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Spatial Prediction And Techniques For Reducing Soil Compaction In The Central Pre-Caucasus Region.

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ABSTRACT

The article provides an analytical review of the problems of soil compaction of various genesis under the action of propulsion of wheeled and tracked vehicles in the process of performing technological operations in crop production. The analysis of the multiplicity of compaction showed that in the cultivation of soybean according to the “zero” technology, the compaction area of different multiplicity of traces is 67.1%, and according to classical technologies: for winter wheat - 82%, for corn for grain - 90.8%, that is, “zero” technology in an ecological sense is more soil-saving. Based on the estimated scores of soil responsiveness to compaction, depending on the mechanical composition, a map of soil susceptibility to compaction with the imposition of areas of the Stavropol Territory has been developed. The proposed method of movement of the unit across the field in the process of performing technological operations on tillage, with each subsequent operation on the other side of the field, will reduce the sealing effect of propulsion on the soil, improve the performance of the units and reduce the specific fuel consumption.

Keywords: spatial forecasting, soil compaction, Central Ciscaucasia zone.

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INTRODUCTION

Increased crop yields and the need to reduce labor costs in the intensification of their production led to the emergence on the fields of various machines and tractors with an increasing unit mass. So, powerful tractors K-744R3, MTZ-1523 have a mass of 1.3-2.4 times more than their predecessors. A similar trend is observed abroad. In the USA, for example, over the past two decades, the average weight of tractors with a capacity of over 50 kW has increased by 50%, in Germany the weight of a single tractor has increased 2.3 times during the same time, and the weight of trailers 2 times [1].

Consequently, an increase in the compaction effect of the undercarriage systems of tractors and agricultural implements on the soil is associated with an increase in the weight indices of the machine-tractor units. At the same time, the agrophysical properties of the soil are influenced by both the magnitude of the sealing pressure and the multiplicity of its effect, depending on the number of passes across the field.

In the process of preparing the soil, sowing, caring for plants and harvesting, various machines pass through the field 5–15 times, the total area of the tracks of these vehicles thrusters is twice the area of the field site, 10–12% of the field area is affected from 6 to 20 times , 65–80% - from one to 6 times and only 10–15% of the area is not affected by the wheels of cars. As a result of the impact of the wheels (caterpillars) of tractors, automobiles and agricultural machinery machines marked a significant increase in soil density at a depth of 50–60 cm [2]. In addition, the resistance to tillage on the track of tracked tractors increases by 25%, on the track of wheeled tractors - by 65%, compared to the resistance when processing unconsolidated areas, which leads to additional fuel costs and reduced productivity of the unit [3].

As a result of increased anthropogenic impact on the soil, due to the intensification of farming, cases of degradation of soil fertility have become increasingly common: a decrease in the content of humus, a deterioration in soil structure, a decrease in water permeability and field capacity [4]. Particularly intensified the destruction of the soil structure under the influence of heavy machinery and tools. In the literature there are numerous data showing that an increase in the number of passes of tractors, with modern technologies of growing crops, leads to a compaction of the root zone, which leads to a decrease in the amount of available moisture for plants [5, 6, 7].

The ability to self-decompaction of soils of different genesis under the influence of seasonal fluctuations in temperature, the introduction of large doses of organic and mineral fertilizers, deep chiseliness, in order to enhance the biological activity of the soil and improve the agrophysical conditions of the arable layer, to some extent solve the problem of restoring soil density to the optimum value (for grain crops about 1.0–1.3 g / cm^3). However, the deep layers of the soil (30–60 cm and more), which are in a state of compaction accumulating over the years, decompose much more slowly due to poor water permeability and low biological activity.

The mechanical impact of thrusters on the soil cannot be considered only from the side of the compressing effect, since at the same time there is an intensive destruction of the soil structure under the influence of slipping of the thrusters [8], and consequently its fertility and crop yield decrease. In VIM experiments on chernozems of the Kuban, with double continuous coverage of the field with traces of T-150K and K-701 tractors, the yield of crops of continuous seeding decreased by about 1/3, and with four-fold, by 43–45% [2].

MATERIAL AND METHODS

To determine the effect of compaction on the agrophysical properties of the soil and the development of plants, it is advisable to have an estimated indicator of the impact of running systems on soils of a certain mechanical composition in the cultivation of crops using a particular technology, that is, to develop a methodological concept for assessing the soil by their response to compaction. For this purpose, at the first stage of research, the multiplicity of soil compaction with the machine running systems for the cultivation of winter wheat and corn for grain according to standard technologies was determined by the graph-analytical method, and soybeans by the technology without tillage (Table 1) under the conditions of the Stavropol Territory [9].

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Table 1: The multiplicity and area of the field compaction by the running systems of the aggregates during the cultivation of agricultural products. cultures

Impact	Compaction area, %									
	Multiplicity of compaction									
	0	1	2	3	4	5	6	7	8	9 and more
Black steam - winter wheat										
Total compaction area	18,0	28,0	15,0	12,0	8,0	5,0	5,0	2,0	1,4	5,6
Corn for grain										
Total compaction area	9,2	13,9	18,7	16,7	17,4	9,5	11,0	1,2	1,7	0,7
Soy										
Total compaction area	32,9	51,9	7,5	2,2	5,5	–	–	–	–	–

At the same time, the minimum required set of operations was adopted without taking into account additional treatments related to various weather conditions that take shape in different years in different ways (destruction of the soil crust after rain, additional cultivations, etc.).

RESULTS AND DISCUSSION

Analysis of the research results showed that in the cultivation of winter wheat by a couple of times, 15% of the field area is exposed to a couple of times, 12% three times, 5% six times, 18% is not compacted. The area of 2- and 3-fold compaction in the cultivation of corn for grain is somewhat larger (18.7 and 16.7%, respectively) than in the cultivation of winter crops, since inter-row cultivations were carried out. When cultivating soybean using the technology without tillage, a significantly smaller compaction area of various multiplicity of tracks is observed, which is 67.1%, while according to classical technologies this indicator is equal: for winter wheat - 82%, for corn for grain - 90.8% i.e. technology without tillage in an environmental sense is most favorable.

For practical purposes, it has become necessary to develop a spatial cartographic prediction of soil resistance of various mechanical composition to machine load (using the example of the Stavropol Territory). For this purpose, the gradation criteria for the predisposition of soils of different mechanical composition to over-compaction, developed by V.A. Kovdoy [2]. At the same time, he assumed for the working hypothesis that soils of heavy mechanical composition are more susceptible to over-compaction and dry light soils are much less compacted. In accordance with accepted criteria, sandy and sandy-loamy soils are slightly prone to overcompaction, light loamy to medium degree, medium loamy to high degree, and heavy loamy and light clayey soils to very high degree of susceptibility to overpacking.

The developed forecast map, with the imposition of the contours of administrative districts on it (Fig. 1), will allow the farms to orient themselves in the expediency of acquiring and using energy resources with high specific pressure on the soil, when developing flow charts on the cultivation of crops.

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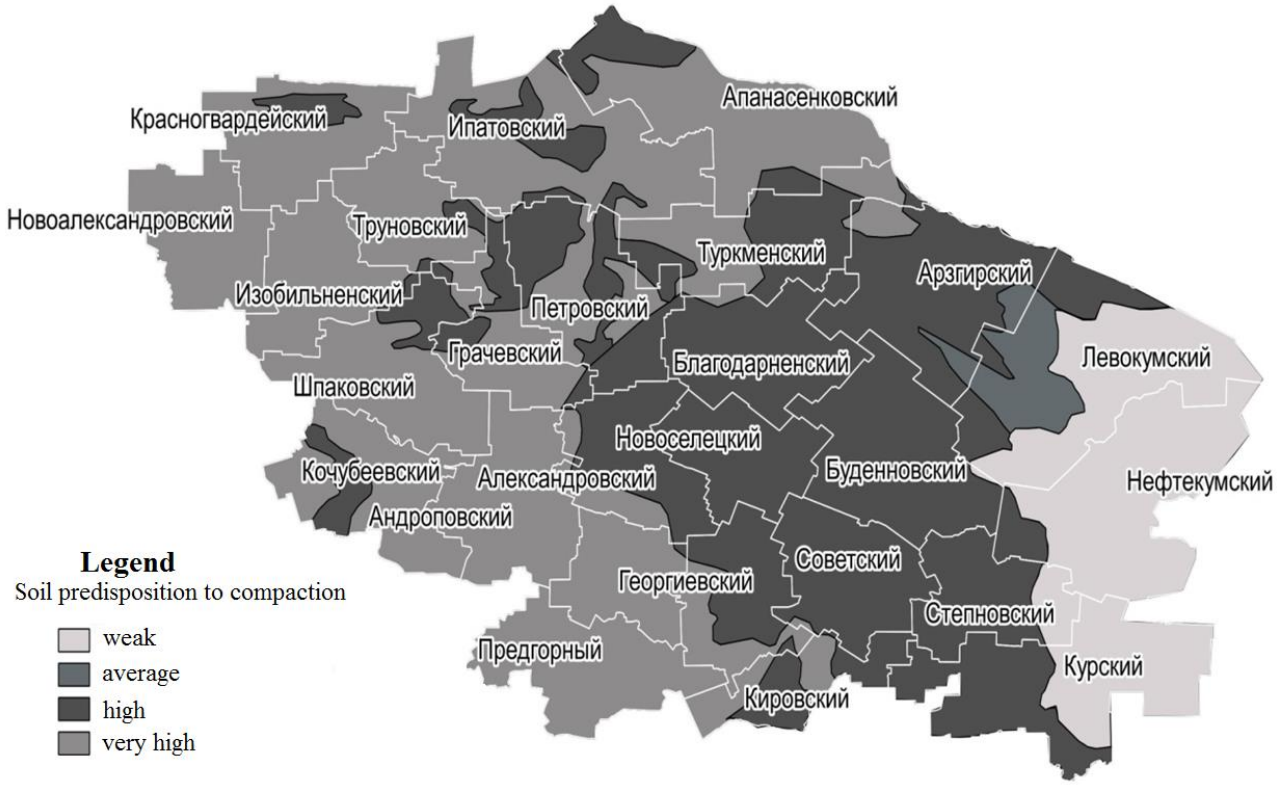

Figure 1: Map of predisposition of soils of different texture to repacking by machine-tractor unit

When performing various works, the movement of units across the field is performed along the field, across it and diagonally. The proportion of such movements is 68, 24 and 8% [2]. The All-Union Research Institute of Sugar Beet (Voronezh Region) recommends to perform all subsequent operations after plowing at an angle of 20 - 25 º to the direction of the previous treatment [10] to improve the leveling of the load on the surface of the field. However, this technique has an excessive re-compaction in the central part of the field, since there is a repeated imposition of traces of the wheels of the aggregates in this zone.

The most economical and less energy-intensive ways of movement of the unit before and after the continuous main tillage, including and on the fields of arbitrary quadrilateral shape.

Known shuttle mode movement of the unit in the fields of rectangular shape with pear-shaped loops on the headlands on both sides of the field, which are processed later in the transverse aisles [11]. At the same time, soil compaction is observed by the drivers on the headlands and the aggregate productivity decreases. The method of movement of the aggregate is also used when tilling the soil in the fields of an arbitrary quadrilateral shape [12], the essence of which is that the selected areas of a triangular and rectangular shape are processed separately by the gon method. The disadvantage of this method of tillage is the fact that when processing fields of a triangular shape, there is a loss of the technological time of the unit operation and soil consolidation on the headlands.

The proposed method of movement of the unit [13] when processing fields, including an arbitrary quadrangular shape (Fig. 2) implies the beginning of processing from working aisles 1 of the peripheral parts of the field with movement to the center due to the shuttle mode of movement along the open perimeter line with the formation of a headland 2 on the longest field side. In the turn zones, the working bodies of the unit are deepened, i.e., idling 3 is carried out, leaving the untreated sections 4 [13].

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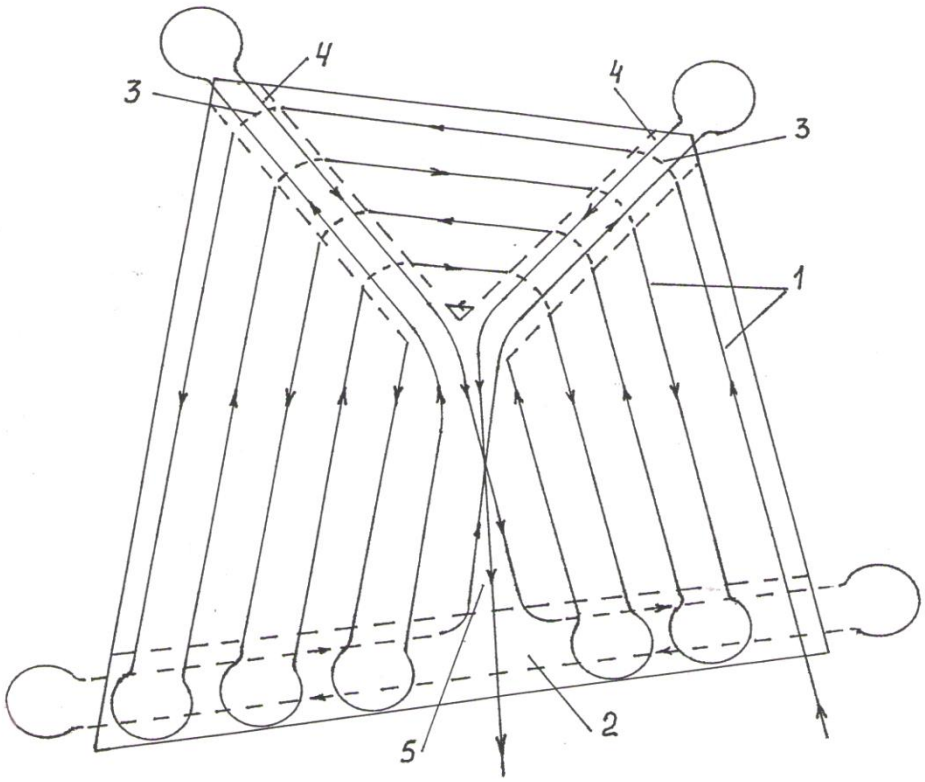

Figure 2: The route of the soil tillage unit on the open perimeter

When there is practically no space for the tractor unit to turn around in a shuttle pattern, the unit continues to move in a loopback way, processing the left untreated sections 4, the headland 2, and finally covering up the raw section 5 when leaving the field. Each subsequent tillage operation begins on the other side of the field. This method of movement of the unit will reduce the area of headlands, reduce the multiplicity of soil compaction, increase the productivity of soil-cultivating units and, to a certain extent, eliminate the sealing effect of propulsion on the soil. Production tests of this method of movement during the cultivation of vapors by the MTZ-82 + KSPS-4.0 unit on the fields of Agro-Smeta LLC of the Georgievsky district showed that the performance of the MTZ-82 + KSPS-4 unit increased by 17%, and the fuel consumption decreased by 1.8 kg / ha.

CONCLUSION

The developed forecasting map-scheme of soil predisposition of various mechanical composition for re-compaction and the proposed method of movement of the unit will allow specialists to decide on the feasibility of equipping tractors with twin wheels with low pressure tires and the use of combined tillage units in a particular farm.

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