Technical and Technological Ways to Reduce Soil Compaction to Preserve Its Fertility

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Abstract. Article village to the farm intended of lands productivity save important from the conditions one has been soil of compression ahead to get technician and technological ways work to exit dedicated. In this village economy technique and their aggregates by the soil too much except compression problems was studied. Village economy of the car complex parameters and soil situation account received without, to the soil of movers pressure equations that determine the power were proposed.

This topic according to different scientific and practical materials used, research static information systematic analysis to do and again work method with done increased.

Key words: soil compaction; water-air regime, crop; technical and technological way; unit passage; multifunctional unit; agricultural machine; heavy machinery, undercarriage pressure.

Introduction. The world fleet of all types of traction-transport-harvesting equipment used in the agro-industrial complex is steadily and rapidly developing, productivity, power and, as a result, the operating weight of these vehicles is growing, which, in turn, leads to excessive soil compaction. The scale of adverse impacts on land fertility over the next 30 years could lead to detrimental environmental impacts and threats to food security.

The priority direction for improving the tracked undercarriage system is the use of rubber-reinforced tracks [1,2], which are widely used in the designs of tracked vehicles abroad. At present, the largest tractor and combine harvester companies: John Deere, Caterpillar, Klaas, Case, New Holland and others are conducting experimental development and serial production of tractors and combine harvesters on rubber-reinforced caterpillars, which makes it possible to reduce the harmful effects compared to wheeled vehicles traditional for Western countries. On the soil and improve the traction properties of machines.

The need to reduce labor costs during the intensification of crop production has led to an increase in the energy intensity and weight indicators of machine and tractor units, while the compacting effect of the running systems of tractors and agricultural implements on the soil has increased. This led to a change in the agrophysical parameters of the root and subarable soil layers associated with the value of the compacting pressure of the wheels on the soil [3, 4]. There are numerous data in the literature showing that the shear vertical load on the soil from the propellers of wheeled and tracked vehicles leads to a change in the orientation of silty lamellar soil particles that change their position in space and cause the movement of water and air [5]. The soil is under pressure for a short time, which greatly limits the ability to move water, i.e. soil volume decreases and moisture content increases [6]. During the growing season, further soil compaction continues, therefore, the specific shear resistance also changes depending on changes in soil moisture and the action of root systems, which is associated with a change in soil fertility and crop yields [7,8].

Materials and methods. The article explores the problems of over-compacting the soil by agricultural machinery and their units. At the same time, various scientific and practical materials on this subject will be used. The research was carried out by the method of system analysis and processing of static data.

Systematic soil compaction to a depth greater than the depth of loosening by modern subsoilers (40–45 cm) disrupts the normal course of heat and mass transfer processes, and changes in the ratios of moisture, air, and soil skeleton do not contribute to the development of soil microflora. To resolve the issue of the advisability of using a particular machine to move on the ground, it is necessary to have information about the consequences of the impact of the mover, i.e. we are talking about the environmental compatibility of the machine with the soil, which has a certain moisture content in depth. A machine that is environmentally compatible with the soil does not, as a result of its work, create changes that cause a violation of the natural processes occurring in the soil.

Results and discussion. The deterioration of the water-air regime, dehumidification, destructuring, and overcompaction of the soil, depends on their intensive use and the applied cultivation technologies. It becomes obvious that to continue the introduction of agriculture on the same basis (high chemicalization and energy-intensive technologies for growing crops, lack of a landscape approach to farming systems, erosion, etc.) would mean completely destroying the fertility of unique soils. The restoration of the soil structure is facilitated by the use of organic fertilizers, the rational combination of moldboard and non-moldboard tillage, the widespread use of well-known effective environmentally friendly agricultural practices in combination with modern ones in science and technology [9.10].

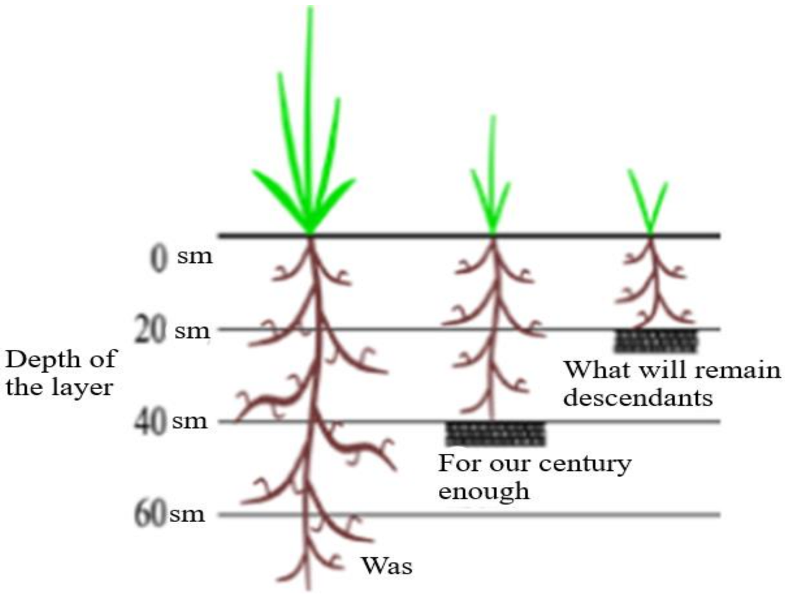

Fig.1. Possible dynamics of the ecological state of the soil Source: joint development of the author with G.A. Klysak (Konsima company)

Excessive agroecological requirements seriously threaten the state of fertile soils (Figure 1). As a result of the withdrawal of equipment in the field in excess of the permissible norms, the impacts of the soil are extremely over-compacted, do not have time to loosen on their own (especially deeper than half a meter), degrade and lose their natural fertility, biological and metabolic processes worsen. The roots stop growing deeper than 51 cm, soil moisture does not rise from the deep layers, and atmospheric moisture cannot penetrate deeper than 40–50 cm and create a reserve. With climate warming, the problem of water and air supply to the land is becoming more acute and the loss of fertility is progressing. Due to the reduction of pore space, soil resistance to cultivation increases, machines fail, fuel consumption increases (sometimes twice).

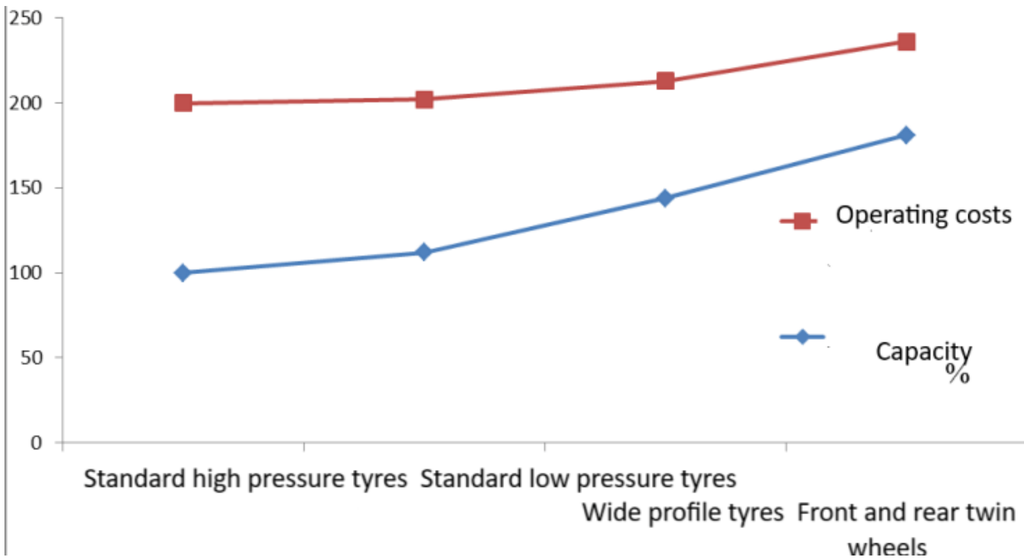

Fig. 2. Comparative schedules of tractors depending on tyre types (Grasdorf Wennekamp)

Wide-section and dual tires significantly reduce soil compaction and associated crop losses, increase the output of aggregates, reduce fuel consumption by 30-40%, reduce slipping and tire wear by 2.5 times (Fig. 2).

According to the German company Grasdorf Wennekamp, when using wide-profile low-pressure tires on tractors, productivity increases by 40%, costs are reduced by 30%, and when dual wheels are used, productivity is increased by 80%, costs are reduced by 45%. With an increase in the width and length of the tire patch, the costs will not be large and the performance will increase dramatically.

Over the past 50 years, heavy agricultural machinery weighing more than 8 tons has been created in cooperation between independent states. The predominant development of a conservative traction concept, when the tangential traction force increases based on weight growth, has led to the creation of heavyweights of about 20 tons. Combinations of other designs began to be used: rubber-reinforced caterpillars, half-track variants, etc. However, their prices are too high, and therefore the requests of agricultural producers for equipment with such a running system are still met by no more than 10%. Nevertheless, research in this direction is actively continuing (Fig. 3).

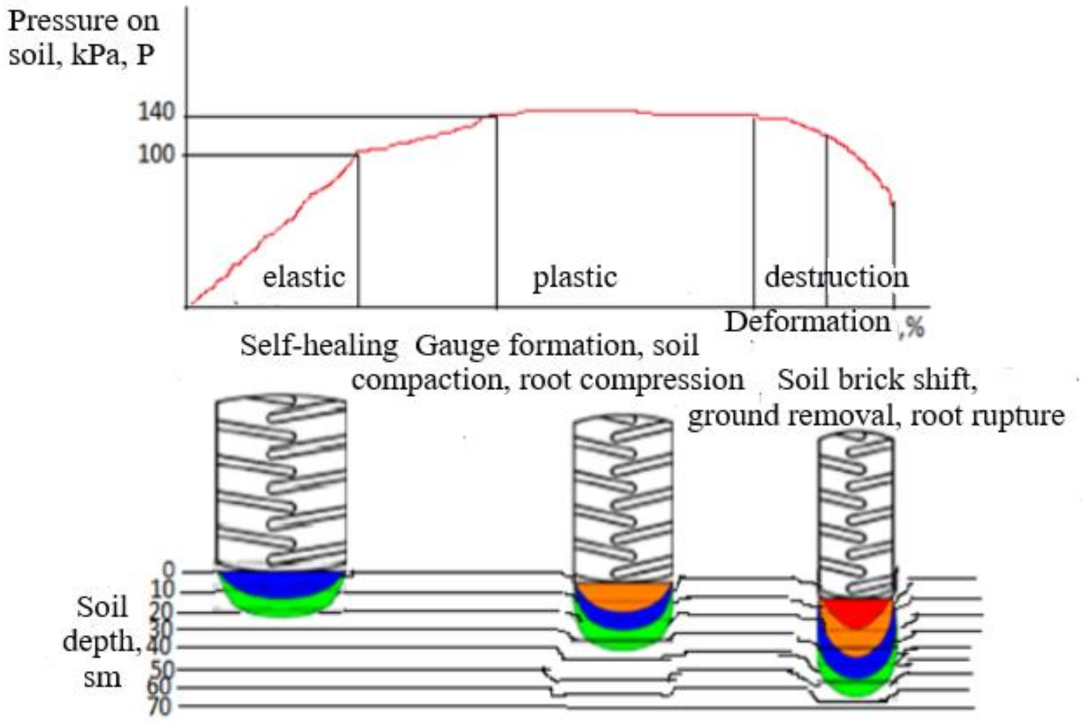

Fig.3. Graphical reflection of the stress state of the soil and the relationship between the parameters of the mover and the stress in the soil. Source: joint development of the author with G.A. Klysak (Konsima company)

The system method for assessing the actual loading mode of the undercarriage system makes it possible to correctly select the type of propulsion unit, its parameters and configuration options for a specific machine model to perform certain technological operations. Practice shows that the loads affecting the stress-strain state of the mover (tires) differ significantly from the static load, which depends on the mass of the tractor, up to doubling. Such growth has a significant effect on traction and slippage, but sharply increases the maximum pressure on the soil in the contact patch. For standard tires, the indicators reach 1.2-2.0 kgf / sm^2 - for light tractors, up to 2.5-3.5 kgf / sm2 - for heavy ones, up to 3-5 kgf / sm^2 - for combines and trailers in static condition at full load /11-13/.

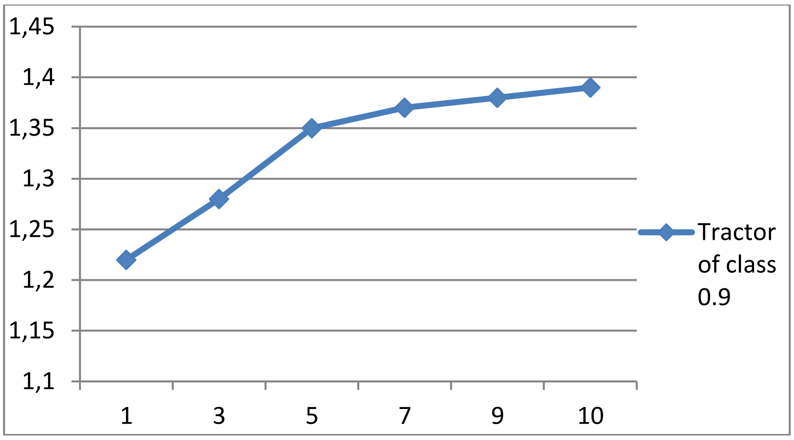

Fig. 4. Soil compaction depending on the number of tractor passes in the field, 0-0.30 cm, g/sm^3

The density was measured in layers of 0...10 sm, 10...20 sm and 20...30 sm [14-16]. If the T-150K tractor makes 5…6 passes, then the irrigation water is practically not absorbed into the soil (Fig.4). At the same time, the water permeability of the soil compacted by running systems decreases by 3...5 or more times. It can be said that with the mechanical compaction of the arable layer, the water permeability of the soil is significantly reduced. An important component of the water balance - the total evaporation of moisture also directly depends on soil moisture and is inversely proportional to its density.

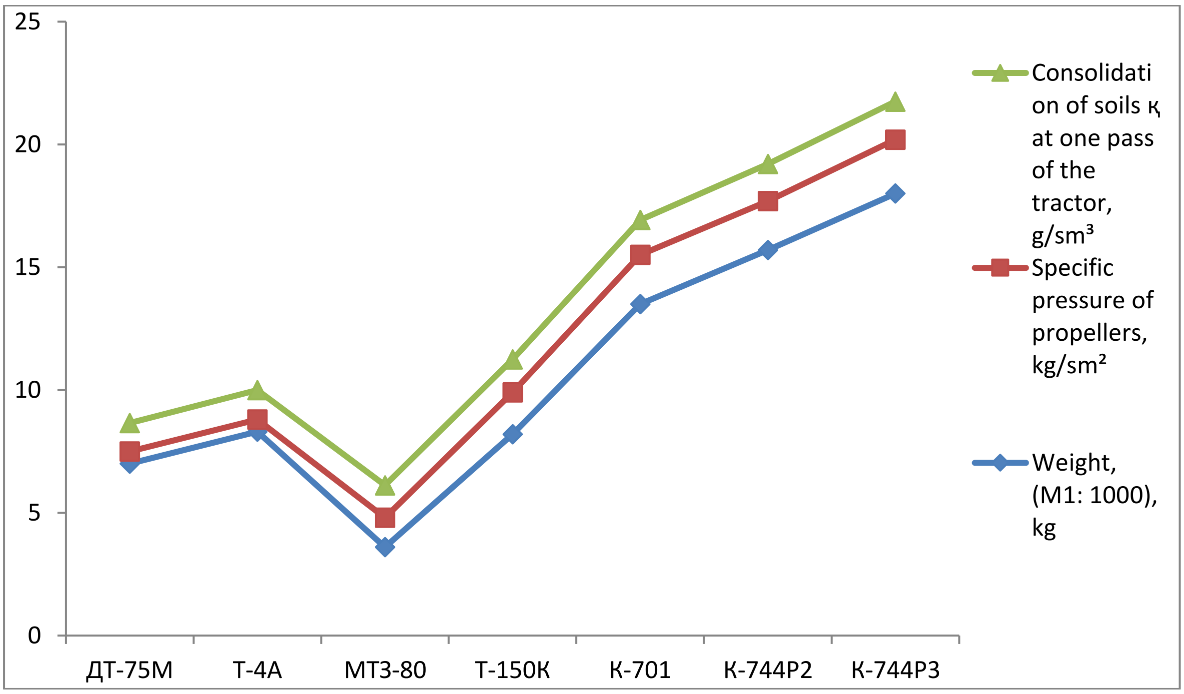

Fig.5. Impact of propellers of various brands of tractors on the soil

The specific pressure of the propellers and soil compaction during one pass of the tractor is directly proportional to the mass of the tractor. How much less the value of the mass of the tractor is so much less than the specific pressure of the propellers, and vice versa. As an example, the smallest mass and specific pressure of the MTZ-80 tractor propellers is 3.6 tons and 1.2 kg /sm² and the largest on the K-744R3 is 19 tons and 2 kg / sm², here the mass and specific pressure of the propellers increase proportionally.

The pressure on the soil of the undercarriage of a mobile power facility on the ground can be determined by our proposed formula

$$P_u \leq 0{,}01(Q_{es} + Q_a + Q_z)\, k_{vl} k_\rho k_{ud}/0{,}49 \cdot S \sum\nolimits_1^i r_i b_i$$

here P_u – ground pressure force, kPa; Q_{es} - mass of the mobile power vehicle, kg; Q_a- mass of mounted or attached units, Q_z- weight of loaded cargoes in the bunker, kg; k_{vl}- soil moisture factor, k_ρ- density factor, k_{ud} - coefficient taking into account the volume of mineral and organic fertilizers in the soil; r_i - road wheel radius, m; b_i - support wheel width, S- the value that determines the design and material features of the wheel tire.

The solution of problems in the direction of energy saving and greening are the following organizational and technological measures:

- creation and use of economical and environmentally friendly methods and technologies of tillage with the most efficient resource indicators with minimal negative impact on soil fertility. Techniques should take into account the soil and climatic conditions, biological and technological characteristics of crops, the availability of related technical resources on the farm and the characteristics of the agricultural landscape;
- the use of high-performance wide-grip and multifunctional machines and units with the maximum combination of technological operations;
- wide use of methods of minimum tillage;
- the use of mobile power equipment with a lower specific pressure of running systems;
- rational selection of working bodies of tillage equipment;
- elimination of residual deformations in the subsurface layers using deep chiseling, slotting and other methods;
- the use of tires in the running systems of oversized mobile machines, arched and wide-profile tires, twin wheels, semi- and pneumatic caterpillars;
- rational regulation of technological parameters and speed modes of operation of soil-cultivating units;
- the use of a special universal frame as a carrier machine with a set of quickly replaceable working bodies for compiling units that perform several technological operations in one pass.

Summary.

The basis of the technical and technological methods of solving the problem of reducing soil compaction in order to maintain the fertility of the land is as follows: harmonization of technological operations during one passage of the aggregate across the field, simultaneous tillage and planting, fertilizing in the system and the use of multifunctional aggregates such as tillage and soil compaction. simultaneous pinching of grain crops, simultaneous harvesting of husks or pressing of straw, etc., rejection of the use of additional heavy machinery, trucks and tractors with a narrow chassis in the fields.

Taking into account the set of parameters of the portable power structure and the condition of the soil, equations were proposed that determine the pressure force at the bottom of the portable power structure.

For driving a large and heavy tractor, it is recommended to choose a small-sized tractor for horticulture, as well as a portable power tool depending on the type of soil cultivation.

The use of seats with rubber-reinforced tracks leads to the saving of resources and an environmentally favorable impact on the soil.

Soil moisture maintained by watering, it is better to ensure optimal moisture. creating conditions for good growth and development of plants and increasing their productivity, but at the same time, the use of machinery with a large mass and making too many passes through the field led to excessive consolidation of the soil.

Is significantly reduced compared to uncompacted soil, and the filtering capacity of the topsoil can greatly impede the flow of irrigation water into the soil.

When using wide-profile low-pressure tires on tractors, productivity increases by 45%, costs decrease by 35%. By increasing the width and length of the tire patch, the costs will not be large and the performance will increase significantly.

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