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RESEARCH OF THE DEGREE OF FIXATION OF ABRASIVE PARTICLE IN THE SOIL

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An adaptation was developed for measuring the soil shear resistance.. Studied the influence of the type and moisture content of the soil, as well as on the content of the root system on it, on the degree of fixation of the abrasive particles in the soil. The regularities of the degree of fixation of the abrasive particles in the soil are established depending on the mentioned factors. The directions of further research are determined.

Key words: abrasive particle, soil, degree of anchorage of abrasive particles, soil cultivating machines, seeding machines, coefficient of internal friction, specific gravity.

Introduction

So far, the soil as an element of the tribosystem has not been studied sufficiently, therefore the properties of this abrasive environment, which determine the intensity of deterioration of the working elements of soil cultivating and sowing machines, are not fully elucidated.

The abrasive particles in the soil that interact with the surface of the working organ can be fixed on one, two or three sides, that is, to have a different number of degrees of freedom, which substantially affects the flow of processes in the contact area of the particle with the surface of the friction.

The characteristic of the bound state of particles is the degree of abrasion fixation [1], which is one of the leading factors in the wear process. For example, when using heavy disk blowers, the front row of disks vanishes 1,5 ... 2 times faster than the rear, which is explained by the decrease in the degree of fastening of abrasive particles in the soil, which is processed in the back row, as other factors in both rows of discs are the same .

In order to take into account the degree of abrasion fixation in the design and production of working bodies of soil cultivating and sowing machines with high wear resistance, it is necessary to develop a method for determining this indicator and carry out its quantitative assessment. The study of the effect of soil moisture on the degree of abrasion fixation will allow you to choose the optimal timing for soil cultivation to reduce the intensity of deterioration of the working organs of soil cultivating and sowing machines.

Analysis of published materials in this problem

In the works [2, 3] the leading role of the strength of sand fixation in the soil mass on its abrasiveness is noted. For example, in a dry soil, where sand particles are firmly fixed, the most intense abrasive wear of the metal occurs [2].

Soil is an environment the particles in which are in a non-rigid state and are able to move relative to one another, and also to rotate around its own axis under the action of normal and tangential stresses from external action [4]. The degree of fixation of abrasive particles in the soil is characterized by tangential stress and is determined by the displacement tensile strength τ [5].

The degree of fixation of abrasive particles in the soil depends on the number of dust particles smaller than 0.01 mm [4].

At present, during the design and operation of the working bodies of soil tillage and sowing machines, the degree of fixing of abrasive particles is not taken into account, since its actual value for soils of Ukraine remains uncertain.

Goal

To study the impact of type and humidity of soil and the content of root system in it on the degree of fixation of abrasive particles in plowing soli layer.

Methods of research

The resistance of the soil shear consists of the adhesion due to the molecular and capillary forces, as well as the forces of internal friction [6].

For a real soil, the displacement resistance can be determined by the formula:

$$\tau = c + \sigma \cdot f, \tag{1}$$

where f is a coefficient of internal internal friction of the soil;

σ is the normal tension, Pa;

c is the specific coupling, Pa.

In the field conditions the soil shear resistance was determined on the developed device, the scheme of which is shown in Figure 1.

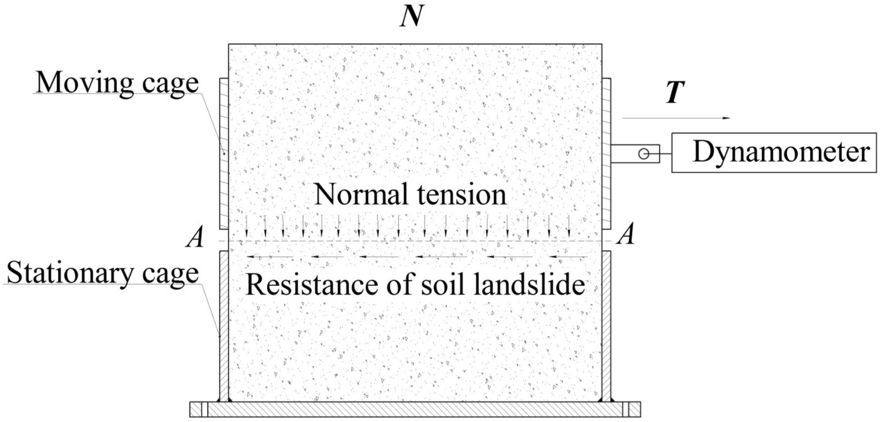

Fig. 1 – Scheme of adaptation to determine the resistance of soil landslide:
***T* – horizontal displacement force, N;**
***N* – vertical force or normal load (depends on the weight of the soil and additional loads), N**

For the measurements on the test field, a sample of soil (length 150 mm, width 150, and height depending on the location of determination of the resistance of the soil shift of the table 1).

A sample of soil was placed in a device (Fig. 1) with a cross-sectional area A = 0.0225 SQM and gradually applied the displacement force T. In this case, the landslide stress τ appeared in the plane A-A.

After reaching τ_{edge} there is a shift in the ground in the plane A-A. By the results of research we established:

$$\tau_{edge} = T / A, \tag{2}$$

where T is the horizontal sliding force, at which the movement of the upper layer began with respect to the lower one;

τ_{edge} is the resistance of soil landslide.

Table 1

Height of researched samples

№	Depth of determination of the resistanceof soil landslide, mm	Sample height, mm
1	100	200
2	200	300
3	300	400
4	400	500

Normal stresses were determined according to the correlation:

$$\sigma = \frac{N}{A}. \tag{3}$$

The coefficient of internal friction f and specific gravity c were determined graphically (Figure 2).

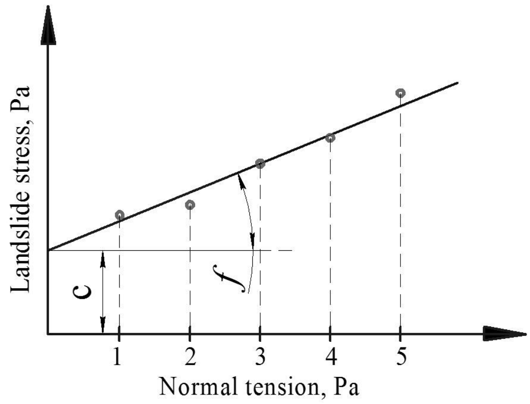

Fig. 2 – Schedule for determining the coefficient of internal friction *f* and specific coupling *c*

In order to take into account the influence of the root system of agricultural crops on the degree of fastening of abrasive particles in the ground, the research was carried out in the fields after harvesting. In this case, the difference between the resistance of the soil shift, containing the root system and without it at the same depth (Table 2) was determined.

To determine the effect of soil moisture on the value of the coefficient of internal friction f and specific traction on different soil types, studies have been carried out in accordance with the table 2.

Table 2

Characteristics of Fields

№	Location	Coordinates	Type of soil (mechanical structure)	Plants	Soil humidity, %
1	Ovruch district	latitude: 51,27799804, longitude: 28,80246162.	loamy	After corn	10,06
2	Ovruch district	latitude: 51,27799804, longitude: 28,80246162.	loamy	After corn	8,21
3	Zhytomyr district	latitude: 50,13356399 longitude: 28.78126144	Clayey soil	After winter wheat	16,8
4	Zhytomyr district	latitude: 50,13356399 longitude: 28,78126144	Clayey soil	After winter wheat	14,3
5	Korosten district	latitude: 50,78765206 longitude: 28,34549904	Sandy	Perennial meadow grasses	8,6
6	Korosten district	latitude: 50,78765206 longitude: 28,34549904	Sandy	Perennial meadow grasses	7,3
7	Vinnytsia region, Koziatyn district	latitude: 49,79478502 longitude: 28,73422623	Clayey soil	After soya	13,3
8	Vinnytsia region, Koziatyn district	latitude: 49,79478502 longitude: 28,73422623	Clayey soil	After soya	17,7

Results of research

The installation for studying the degree of fastening of the abrasive particles in the soil and the coefficient of internal friction of the soil is presented in Fig. 3. All studies were carried out in the spring-autumn period of 2018.

Fig. 3 – Installation for studying the degree of fastening of the abrasive particle in the soil and the coefficient of internal friction of the soil

Measurement of soil moisture was carried out by drying to a constant mass in accordance with National Standard of Ukraine B.V.2.1-17:2009 [7].

Results of experiment number 1 (table 2) are presented in Fig. 4 - 6.

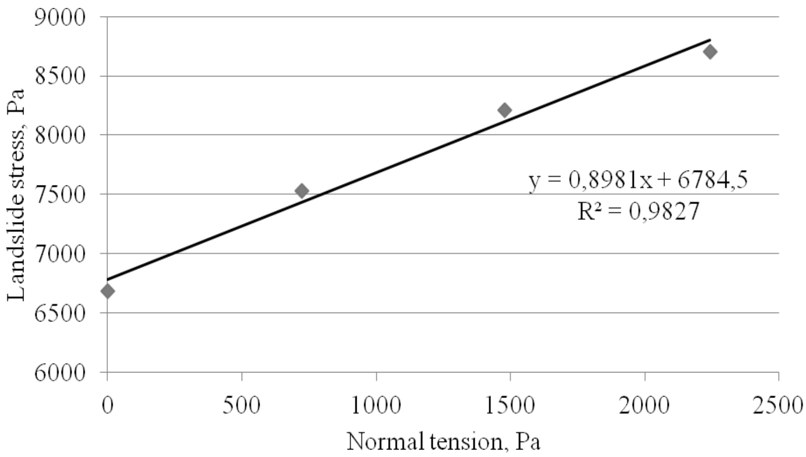

Fig. 4 – Results of researches on determining the coefficient of internal friction f and specific gravity on the sandy soils (cut depth 100 mm.)

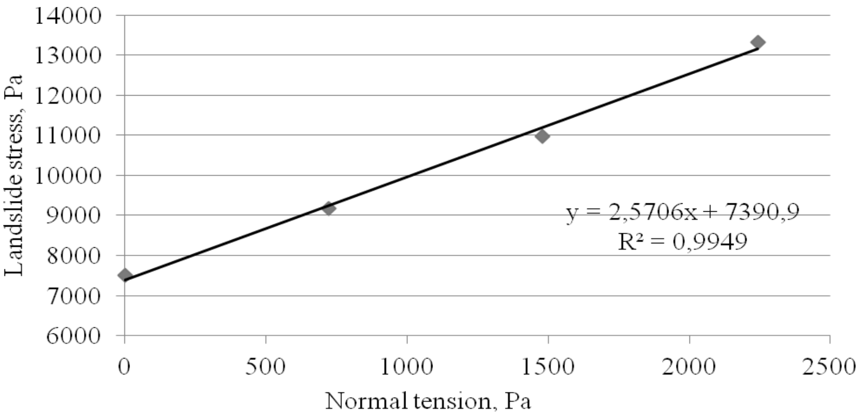

Fig. 5 – Results of studies on determining the coefficient of internal friction *f* and specific adhesion *c* on the sandy soils (cut depth of 200 mm)

Based on the graph, one can conclude that the coefficient of internal friction of sandy soils at humidity 10,06 is 0,8981, and the specific gravity is 6784,5 Pa.

At a depth of 300 mm, experiments on sandy soils were not carried out because the goose layer was 260 mm. To determine the pouring of the root system of plants by the coefficient of internal friction f and specific adhesion c from the conducted experiments with the presence of the root system.

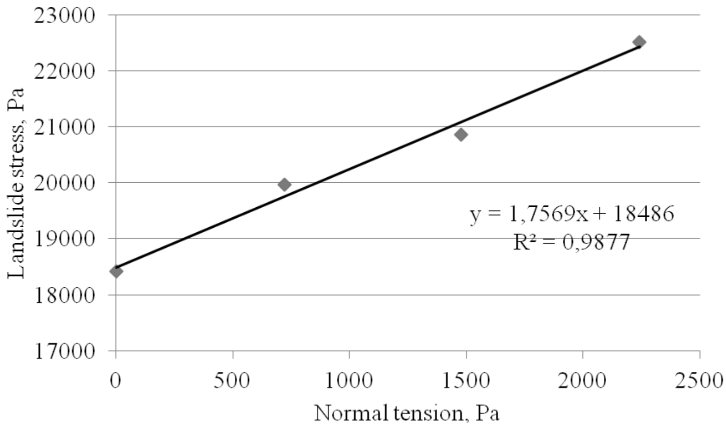

Fig. 6 – Results of researches on determining the coefficient of internal friction f and specific gravity on the sandy soils (cut depth 100 mm)

The results of other researches carried out are given in table 3.

Table 3

Results of research

№	Location	Type of soil (mechanical structure)	Humidity	Available root system	Depth from surface	Specific adhesion c, Pa	Coefficient of internal friction
1	Ovruch district	Sandy	10,06	No root system	100	6784,5	0,8981
					200	7390,9	2,5706
				With corn root system	100	18486	1,7569
2	Ovruch district	Sandy	8,21 %	No root system	100	6239,03	0,8034
					200	8125,76	2,3681
3	Korosten district	Loamy	8,6	Root system of perennial grass	100	5397,3	1,4215
					200	5689,6	1,5686
4	Korosten district	Loamy	7,3	Root system of perennial grass	100	5134,68	1,3872
					200	5702, 4	1,4973
5	Koziatyn district	Clayey	13,3	Soya root system	100	5615,34	1,4022
					200	11435	2,1591
6	Koziatyn district	Clayey	17,7	Soya root system	100	6663,1	1,4322
					200	11936,2	2,2945
7	Zhytomyr district	Clayey	14,3	Root system of winter wheat	100	5834,15	1,3921
					200	9721,89	2,1342
8	Zhytomyr district	Clayey	16,8	Root system of winter wheat	100	6407,1	1,4596
					200	10927, 8	2,429
				No root system	100	5640,45	1,0463

The presence of the root system significantly increases the coefficient of internal friction and the degree of attachment of abrasive particles (specific gravity *c*) on sandy soils, the presence of the root system of maize at a depth of 100 mm increases the data in 1.95 and 2.72 times respectively, and on clay soils, the presence of root wheat systems increases respectively 1.39 and 1.14 times, respectively. Such a significant difference in the indicators is due to the difference in the root system of wheat and corn.

Increasing the humidity on clay soils increases the coefficient of internal friction and the degree of fastening of abrasive particles (specific gravity *c*). This process will continue until the soil is saturated with moisture and the appearance of free water, after which the coefficient of internal friction and specific adhesion will begin to decrease. The reduction of the coefficient of internal friction and specific gravity on sandy and sandy soils is also observed when the soil is saturated with moisture and the appearance of free water, but the moisture content in which it appears in this case is much smaller. With the increase in the depth of the research from the surface of the soil, the degree of fastening of abrasive particles (specific gravity *c*) increases. Thus, with the change in depth from 100 mm to 200 mm on clay soils, specific gravity increases in 1.66 ... 2.0 times, on sandy and sandy - in 1.05 ... 1.3 times.

Conclusions and directions for further researches

1. The degree of fixture of abrasive particles on clay soils is greater than on loamy and sandy soils.
2. Increased soil moisture leads to an increase in the degree of fixture of abrasive particles on all types of soils, this pattern is observed until the soil is saturated with moisture.
3. The presence of the root system significantly increases the degree of fastening of abrasive particles in the soil and depends on the type of root system and its state.

In the future it is necessary to investigate the effect of the degree of fixture of abrasive particles of soil on the intensity of wear of working bodies of soil-working machines.

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Дворук В.І., Борак К.В. **Дослідження ступеню фіксації абразивного частинки у ґрунті.**

Розроблено адаптацію для вимірювання стійкості до зсуву ґрунту. Вивчено вплив типу і вологості ґрунту на вміст кореневої системи, на ступінь фіксації абразивних частинок у ґрунті. Встановлено закономірності ступеня фіксації абразивних частинок у ґрунті залежно від згаданих факторів. Визначено напрями подальших досліджень.

Ключові слова: абразивна частка, ґрунт, ступінь закріалення абразивних частинок, ґрунтообробні машини, сівалки, коефіцієнт внутрішнього тертя, питома вага.