EXPERIMENTAL STUDIES OF THE INTERACTION OF TRACTOR DRIVE WHEELS WITH THE SOIL IN THE PLOWED FIELD
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ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ ВЗАЄМОДІЇ ПРИВОДНИХ КОЛІС ТРАКТОРА ІЗ ҐРУНТОМ НА ЗОРАНОМУ ПОЛІ

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ABSTRACT
The article defines the influence of structural and operational parameters of a machine-tractor unit on changes in the hardness of freshly plowed soil due to deformation and compaction of the soil by wheeled running systems. An experimental model of the effect of pressure in the pneumatic chamber of the wheel, working width, and speed of the unit on changes in soil hardness in the area of operation of running systems is obtained. The obtained mathematical models make it possible to reduce the negative impact on the soil by optimally completing, configuring, and selecting a machine-tractor unit operating mode.

РЕЗЮМЕ
У статті визначено вплив конструкційних та експлуатаційних параметрів машинно-тракторного агрегату на зміну твердості свіжозораного ґрунту внаслідок деформації та ущільнення ґрунту колісними ходовими системами. Отримано експериментальну модель впливу тиску в пневматичній камері колеса, ширини захвату та швидкості руху агрегату на зміну твердості ґрунту в зоні дії ходових систем. Отримані математичні моделі дозволяють зменшити негативний вплив на ґрунт ходових систем за рахунок оптимального комплектування, налаштування та вибору режиму роботи машинно-тракторного агрегату.

INTRODUCTION
In the context of the intensification of agricultural production, more and more attention is paid to the issues of soil conservation and reducing the negative impact on the environment (*Jimenez et al., 2021; Usowicz et al., 2017*). Current trends in Mechanical Engineering consist in increasing the productivity of machine-tractor units (MTU) by increasing the working width and increasing power. As a result of the action of running systems, deformation, compaction and changes in the porosity of the soil occur, the processes of air and moisture permeability are disrupted (*Peth et al., 2010; De Lima et al., 2017*). Under the influence of cyclic loads, there is a change in the soil structure (*Pulido-Moncada et al., 2019*) and a shift in soil layers (*Huang et al., 2021*), which has a more negative impact than deformation and compaction. As a result, the conditions for the development of plant root systems worsen (*Nawaz et al., 2013; Batey, 2009*), which leads to a decrease in crop productivity and yield (*Mueller et al., 2010; Golub et al., 2019*). Taking into account global trends, the issue of reducing soil degradation under the influence of running systems is an urgent task.

Most of the studies performed on the influence of contact interaction of running systems with the ground can be divided into two main areas. The first direction of this study is related to determining the influence of a certain factor of contact interaction of the wheel with the fertile soil layer. In (*Carman, 2002; Taghavifar, H. et al., 2015*), the influence of vertical load from tractor weight on the process of soil degradation is considered. The authors (*Pulido-Moncada et al., 2019; De Pue et al., 2020*) found out that as a result of the action of traction force the soil is destroyed in the horizontal direction. However, the process of changing the properties of the fertile soil layer cannot be limited to analyzing changes in the soil condition as a result of certain loads. In (*Kurjenluoma et al., 2019; Carman, 2002; Vennik et al., 2019*), diverse studies were performed to determine the structural parameters of tires and vertical loads on soil compaction, rolling resistance, and track formation.

One of the most important indicators of the interaction of the wheel with the soil is sliding (*Mason et al., 2016; Gray et al 2016; Damanauskas, 2015*), which directly affects the effective performance of MTU and leads to the destruction of the fertile soil layer. The data obtained as a result of such studies allows obtaining regression models suitable for modeling the influence of certain factors on the parameters of wheel interaction with the ground. These studies give a complete picture of the effect of a particular factor and the consequences that this factor entails. However, the practical application of such studies is limited by the fact that when the wheel interacts with the ground, all factors act in a complex way, affect each other and have certain relationships. In (*Taghavifar, H. et al., 2015; Golub et al., 2017*), the factors of contact interaction are combined on the basis of the effect on the traction power of the power tool. However, studies (*Taghavifar, H. et al., 2015; Golub et al., 2017*) do not fully take into account the parameters of the soil environment and their changes under the influence of loads.

The second area of research is related to the creation of mathematical models that allow linking the parameters of the soil environment and the parameters of contact interaction of running systems with the soil and are aimed at reducing the negative impact on the soil. In (*Défossez et al., 2002; Smith et al., 2000*), the soil is considered as a certain homogeneous elastic element. The use of such models for determining deformations and compaction of the soil is somewhat limited by the fact that the soil has a heterogeneous structure and the effect of contact loads exceed the elasticity of the soil. A number of analytical models of VTI (Vehicle Terrain Interface) have been developed to determine the indicators of soil deformation and track formation (*Carman, 2002; Vahedifard et al., 2016; Golub et al., 2019*). The use of analytical models requires a significant amount of experimental data on determining the parameters of the agrotechnological environment. There are a certain number of finite element models (FEM) (*González Cueto et al., 2016; Silva et al., 2018*) that take into account the contact interaction of running systems and allows determining soil deformations. However, most finite element models focus on determining the effect of soil environment properties on the stress distribution and deformation of the soil. The use of FEM models to take into account the design parameters of running systems and MTU operating modes requires the search for partial solutions to the interaction of the corresponding parameters and the determination of a certain number of initial parameters. The SoilFlex model (*Keller et al., 2007*) and the varieties obtained on its basis (*Keller et al., 2015; Lozano et al., 2013*) are most widely used for predicting soil deformations. These models allow combining the parameters of the contact interaction of the wheel with the soil, take into account the properties of the soil and allow determining the volume of the soil deformation in different directions. However, these models are not yet suitable for determining the optimal effective indicators and operating modes of the MTU.

The volume of research performed to date provides an understanding of the influence of various factors of contact interaction of running systems on the fertile soil layer. However, the obtained results do not make it possible to perform a comprehensive simulation of the impact of MTU running systems on the fertile soil layer and search for optimal driving modes. When modeling the impact of running systems, it is necessary to understand that the load-bearing capacity of the soil and its ability to deform significantly depends on the composition of structural elements, the content of substances, porosity and moisture of the soil.

The purpose of the research is to determine the relationship between the operational parameters of the MTU due to the settings of wheel running systems and their impact on the fertile soil layer. A freshly plowed soil layer was chosen as the soil medium for conducting experimental studies. In this phase, the soil is loosened as much as possible and is maximally exposed to the negative effects of running systems. The change in the forces of contact interaction of the wheel with the ground was modeled by a change in the pressure in the pneumatic chamber of the wheel, a change in the gripping width of the working unit, and a change in the speed of movement. These factors directly affect sliding, rut formation, and changes in soil parameters. This combination made it possible to determine the influence of the design and operational parameters of the MTU on the indicators of changes in the soil environment and determine the effective performance of the MTU.

MATERIALS AND METHODS

Studies of the effect of wheel thrusters on the fertile soil layer were performed using a multi-factor experiment according to the D-optimal Box-Behnken design for the three studied factors (*Golub et al., 2018*). The adequacy of the obtained regression equations was evaluated by the Fischer criterion. Statistical estimation of the level of variance of the obtained results was carried out according to the Cochrane criterion for a 95% confidence probability level. The intervals of values and levels of variation of variable factors that were used in the research are shown in Table 1.

When performing experimental studies, a Kyi-14102 tractor with a total weight of 37.5 kN and a PRO-3 plow weighing 8.5 kN were used (Fig. 1, a, b). To determine the influence of the studied factors on changes in soil hardness, a rectangular section of the field with a length of 150 m and a width of 100 m was previously plowed to a depth of 30 cm.

Table 1

Intervals of values and variation levels of research factors

Name of the factors	Marking	Factor levels			Variation intervals
		-1	0	+1	
Driving speed, [km/h]	V_T	4.6	6.4	8.2	1.8
Pressure in the pneumatic chambers of the wheel, [atm]	P_P	1.4	1.8	2.2	0.4
Working width of the unit, [m]	L_U	0.35	0.70	1.05	0.35

The change in the traction resistance applied to the tractor was modeled by changing the width of the plow grip (the number of installed plow housings was changed). Before starting the research, the plow was set up so that all its housings were evenly buried by 30 cm when the tractor was moving on a horizontal surface. After setting the appropriate pressure in the pneumatic chambers of the wheels and adjusting the width of the plow grip, the tractor was driven through freshly plowed soil. The change in soil hardness was determined by measuring the taper index of the soil profile.

The taper index of the freshly plowed soil profile was measured using a DATAFIELD manual electronic penetrometer (Fig. 1, c), in the range of soil profile depth from zero to 30 cm in 25 mm increments. Measurement of the taper index in the track from the contact interaction of the wheel with the ground was carried out to a depth of 30 cm from the horizontal surface of the field.

Fuel consumption was measured by a portion fuel flow meter, which was connected to the tractor fuel system using two three-way cranes. Thanks to the parallel connection of the fuel flow meter in the fuel supply and return line from the high-pressure fuel pump, it was possible to instantly switch the engine power from the standard fuel supply system to the batch fuel flow meter.

Wheel slip was defined as the path that the wheel passes in one complete turn. To determine the amount of rotation, the wheel was divided into eight equal sectors, each of which had neodymium magnets placed on the wheel rim. A bracket with a reed switch connected to the pulse counter was installed on the tractor fender. During the passage of the control section of a given length, the number of pulses was measured, which made it possible to determine the actual path travelled by the wheel during the passage of the control section.

Using a measuring tool, the depth of the track was recorded after the tractor passed through. The experiments were performed in threefold repetition.

a b c

Fig. 1 - Equipment used in conducting experimental studies:

a – preparation of the field for conducting experimental studies; b – plow with a variable number of housings for modeling the tractor load; c – manual electronic penetrometer for measuring the taper index of the soil profile

To estimate the change in soil hardness after the tractor wheels passing, the soil hardness coefficient was applied, which was determined by the following expression:

$$k = \sum_{i=1}^{n} \frac{T_{Bi}}{n} \Big/ \sum_{i=1}^{m} \frac{T_{Ai}}{m} \text{ [rel. un.]} \quad (1)$$

where:

k_H – soil hardness coefficient, [rel. un.]; T_{Ai} – hardness of the soil profile of freshly plowed soil at the appropriate depth, [kPa], m – number of measurements of the hardness of a freshly plowed soil profile; T_{Bi} – hardness of the soil profile in the track at the appropriate depth, [kPa], n – number of soil profile hardness measurements in the track.

To determine the change in the hardness of the soil profile, a 5-fold measurement of the taper index in the track of the corresponding experiment was performed and its average value was determined.

RESULTS

As a result of mathematical processing of experimental research data, regression equations were obtained, which are given in table 2.

Table 2

Regression equations obtained as a result of mathematical processing of experimental data

Indicator name	Regression equation	Number
Soil profile hardness coefficient, k_H, [rel. un.]	$k_H = 8.06667 + 1.31061V_T + 1.38863P_P + 3.12633L_U + 0.563635V_T^2 - 0.53096P_P^2 - 0.16071L_U^2 - 0.02792V_TP_P - 0.14897V_TL_U - 0.125P_PL_U$	(1)
Track depth, h_K, [mm]	$h_k = 172.028 - 3.7158V_T - 108.2558P_P + 0.1072L_U + 0.8128V_T^2 + 38.2813P_P^2 - 0.0008L_U^2 - 0.5671V_TP_P + 0.0134V_TL_U + 0.1548P_PL_U$	(2)
Wheel sliding, δ, [rel. un.]	$\delta = 8.7787 - 0.0498V_T - 10.0464P_P + 0.0632L_U + 0.0175V_T^2 + 3.6279P_P^2 - 0.0003L_U^2 + 0.0152V_TP_P + 0.0011V_TL_U$	(3)
Fuel consumption, G, [kg/h]	$G = 21.0211 - 1.4247V_T - 19.0972P_P - 0.0993L_U + 0.1475V_T^2 + 5.5259P_P^2 + 0.0004L_U^2 + 0.3306V_TP_P + 0.0074V_TL_U + 0.0251P_PL_U$	(4)

A graphical interpretation of equations (1-4) is shown in Fig. 2-5.

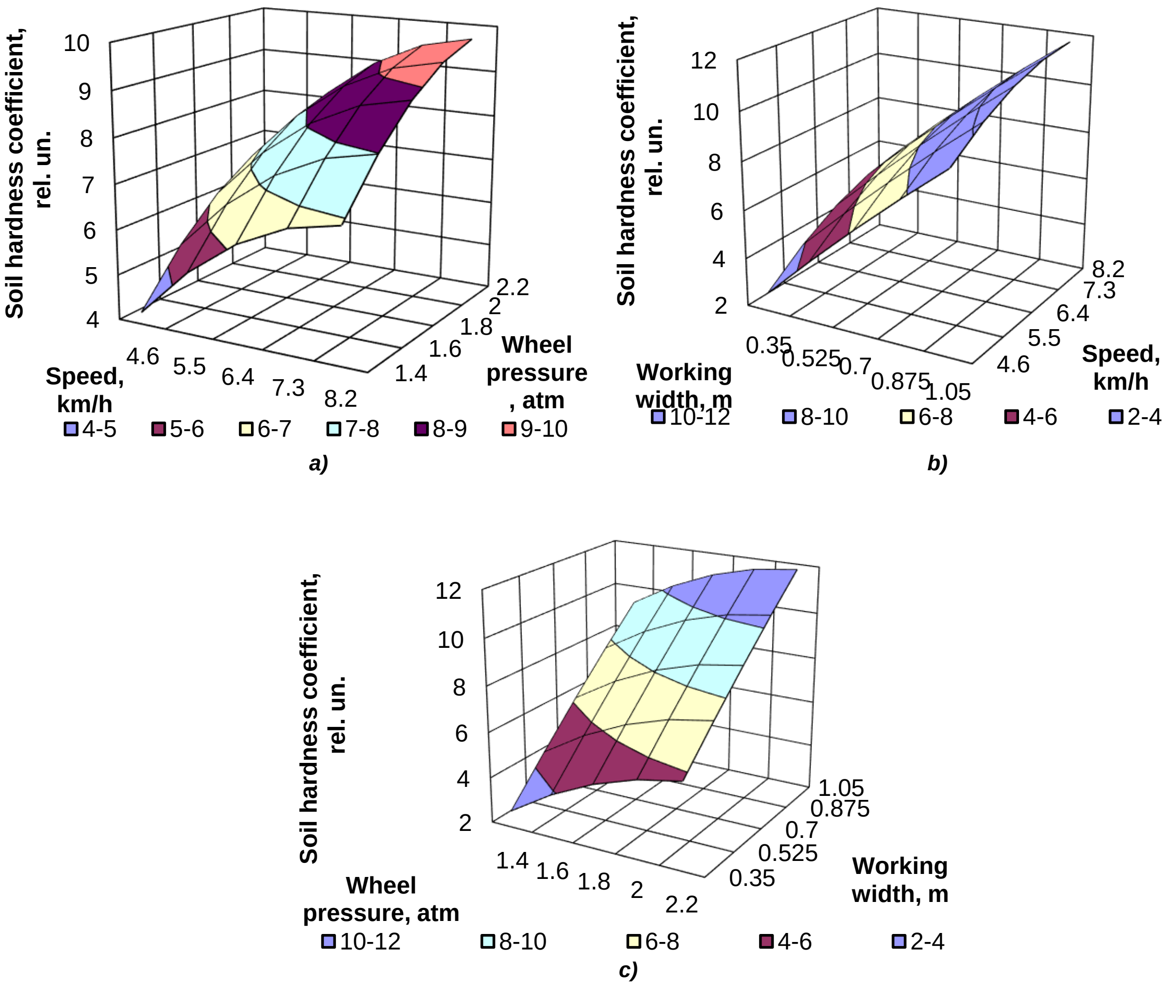


Fig. 2 - Graphical dependence of the soil hardness coefficient on:

a - driving speed and pressure in the pneumatic chambers of the wheel with a working unit working width of 70 cm;
b - driving speed and working width of the unit at a pressure in the pneumatic chambers of the wheel of 1.8 atm;
c - pressure in the pneumatic chambers of the wheel and the working width of the unit at a speed of 6.4 km/h.

It should be noted that the value of the hardness coefficient of the soil profile after plowing in relation to the untilled field was 42.8. Based on the obtained data, it can be stated that the maximum soil hardness in the track after the tractor passes reaches almost 25% of the field hardness before plowing.

With a working width of a working unit of 0.7 m, the minimum value of the soil hardness coefficient is obtained at a speed of 4.6 km/h, and the pressure in the pneumatic chamber of the wheel is 1.4 atm, namely 4.273. Increasing the speed of the tractor to 8.2 km/h leads to an increase in the hardness coefficient by 61.3%. Pressure increase to 2.2 atm. at a speed of 8.2 km/h leads to the increase of the soil hardness coefficient by 40.3%. Changes in the speed of movement and pressure in the pneumatic chamber of the wheel have almost the same effect on the soil hardness coefficient, since the difference between the values of the change Δk_H is less than 6%.

At a pressure in the pneumatic chamber of the wheel of 1.8 atm, the minimum value of the soil hardness coefficient is obtained with a working unit working width of 0.35 m and a driving speed of 4.6 km/h, namely 2.756. Increasing the tractor speed to 8.2 km/h leads to a 106% increase in the hardness coefficient. Increasing the working unit working width to 1.05 m at a speed of 8.2 km/h increases the soil hardness coefficient by 105%. A change in the working width (an increase in traction resistance) has a more significant effect on soil compaction than the speed of movement, since the difference between the values of the change Δk_H is about 124.4%.

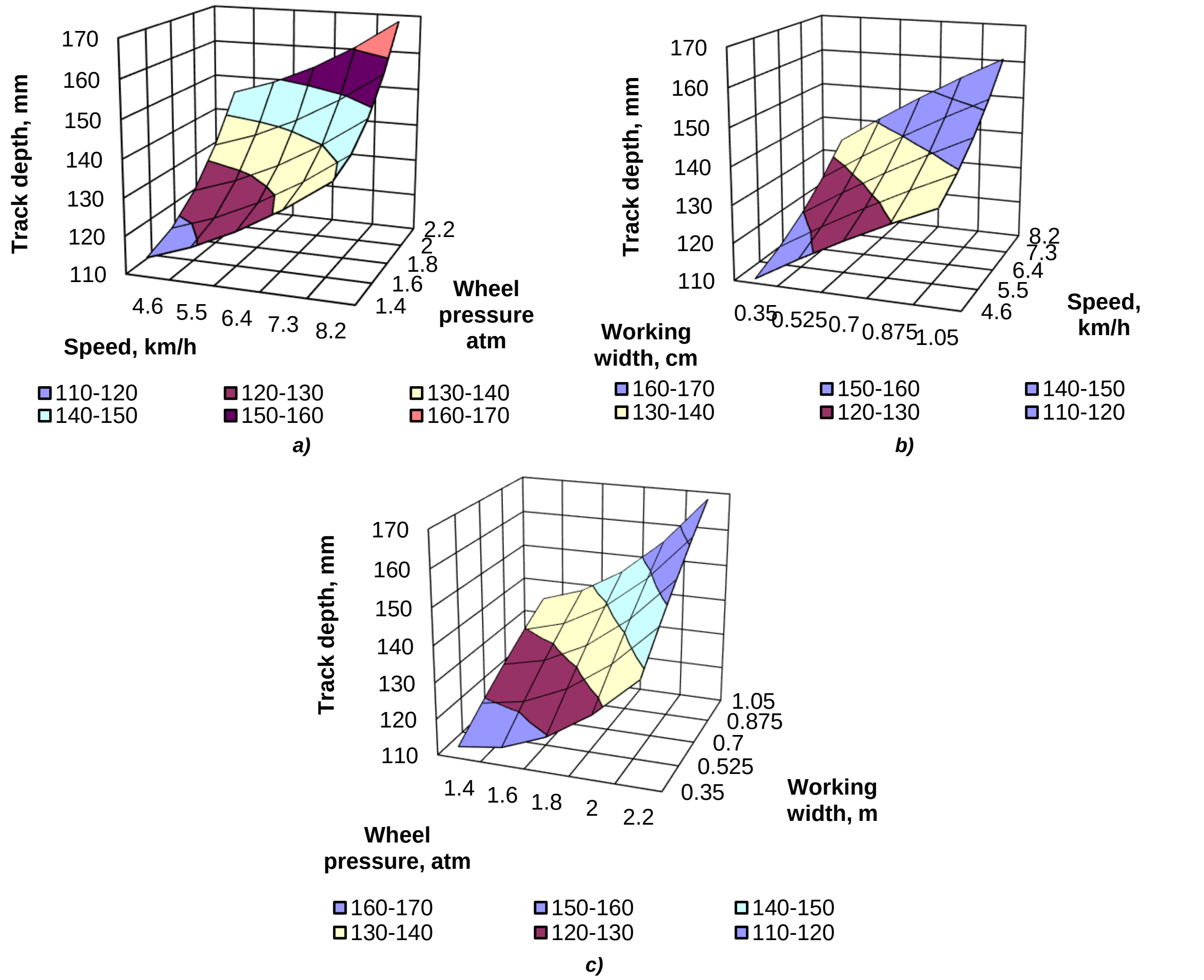


Fig. 3 - Graphical dependence of the track depth on:

a - driving speed and pressure in the pneumatic chambers of the wheel with a working unit working width of 70 cm;
b - driving speed and working width of the unit at a pressure in the pneumatic chambers of the wheel of 1.8 atm;
c - pressure in the pneumatic chambers of the wheel and the working width of the unit at a speed of 6.4 km/h.

At a tractor speed of 6.4 km/h, the minimum value of the soil hardness coefficient is obtained with a working unit working width of 0.35 m and a pressure in the pneumatic chamber of 1.4 atm, namely 2.735.

An increase in the pressure in the pneumatic chamber to 2.2 atm leads to an increase in the hardness coefficient by 110.7%. Increasing the working unit working width to 1.05 m at a pressure in the pneumatic chamber of 2.2 atm leads to an increase in the soil hardness coefficient by 104.2%. A change in the working width (an increase in traction resistance) has a more significant effect on soil compaction than the pressure in the pneumatic chamber of the wheel, since the difference between the values of the change Δk_H is about 114.8%.

In the studied range, the simultaneous action of the maximum values of parameters in comparison with the minimum values for the pressure in the pneumatic chamber and the speed of movement leads to an increase of 126.3% in the coefficient of soil hardness, working width and speed of movement – by 322%, working width and pressure in the pneumatic chamber – by 330%. The obtained data show that the traction force that the tractor implements when performing a technological operation has a significant impact on soil compaction and changes its hardness. It should also be noted that an important factor affecting the compaction of soil and changes in its hardness is the area of contact interaction of the wheel with the soil, which disproportionately changes with changes in pressure in the pneumatic chamber.

With a working unit working width of 0.7 m, the minimum track depth value is obtained at a driving speed of 4.6 km/h. and the pressure in the pneumatic chamber of the wheel is 1.4 atm, namely 115 mm. Increasing the tractor speed to 8.2 km/h increases the track depth by 21.7%. Increasing the pressure in the pneumatic chamber of the wheel to 2.2 atm at a speed of 8.2 km/h leads to an increase in the track depth by 20.7%. The pressure in the pneumatic chamber of the wheel has a slightly greater effect on the formation of the track than the change in the speed of movement, since the difference between the values of the change Δh_K is about 20%.

At a pressure in the pneumatic chamber of the wheel of 1.8 atm, the minimum value of the track depth is obtained with a working unit working width of 0.35 m and a driving speed of 4.6 km/h, namely 111 mm. Increasing the tractor speed to 8.2 km/h results in a 19.8% increase in track depth. Increasing the working unit working width to 1.05 m at a speed of 8.2 km/h increases the track depth by 20.3%. Changes in the operating width (an increase in traction resistance) and the speed of movement affect the formation of the track to almost the same extent, since the difference between the values of the change Δh_K is about 9%.

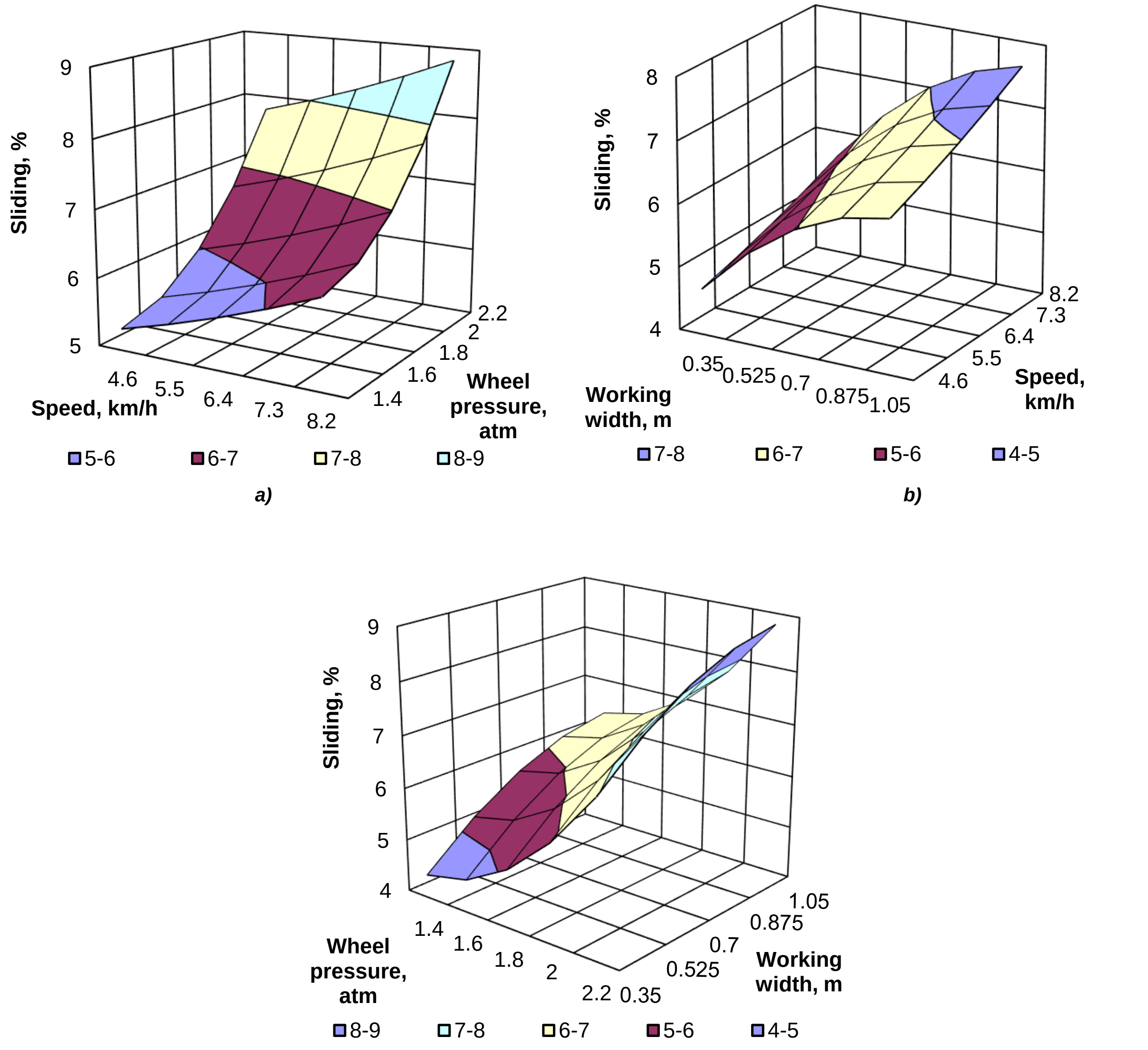
At a tractor speed of 6.4 km/h, the minimum track depth value is obtained with a working unit working width of 0.35 m and the pressure in the pneumatic chamber of 1.4 atm, namely 113 mm. An increase in the pressure in the pneumatic chamber to 2.2 atm leads to an increase in the track depth by 22%. Increasing the working unit working width to 1.05 m at a pressure in the pneumatic chamber of 2.2 atm leads to an increase in the track depth by 21.7%. The change in pressure in the pneumatic chamber of the wheel has a slightly greater effect on the formation of the track than the working width (increase in traction resistance), since the difference between the values of the change Δh_K is about 19%.

In the studied range, the simultaneous action of the maximum values of parameters in comparison with the minimum values for the pressure in the pneumatic chamber and the speed of movement leads to an increase in the track depth by 46.1%, the working width and speed of movement – by 44%, the working width and pressure in the pneumatic chamber – by 32.7%.

The obtained patterns show that the pressure in the pneumatic chamber of the wheel has a slightly greater effect on the formation of the track than changes in the working width and the speed of movement. An increase in the track depth with an increase in pressure in the pneumatic chamber of the wheel is associated with a decrease in the area of the contact spot of the wheel with the ground and, as a result, an increase in the contact load. An increase in the speed of movement and the working width leads to an increase in the traction resistance of the working unit, which in turn leads to an increase in traction forces in the contact zone of the wheel with the ground and, as a result, an increase in soil deformation occurs.

With a working unit working width of 0.7 m, the minimum wheel sliding value is obtained at a speed of 4.6 km/h. and the pressure in the pneumatic chamber of the wheel is 1.4 atm, namely 5.32%. Increasing the speed of the tractor to 8.2 km/h leads to an increase in wheel sliding by 18.5%. Increasing the pressure in the pneumatic chamber of the wheel to 2.2 atm at a speed of 8.2 km/h leads to an increase in wheel sliding by 39.8%. The change in pressure in the pneumatic chamber of the wheel has a greater impact on the change in wheel sliding than the speed of movement, since the difference between the values of change $\Delta\delta$ is about 60.5%.

At a pressure in the pneumatic chamber of the wheel of 1.8 atm, the minimum value of wheel sliding was obtained with a working unit working width of 0.35 m and a driving speed of 4.6 km/h, namely 4.73%. Increasing the speed of the tractor to 8.2 km/h leads to an increase in wheel sliding by 18.39%. Increasing the working unit working width to 1.05 m at a speed of 8.2 km/h results in a 35.77% increase in wheel sliding. A change in the working width (an increase in traction resistance) affects the change in the wheel sliding index to a greater extent than a change in speed, since the difference between the values of the change $\Delta\delta$ is 130.95 %.



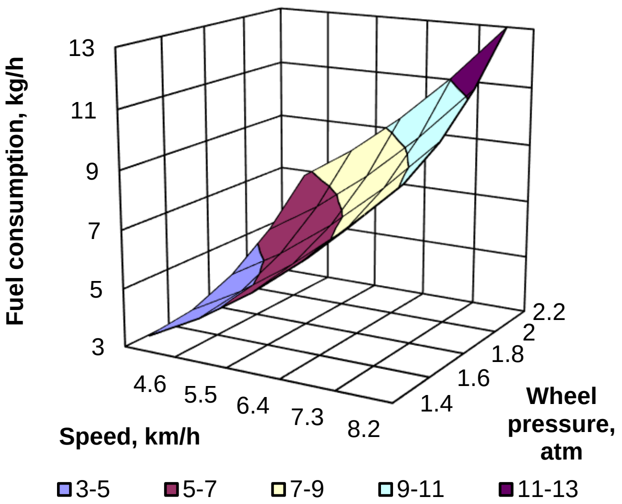
c)

Fig. 4 - Graphical dependence of wheel sliding on:

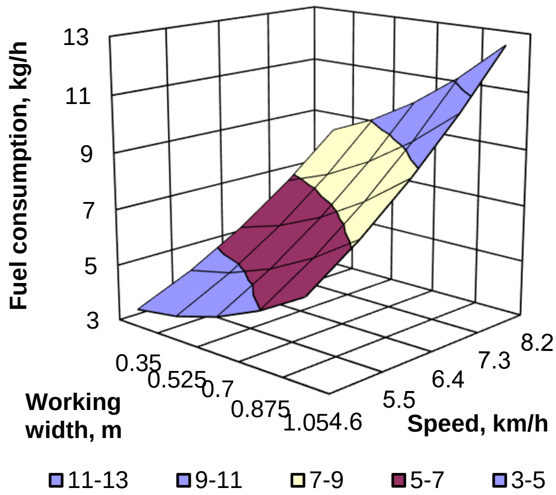
a - driving speed and pressure in the pneumatic chambers of the wheel with a working unit working width of 70 cm;
b - driving speed and working width of the unit at a pressure in the pneumatic chambers of the wheel of 1.8 atm;
c - pressure in the pneumatic chambers of the wheel and the working width of the unit at a speed of 6.4 km/h.

At a tractor speed of 6.4 km/h, the minimum wheel sliding value is obtained with a working unit working width of 0.35 m and the pressure in the pneumatic chamber of 1.4 atm, namely 4.43%. An increase in the pressure in the pneumatic chamber to 2.2 atm leads to an increase in wheel sliding by 56.02%. Increasing the working unit working width to 1.05 m at a pressure in the pneumatic chamber of 2.2 atm leads to an increase in wheel sliding by 41.82%. The change in pressure in the pneumatic chamber of the wheel has a slightly greater effect on the sliding of the wheels than the working width (increase in traction resistance), the difference between the values of the change $\Delta\delta$ is about 33.91%.

In the studied range, the simultaneous action of the maximum values of parameters in comparison with the minimum values for the pressure in the pneumatic chamber and the speed of movement leads to an increase in wheel sliding by 60.51%, the working width and speed of movement – by 60.74%, the working width and pressure in the pneumatic chamber – by 97.86%. When the pressure in the pneumatic chamber of the tire increases, the contact area of the wheel with the ground decreases, which leads to an increase in the amount of contact forces on the support surface. As a result of increasing contact forces, there is an increase in the process of ground deformations in the longitudinal direction, and as a result, there is an increase in wheel sliding. An increase in the working unit working width, as well as the driving speed, leads to an increase in traction power, realization of which must be provided by the driving wheels. As a result of increasing the traction power, the amount of contact forces in the contact zone of the wheel with the ground increases. As a result, the load on the ground increases, its deformation increases, and the volume of wheel sliding increases.



a)



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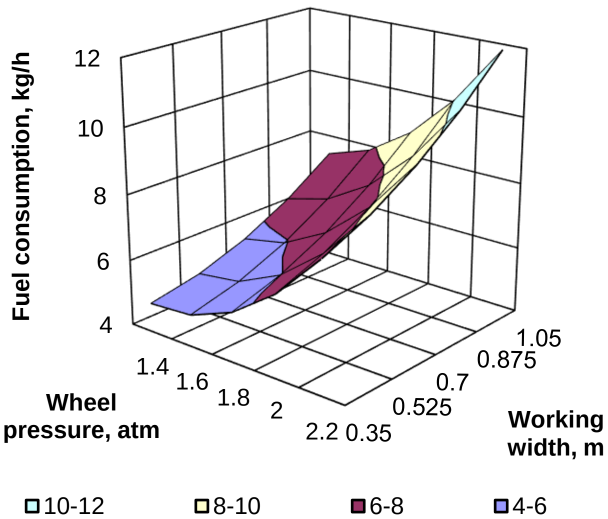

c)

Fig. 5 - Graphical dependence of fuel consumption on:

a - driving speed and pressure in the pneumatic chambers of the wheel with a working unit working width of 70 cm;
b - driving speed and working width of the unit at a pressure in the pneumatic chambers of the wheel of 1.8 atm;
c - pressure in the pneumatic chambers of the wheel and the working width of the unit at a speed of 6.4 km/h.

With a working unit working width of 0.7 m, the minimum fuel consumption value is obtained at a speed of 4.6 km/h. and the pressure in the pneumatic chamber of the wheel is 1.4 atm, namely 3.552 kg/h. Increasing the tractor speed to 8.2 km/h results in a 146.37% increase in fuel consumption. Increasing the pressure in the pneumatic chamber of the wheel to 2.2 atm at a speed of 8.2 km/h leads to an increase in fuel consumption by 48.12%.

A change in driving speed has a greater impact on the change in fuel consumption than the pressure in the pneumatic chamber of the wheel, since the difference between the values of the change ΔG is about 59.5%.

At a pressure in the pneumatic chamber of the wheel of 1.8 atm, the minimum fuel consumption value is obtained with a working unit working width of 0.35 m and a driving speed of 4.6 km/h, namely 3.614 kg/h. Increasing the tractor speed to 8.2 km/h results in a 131.22% increase in fuel consumption. Increasing the working unit working width to 1.05 m at a speed of 8.2 km/h results in a 49.78% increase in fuel consumption. A change in driving speed affects the change in fuel consumption to a greater extent than the working width (an increase in traction resistance), since the difference between the values of the change ΔG is 130.95%.

At a tractor speed of 6.4 km/h, the minimum fuel consumption value is obtained with a working unit working width of 0.35 m and a pressure in the pneumatic chamber of 1.4 atm, namely 4.875 kg/h. An increase in the pressure in the pneumatic chamber to 2.2 atm leads to an increase in fuel consumption by 62.21%. Increasing the working unit working width to 1.05 m at a pressure in the pneumatic chamber of 2.2 atm leads to an increase in fuel consumption by 49.68%. The change in pressure in the pneumatic chamber of the wheel has a slightly greater impact on fuel consumption than the working width (increase in traction resistance), the difference between the values of the change ΔG is about 29.54%.

In the studied range, the simultaneous action of the maximum values of parameters in comparison with the minimum values for the pressure in the pneumatic chamber and the speed of movement leads to an increase in fuel consumption by 264.93%, the working width and speed of movement – by 246.29%, the working width and pressure in the pneumatic chamber – by 330.16%. An increase in the speed of the tractor and the working unit working width leads to an increase in the forces of resistance to movement of the working unit and rolling resistances. Therefore, increasing the speed and working width of the working unit requires an increase in traction power, which leads to an increase in fuel consumption. The increase in fuel consumption with increasing pressure in the pneumatic chamber of the wheel is due to an increase in rolling resistance associated with an increase in track depth and an increase in tractor wheel sliding.

CONCLUSIONS

- ✓ The conducted studies have shown that in the process of compaction of the soil by running systems, the intensity of changes in soil hardness gradually decreases due to the fact that it is necessary to spend more effort to change the hardness of more compacted soil. It should be noted that a decrease in the soil hardness coefficient due to a decrease in pressure in pneumatic chambers practically corresponds to a decrease in the soil hardness coefficient obtained by reducing the speed.
- ✓ Experimental studies for the given intervals of variable factors have shown that changes in the speed of movement and the width of the working unit have almost the same effect on the formation of the track. Based on the obtained results of track formation and taking into account the influence of the studied factors on the productivity of the tractor, it is advisable to increase the area of contact of the running systems with the ground and increase the working unit working width.
- ✓ The results of these studies allow stating that the sliding of wheels largely depends on the parameters of the contact interaction of the wheel with the ground. A significant influence on the sliding of the wheels is played by the size of the contact zone of the wheel with the ground, as well as the traction power that the driving wheels realize. It is these two parameters that affect the amount of contact interaction of the wheel with the soil environment. An increase in the forces of contact interaction leads to an increase in the deformation that the ground undergoes and, as a result, there is an increase in the driving wheels sliding.
- ✓ Analysis of changes in fuel consumption when working on decompressed soil, for the specified intervals of the studied factors, indicates the feasibility of operating the tractor at low pressures in pneumatic chambers. In order to fully utilize the traction power of the tractor and increase the productivity of its operation, it is more advisable to use an increase in the working unit working width than an increase in the speed of movement.

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