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SPIE.

Use of remote positioning technologies to determine damage in case of misuse of agricultural land

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ABSTRACT

The article deals with the problem of assessing damage during seismic surveys on agricultural land used in the production process. The difficulty lies in determining the area of the damaged surface after harvesting the crop. At the same time, the full processing of the entire field to a depth of 35-45 cm will lead to a multiple increase in the cost of reclamation. In order to avoid such a situation, it is proposed to use a GPS tracker, which will indicate the path traveled, and then be able to orient the equipment for spot processing of the field. The purpose of the study is to propose an algorithm for determining damage in case of violation of the fertile surface layer of agricultural land with excessive compaction. To solve this problem, the following tasks are supposed to be solved: - study of a universal methodology for determining damage in case of damage to agricultural land; - to determine the features of the formation of damage during seismic surveys; - formulate proposals for improving the standard methodology. When using a GPS tracker, the cost of reclamation will be reduced from 491 thousand rubles up to 23 thousand rubles (21 times).

Keywords: damage, misuse of agricultural land, remote positioning, soil cover disturbance, GPS tracker, price, lost crop, heavy wheel equipment.

1. INTRODUCTION

Agricultural land requires special protection. Unlike other types of land, agricultural land has productivity and certain technological properties that are easily destroyed, causing significant damage to the land user. In addition to the obvious examples of contamination, mixing of layers, there are more subtle cases of violation of the technological properties of the soil, such as excessive compaction. The movement of heavy wheeled vehicles rams the fertile surface soil layer, reducing its productive properties (figure 1) [1-5].

The sealing action from the wheels extends up to 1 m in depth and up to 0.8 m in the transverse direction. The quality of work when performing technological operations on compacted areas following the tracks of tractors and machines, as a rule, does not meet agrotechnical requirements [6-11]. On the surface of the field there are traces up to 0.12 m deep, in which the density of the soil significantly exceeds the optimal values, the specified depth of cultivation by cultivators is not maintained, up to 48% of seeds of grain crops are not planted to the specified depth, the traction resistance of the working bodies working on compacted areas increases , the quality of harvesting is deteriorating, the structure of the soil is being destroyed, and the yield of grain crops is decreasing [12-15].

With a single pass of heavy equipment, crop losses can reach 50-60%. The consequences of a one-time intensive compaction persist for 2-5 years [16-18].

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Figure 1. Damage to a piece of land during the passage of heavy equipment.

When eliminating the consequences of compaction of the surface layer, two main problems arise: 1) the absence of visible traces of damage after minimal impact on the soil; 2) minimizing the cost of restoring the fertility of damaged areas.

To solve these problems, it is proposed to use GPS trackers.

The purpose of the study is to propose an algorithm for determining damage in case of violation of the fertile surface layer of agricultural land with excessive compaction.

To solve this problem, the following tasks are supposed to be solved: - study of a universal methodology for determining damage in case of damage to agricultural land; - to determine the features of the formation of damage during seismic surveys; - formulate proposals for improving the standard methodology.

2. MATERIALS AND METHODS

In the course of the study, it is planned to investigate the consequences of soil cover disturbance as a result of seismic surveys on agricultural lands.

The damage caused by the technique (U_{sum}) consists of three parts:

$$U_{sum} = U_0 + U_Y + U_{rec} \qquad (1)$$

where U_0 is the damage from previously incurred costs before the disturbance of the soil cover, rub.;

U_Y - lost profit, rub.;

U_{rec} is the cost of restoring the soil cover, rub. [19-22]

To determine all these three components, it is necessary to determine the area of agricultural land (S) on which the soil cover has been damaged.

$$S_p = L \cdot w \qquad (2)$$

where L is the length of the vehicle path, m;

w is the width of the passage of cars (most often coincides with the width of the wheelbase), m [23-26].

To determine the length of the path of vehicles, it is proposed to oblige companies conducting seismic exploration of oil fields to install GPS trackers. In this case, based on the data of such equipment, it is very easy to determine the length of the path of vehicles passing through agricultural land and calculate the amount of damage.

To solve the tasks set, the following methods were used: the empirical method, the statistical method, the calculation and analytical methods.

3. RESULTS AND DISCUSSION

As a basis for the study, data on soil cover disturbance during seismic surveys in 2019 were used. At present (April 2022), it is not possible to determine the area of the damaged surface layer on the ground due to repeated tillage by agricultural machines during technological operations.

However, there are a number of documents submitted (photos, a copy of the act of inspection of crops and plantings of agricultural crops dated September 19, 2019, acts of a planned (raid) inspection, survey of agricultural land dated October 4, 2019 No. 332 / 4, 333 / 4, 334/4, 335/4, 336/4, a cover letter from the Municipal Institution "Department of Agriculture and Food of the Kinel-Cherkassky District Administration) indicate that damage to the surface layer occurred due to the use by the enterprise that carried out the work of a heavy wheel equipment in the process of seismic exploration on land plots with cadastral numbers: 63:23:0704003:12, 63:23:0704003:14, 63:23:0704003:15, 63:23:0000000:5166, 63:23:0000000:4902, 63:23:0000000:4735, 63:23:0702003:60, 63:23:0702003:64, 63:23:0702003:65, 63:23:0702003:66, 63:26:0702003:157 . The source of damage to the surface soil layer (excessive compaction) was the movement of heavy equipment (Sercel Nomad-65 vibrators, the mass of which is 28.5 tons) (figure 2). For comparison: the mass of the K-7 tractor, which is used in the production process, is from 14.0 to 18.8 tons, and the mass of a combine harvester with a full grain hopper is 16.5 tons [27-32].

Figure 2. Vibrators Sercel Nomad-65.

The area of damage is (according to the acts of a planned (road) inspection, survey of agricultural land dated 04.10.2019 No. 332/4, 333/4, 334/4, 335/4, 336/4, conducted by the Office of the Federal Service for veterinary and phytosanitary supervision in the Samara region) a strip with a width of 3 to 6 meters. In total, on the fields occupied by sunflower (63:23:0000000:4902, 63:23:0000000:5166, 63:23:0704003:12), according to the acts of the Administration of the Federal Service for Veterinary and Phytosanitary Surveillance in the Samara Region, 25 bands were observed. According to the Public cadastral map of the Samara region, the width of the fields exceeds 500 m in diameter. Based on this, the minimum area of damage to the surface layer of soil is 4.5 m x 25 pcs. x 500 m / 10000 = 5.6 ha, which shows

that the data given in the letter of the Municipal Institution "Department of Agriculture and Food of the Kinel-Cherkassky District Administration No. 81 of 04/06/2022 are quite reliable.

For the rest of the plots, acts of planned (raid) inspection, surveys of agricultural land were drawn up after harvesting crops, so it is not possible to establish the number of passes of equipment for seismic surveys.

At the same time, based on the data of the GPS tracker, it is easy to determine the length of the path of equipment over agricultural land (figure 3).
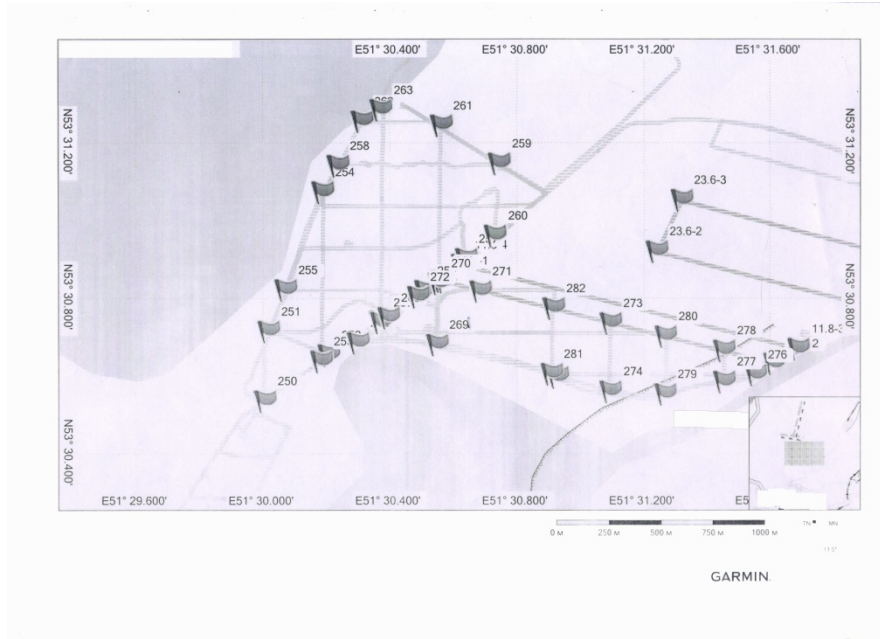

Figure 3. A map of the movement of equipment during seismic surveys using a GPS tracker.

According to this map, it is easy to calculate the damaged area, determine the placement of crops and, as a result, calculate the damage. At the same time, it is easy to repeat the original path when eliminating the consequences of damage to the fertile layer.

To eliminate the negative impact of soil compaction, deep loosening to a depth of 40-45 cm is assumed [33-38]. In accordance with the technological map, the cost of processing compacted soil with a chisel plow (PCh-4.5) at the current price level (April 2022) is 2183 rubles/ha or 23.1 thousand rubles over the entire damage area (10.6 ha). The calculation was carried out using the Program for the calculation of technological maps in crop production, developed at the Department of Economic Theory and Economics of the Agroindustrial Complex of the Samara Agrarian University.

Based on the data specified in the letter of the Municipal Institution "Department of Agriculture and Food of the Administration of the Kinel-Cherkassky District No. 81 dated 04/06/2022, the statistical reporting form of the peasant farm enterprise No. 2-farmer (information on the harvest of agricultural crops) for 2019 and price monitoring data conducted by Samara-ARIS for 2022. (Table 1), the market value of the lost crop in the indicated areas in 2019 was calculated (table 2).

Table 1. The price of most sales in the Samara region in 01.2022-03.2022 (State Budgetary Institution "Samara - ARIS").

Date	01.01.2022	15.01.2022	01.02.2022	15.02.2022	01.03.2022	15.03.2022
Barley	14740	14740	14740	15400	15400	15400
Sunflower	38400	40000	38400	41000	41000	41000

Average price for the period 01.2022-03.2022 amounted to: barley - 15070 rubles / t, sunflower - 39967 rubles / t.

The price of Sudanese grass hay at the beginning of April 2022, according to the Avito.ru portal, was 1,500 rubles. per roll weighing 300 kg. The cost of 1 ton of hay is 5000 rubles/ton.

Table 2. Lost crops due to seismic surveys in 2019.

Crop	Area of crop death, ha	Cadastral numbers of land plots	Productivity (according to the form No. 2-farmer), cwt/ha	Lost crop, t
Barley	2.04	63:23:0704003:14 63:23:0704003:15 63:23:0704003:12 (contour - 1)	32.3	6.59
Sunflower	7.66	63:23:0000000:4902 (contour - 2,3), 63:23:0000000:5166 (contour - 1), 63:23:0704003:12 (contour - 2)	29.9	22.9
Sudanese grass	0.9	63:23:0000000:4902 (contour - 1)	45.0	4.05

The cost of the lost crop in these areas in 2019 at the prices of the beginning of 2022 will be 6.59 tons x 15070 rubles/t + 22.9 tons x 39967 rubles/t + 4.05 tons x 5000 rubles/t = 1034805.0 rubles.

4. CONCLUSION

At present (April 2022), it is not possible to determine the area of the damaged surface layer on the ground, due to repeated tillage by agricultural machines during technological operations. However, the calculations carried out according to the data of the acts of the planned (road) inspection, survey of agricultural land, show the high reliability of the data given in the act of inspection of crops and plantings of crops dated September 19, 2019, according to which the area of the damaged surface soil layer was: in plots 63:23:0704003:14, 63:23:0704003:15, 63:23:0704003:12 (contour - 1) (spring barley) - 2.04 ha; 63:23:0000000:4902 (contour - 2.3), 63:23:0000000:5166 (contour - 1), 63:23:0704003:12 (contour - 2) (sunflower) - 7.66 ha; 63:23:0000000:4902 (contour - 1) (sudanese grass) - 0.9 ha.

The source of damage to the surface layer of the soil was compaction by heavy machinery at the place of its passage. The compaction from the wheels extends up to 1 m in depth and up to 0.8 m in the transverse direction. At the moment of damage, the area of the damaged area is well defined visually, which makes it possible to limit the treatment to only the damaged area. To eliminate the consequences of excessive soil compaction, it was enough to process the damaged area to a depth of 35-45 cm with a chisel plow. In accordance with the technological map, the cost of this operation in this case will be 2183 rubles/ha or 23.1 thousand rubles over the entire damage area (10.6 ha).

Cost of damage from loss (destruction) of spring barley crop on an area of 2.04 ha; sunflower on an area of 7.66 hectares; Sudanese grass on an area of 0.9 hectares, which occurred in the period August-September 2019 as a result of survey work of seismic exploration, in prices as of the current date (April 2022), is 1,034,805.0 rubles.

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