations.

Classic plowing is required in crop rotations, because in the upper drier layer of soil accumulates more fertilizers and other nutrients, which, being wrapped in arable land, are better absorbed by plants due to higher and more stable humidity. In addition, the surface layer of the soil is characterized by high biological activity due to easier access to air. It is dominated by anaerobic bacteria and microorganisms that intensively decompose humus and organic matter. As a result, it should be added, especially after row crops, the rows of which are loosened several times during the season, the top layer often loses its lumpy structure and fertility, and therefore easily weathered. Bacteria, strong heating of the open ground, and rains destroy humus - "glue", in which microscopic aggregates of the earth are grouped into lumps and form a perfect soil structure. Only in certain relatively stable temperatures, humidity, and access of gases from the air and residues of plant biomass soil biota restores humus and structure, and, consequently, fertility. It follows that the task of farming in the periodic

restoration of the strength of the soil structure (V. Williams). It is in the periodic, not in the annual, because the destruction of the structure and, especially, the restoration does not happen immediately, but over several years. It is obvious that the destruction of the soil structure is faster due to another harmful factor of compaction of the soil surface by wheeled engines of tractors and machines. In recent years, this problem has been exacerbated by warm and dry winters, as well as weak soil freezing. Intense freezing of the soil to considerable depths at 50-80 centimeters 30-40 years ago partially destroyed the destructive compaction of the soil by the wheels and working bodies of machines [9].

So, with rational differentiated cultivation, each farmer under the specific conditions of each field must determine the type of cultivation and the actual need for plowing or deep loosening. In the case of a satisfactory condition of the soil structure, it is possible to limit the minimum tillage.

Rotation of the slice raises the lower layer of soil up to the zone of better air access, which activates the entire biota of the arable layer and improves plant nutrition conditions.

Shelving is an effective agronomic measure in weed control. During plowing, the bottom of the furrow gets the most soil-clogged layer of soil. The seeds are exposed to adverse conditions and often die. Some seeds are provoked to germinate and destroyed during pre-sowing cultivation.

Inversion of soil layers is one of the effective methods of pest and pathogen control of cultivated plants. In the process of plowing pests and their oviposition from the upper layers fall into deeper places and die. And in parallel, pests from the lower layer turn to the light and, where they mostly die or are destroyed by natural enemies. Deep plowing is an effective measure to reduce colonies of rodents.

The use of plowing allows you to effectively fight a number of diseases: smut, fusarium wilt, brown rust, powdery mildew, root rot.

After Chernobyl, it was noticed that plowing of infested areas reduces the removal of radionuclides by plants and their accumulation in fruits.

Shelving is very important in conditions of excessive moisture when the soil floats and there is almost no air.

One of the main requirements for the quality of plowing is to carry out smooth plowing without leaving any ridges or overlocking furrows. To meet these requirements, reversible plows are widely used, which have two sections of housings with right-handed and left-handed shelves. After plowing with a reversible plow, the field surface becomes clean and homogeneous, well prepared for sowing. The reversible plow allows better use of the time of the change due to the change of a way of movement of the unit from traditional shading on a shuttle that thereby reduces the length of idling. As a result, the productivity of the plowing unit increases, and the costs per hectare of the plowed field are mixed.

If you plow with a special roller for back compaction, the loss of moisture will be minimal. If you put special chisels behind each plow body, you will never have a harmful seal under the plow layer. Plowing across the slope minimizes erosion. The mere fact of plowing or



using another soil preparation system does not guarantee a positive result. Only a systematic approach gives good results.

The rotation of the formation best opens the soil for moisture accumulation, redistributes soil particles and nutrients in the arable layer. However, it intensively affects the structure, increases the loss of available moisture, with the wrong approach can cause excessive compaction. The concept of a harmful seal is better than a plow sole for two reasons: not every seal is harmful, not every seal is caused by the plow. Harmful compaction is formed during pressure on unstructured soil. The soil does not hold the structure, does not hold the pressure, but transmits it deeper, to the limit of structure. Harmful compaction is formed by machines with excessive pressure and moving wet or loose fields [9].

Cultivators, disc harrows and plows, deep cultivators, and other implements loosen the soil, destroy its macrostructure, and the subsequent mishandling of the field forms a harmful seal. Seals after the disc harrow at a depth of 10-12 cm can be removed with a plow. Seals after the plow at a depth of 27-30 cm are removed with a chisel. But how to remove a harmful seal after a chisel, ripper, or flat cutter. One loosening, without a system to prevent the formation of harmful seals, you can work to transfer the sole to a depth of 70-80 cm. And how to eliminate it there. And it's not very deep. In wheat, the root system is 2.5 meters. And at beets and in general 3,5 meters.

It is possible to struggle with consolidation and the necessary in various ways, for example, V. Mirnenko the expert of the "Pyottinger Ukraine" company recommends:

- Warn. No relocations on physically immature soil (of course - no operations). No relocations on the cultivated field until the return of the soil of natural density (the deeper the tillage, the longer you have to wait). No KAMAZs in the field (road machinery - on the road, field machinery - in the field). Field equipment: rubber

caterpillar - perfect, spark - good, wide tires - only with minimal wheel pressure (permitted by the tire manufacturer). Rapeseed and alfalfa in crop rotation, or green manure with a taproot.

- Diagnose. Not every seal is harmful. The penetrometer is simple and fast, but the shovel is more informative. Dig a hole 70-80 cm deep in the middle of the field. Cover one of the walls with a knife. This will help find the seal, determine at what depth it begins and how thick it is. Pay attention to the soil under the seal. If there are passages of earthworms and the root system, the seal is harmless. The smooth transition of color indicates that the soil from the upper layers is washed down - the seal is harmless. A sharp change in color, an unpleasant odor indicates stagnation of water at a certain depth - the seal is harmful.

- Overcome. Diagnosis will show the depth, thickness, and degree of compaction of the harmful seal. Accordingly, we choose the method of struggle, the unit, and the depth. With a small degree of compaction, the best choice will be green manure with a taproot - inexpensive, with many additional benefits. At a small depth (up to 35 cm) a good option is furrow plowing. Turned to the surface of the seal will loosen well in winter frosts. If you need plowing for the next crop, you can use chisels, which are placed on each body of the plow. Thus, in one pass you will carry out both turn of a layer, and loosening of harmful consolidation. If the seal is deep and thick, you should think about loosening it with a paw unit.

The third item "Overcome" will only make sense if you go to the first "Warn" after it. The fight against harmful compaction is a complex work during the year, not a matter of basic cultivation [9].

However, the possible serious economic consequences of delaying sowing, harvesting, or other operations may outweigh the loss or damage from compaction. The dilemma that farmers face in wet spring or autumn is difficult to solve.



Fig. 3. Plowing by the Master L. plow firm Kuhn

Source: [10]

Many of the world's leading companies specializing in the production of tillage equipment are engaged in the manufacture of plows. And in recent years, domestic agricultural producers, technicians also offer farmers a large number of rotating plows, interesting in their technological features, design, and model lines, which are aggregated with virtually the entire line of tractors.

Lemken is the market leader among the major manufacturers of foreign plows. The company offers a wide range of rotary plows for a variety of soil and climatic conditions. Every second plow imported to Ukraine is manufactured at the Lemken plant. The company offers plows from 2 to 13 cases, having both the simplest mechanical adjustment and full electro-hydraulic control, including Isobus [11].

The unequivocal leader among semi-mounted plows in Ukraine is Lemken Diamant 16. The main reasons for success have long been known to all: low fuel consumption, maneuverability, and controllability of the unit.

And the OptiLine system, which is unique and unique for semi-mounted plows, allows you to work without lateral wear. OptiLine compensates for lateral wear due to the asymmetrical position of the plow relative to the tractor. It is a controlled hydraulic cylinder that transmits additional torque to the tractor, and the traction line "tractor-plow" moves to the center of the rear axle of the tractor. This system saves up to 10% of fuel. It also makes the tractor driver's job easier - he no longer has to steer the wheels so that the tractor moves in a straight line.

The reduction of fuel consumption is also significantly influenced by the long-known hydraulic thrust booster, equipped with a functional system of pressure change at the end of the bend. Because of this, more pressure can be created in the system, which makes it possible to transfer the weight of the tractor even more from the front to the rear. This equipment improves the tractor's traction on the ground.

The Onland system allows the use of plows with tractors up to 4 meters wide and has two working positions. Due to this, in difficult conditions of use, there is always a sufficient distance from the wheels to the edge of the furrow. Convenience in work is added by stepless change of depth of processing by means of hydraulics which is in a base complete set of the unit.

Diamant 16 has from 5 to 9 cases which at the request of the client can be continuous or strip. Plows are equipped with adjustable pre-plows which allow coping with a large number of crop residues.

The base height of the frame is 80 cm, and to increase the passability of the unit in fields with a large amount of poorly crushed plant mass, you can choose a plow with a ground clearance of 85 or 90 centimeters.

To increase versatility in use, the Diamant is equipped with the Vari hydraulic system for stepless change of capture width.

The plows are used with VarioPak compaction rollers, which grind and roll loose soil: as a result, it loses less precious moisture. And all this in one pass of the tractor. Also, the racks of the case can be completed with the deep rippers helping to blow up a plow sole.

New Holland plows have been produced for over 165 years. Thanks to their efficient design, New Holland plows require 15% less traction than other plows. Less effort means lower fuel consumption and lower overall operating costs.

New Holland plows are equipped with a standard adjustment system that automatically aligns the plow when adjusting the first housing. This system uses a parallelogram that adjusts the plow after basic adjustment. As soon as the plow is properly adjusted - optimal results will be achieved [11].

New Holland has developed a number of plows so that farmers can choose the unit that is best suited for their farm. The line of plows includes units from the simplest hinged three-case models to eight-case semi-hinged with hydraulic adjustment of the width of capture and with the hydraulic system of protection of plows "on the field".

Kunh makes the largest number of rotating plows in the world. Kunh plows are different and are designed for tillage of varying severity. All of them are durable, easy to use, and reliable.

The Vari - master L plow is controlled by the Isobus terminal, which allows the operator to automate the main functions of the plow during fieldwork, namely: plow rotation, body lift, grip width, depth of entry, etc. Exclusive features such as Smart Plowing-Lift and Smart Plowing-Line are added to Vari - master L.

Smart Plowing-Lift complements the basic functions of the automatic lifting of individual housings and plows rotation at the end of the turn-based on GPS data. This system is used to manually control the housings directly from the operator's cab.

The plow can be used in asymmetrical mode (for example, digging four housings into the ground on one side and six housings on the other), which will help reduce traction resistance. This is especially true on the slopes.

Smart Plowing-Line adjusts the working width using GPS. Its control is carried out through Isobus, which is integrated into the design of the plow. SP-Line provides perfectly even plowing, even on uneven terrain.

Vari - master L works with all the "smart plowing" functions available on the Isobus terminal. It is possible to prepare a plow for work very quickly: it is enough to connect it through a cable (bus) Isobus. All plow settings (such as working width, working depth, offset, leveling, etc.) can be controlled, and all of them can be stored on the Isobus working terminal located in the operator's cab. Smart Plowing is a clear and easy-to-use technology that allows the operator to focus only on driving the tractor.

Vari Leader NSH is a plow that allows you to change the width of the body from the tractor cab and is equipped with a system of hydraulic protection of the body from overload.

This is a fully hydraulic plow that combines the Non-stop Hydraulic system, which protects the plow frame from damage without stopping, and the Vari system, which allows you to change the plow width from 35 to 50 cm from the tractor cab in less than 5 seconds.

Tillage with Vari Leader guarantees reliability and ease of adjustment, as well as eliminates the "human factor" because the fully hydraulic protection system in severe working conditions (severe soil drought) self-aligns the plow and returns it to working position, while other manufacturers in such conditions the protective bolt breaks [11].

Among domestic plow manufacturers, we can highlight Veles Agro - one of the few machine-building enterprises in Ukraine, which manufactures agricultural machinery of high technical and technological level, which allows it to successfully compete today with products of leading European and world manufacturers. The company has two series of plows - conventional PNV mounted plows and Pon reversible mounted and semi-trailed plows, which are aggregated with tractors with a capacity of 80 to 330 hp.

PJSC "Umanfermmash" manufactures mounted rotary plows PON-3 and PON-5, which are designed for smooth plowing to a depth of 30 cm and are aggregated with tractors of class 1.4 (MTZ-80/82) and 3 (T-150K).

To date, the most popular in Ukraine are rightly considered to be plows with 4 to 9 bodies. Given that each plow body requires 40 - 50 hp, such models are optimally combined with tractors available on farms, with a capacity of 150 to 400 hp. Although, traditionally it is necessary to have in reserve 10-15% of capacity for unforeseen circumstances.

Wide-reaching plows - from 9 cases are made with the hinged back section that provides uniformity of depth of plowing. Aggregated with powerful tractors, such plows work with high efficiency, because they are placed without deviation of the traction line from the direction of movement. In this case, the tracks or wheels of a powerful tractor move across the field, not along the furrow. The number of passes of the plow unit in the field area decreases by 1.5-2.3 times [13].

A suitable plow model must be correlated with the real conditions in which you will have to work before making a purchase decision. The determining factor here is the number and type of plant remains on the field surface. This applies, as we have noted, especially corn, which often does not have time to kill with a disc harrow and immediately plowed. That's why you need a plow with good plowshares that will carefully plow the stalks and leaves of corn, and not pile up piles all over the field. This is a common criterion for assessing the quality of the plow, which should be considered at the stage of choosing a unit.

Of course, you need to pay attention to the fact that the plow model should work properly both in the furrow and outside it.

Increasingly, farmers are choosing the second option given its cost-effectiveness in terms of resource life and lower operator fatigue. However, situations are different and the key here should be the factor of universality.



a)



b)

Fig. 4. The results of plowing the field after harvesting corn:  
a) without disking and without plowshares;  
b) after the mulcher and with plowshares/

Source: generated by the author

Another important issue is the type of plow adjustment. First of all, we mean adjusting the width of the housings, which are adjustable either manually or hydraulically. If the unit will mainly work on a uniform flat terrain, this problem is not particularly difficult. However, if you need to regularly plow on soils of different types with significant uneven terrain, you should still choose a model with a hydraulic method of adjustment. Otherwise, the operator will constantly waste time and nerves to change the settings, which can lead to the fact that tractor drivers will secretly ignore all the requirements of management for the correct choice of settings.

Ideally, the plow should be turned over and set to the desired performance with literally a few finger presses. There should be no keys or hammers, because it will really cause a loss of time and effort, along with reduced quality and productivity.

This is all the more important if we are talking about such an important nuance as adjusting the plows and harmonizing them with the settings of the tractors. The fact is that the quality of plowing, and productivity, and fuel consumption, in this case, can be very different. Conventionally speaking, incorrect adjustment of the plow and illiterate operation of the operator can lead to overconsumption of fuel by 30-40% and even more. So to speak, on an equal footing.

In order to work effectively with the plow, it is first necessary to properly ballast the tractor, as well as to set the tire pressure and the length of the attachment of the rear levers of the tractor. In the future, this will allow in the process of working to adjust only the plow, not the tractor and the tractor at the same time, not understanding what is affecting.

If we work in a furrow, we must take into account that the width between the front and rear wheels should not exceed a few centimeters. The width of the front furrow should correspond to the width of the plow in general. The displacement of the front body relative to the middle of the plow allows the unit to be adapted to the existing track of the tractor. In any case, special attention should be paid to the front furrow of the tractor. If the settings here are made incorrectly, then normal operation will not work - the machine with a plow will sway all over the furrow. This will lead to increased fuel consumption, rapid depletion of equipment, and increased operator fatigue, which will affect the quality of plowing.

The modern plow must be approached with the realization that it is a fairly intelligent technique that must fall into the hands of skilled hands. To begin with, at least go to the engineer of the manufacturing company to make all the necessary adjustments.

**Conclusions.** After the intensive promotion of minimal tillage and direct sowing, practitioners are increasingly turning to differentiated tillage, in which a significant place is occupied by shelf plowing with plowshares. Perfect wrapping of crop residues and organic fertilizers, control of glyphosate-resistant weeds,

and restoration of the heterogeneous structure of the arable layer make plowing relevant and indispensable.

Abandonment of annual plowing and its replacement by differential tillage, which alternately applies minimal tillage, deep loosening, and worm plowing makes it possible to achieve satisfactory results even in conditions of insufficient moisture.

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