Influence of natural production conditions on efficient operation of wheel tractors

Aleksandr A. Shuravin*, *Vladimir* Leonov, *Elena* Polikutina, *Sergey* V. Shchitov, and *Evgeny* E. Kuznetsov

Far Eastern State Agrarian University, Polytechnicheskaya street, 86, Blagoveshchensk, Russia

Abstract. For the zones of "risky farming" characteristic of the Far East of the Russian Federation, the natural production conditions of the region are an important problem in preparing the soil for further basic agricultural work. So, when carrying out early spring agricultural work, due to presence of a solid underlying layer in the form of permafrost, they shall be completed in operational terms no more than 10 days, until the permafrost base thaws and the soil has not lost its bearing capacity. In addition, due to the peculiarities of the relief, the soil does not thaw equally in depth everywhere, which reduces the quality of field work and harrowing, as the most common operation, namely. This article provides theoretical and experimental studies on the adaptation of a wheeled tractor as part of a machine-tractor unit (MTU) used in harrowing to natural production conditions by installing a device that automatically regulates the load on the working body of the disc harrow or on the propellers of the energy device, depending on the conditions of use or the state of the motion surface.

1 Introduction

The primary cultivation is a set of measures, the main purpose of which is to provide favorable conditions for the growth of agricultural crops. Among the main functions of this operation are cutting weeds, accumulating moisture, combating pests and diseases of agricultural crops, creating favorable conditions for biological processes, increasing fertility due to conservation and productivity. It shall also be noted that the planning and conduct of operations related to the primary cultivation shall be carried out taking into account the natural production conditions of the region, as well as the general physical and physical and mechanical properties of the cultivated soil (aggregation, porosity, density, hardness, weediness, and etc.) [1,2].

In the Amur Region, soil preparation for sowing begins as the soil thaws to the depth of cultivation, usually in late April or early May of the current year. This operation, including sowing, must be completed as soon as possible, since as daytime temperatures increase, intensive thawing of the permafrost subsoil occurs, and precipitation at the same time sharply reduces the bearing capacity of the soil.

* Corresponding author: sh.aleksandr.2019@mail.ru

It shall be noted that the moisture content of the upper soil layer allows agricultural work, and the lower soil layer, due to the increased moisture caused by the above conditions, has a low bearing capacity. In these conditions, in order to implement the possibility of MTU movement, it is necessary to adapt the used machine and tractor units to the above specific features of the region, by reducing the normal pressure of the propellers on the soil in particular.

In the region under consideration, as previously conducted studies have shown, the most acceptable ways to reduce the normal pressure of the wheel propellers on the soil is to install double wheels or redistribute the adhesion weight [3].

Due to the fact that the soils of the region are heavy in texture and have a high degree of stickiness, such an agricultural operation as harrowing with heavy disc harrows is most widespread in early spring agricultural works. The choice of this tool is justified by the fact that in the process of snow melting on clay soils, the upper layer is "pulled in" and a crust is formed.

Use of light harrows for these purposes is impractical, since they do not always cope with the task due to the low weight of the harrow, which does not allow the working bodies to be deepened to a sufficient depth. In this connection, depending on the condition of the soil, ballasting of the harrow with additional weights is used to improve the depth of cultivation [4, 5, 6]. Considering that during the harrowing period, due to the different relief of even one agricultural landscape, the soil thaws unevenly, it becomes difficult to choose the mass of ballast and the positions of its distribution on the harrow. Therefore, in these conditions, it is necessary to use other methods of correcting the weight on the working body of the harrow (disc).

In previous studies, it was proved that the most acceptable way to increase the load on the working bodies of an agricultural machine is to install devices that make it possible to correct the redistribution of weight in the system of the machine-tractor unit itself. In other words, such devices make it possible to use part of the weight of an agricultural machine to increase the traction-coupling properties of an energy device, and, if necessary, to reload its working bodies, the weight of an energy device [7, 8].

In this connection, the purpose of the offered work is creation, manufacture, testing and implementation of a device that allows to automatically increase the traction and coupling properties of the energy device and adjust the weight on the working body of the disc harrow.

2 Material and Methods

As an example of the aforementioned device capable of automatically adjusting the traction and coupling properties of an energy device and the load on the working body of a disc harrow, the use of a device of a new promising design, which, when installed on a tractor, allows to adjust and redistribute the weight of the MTU between the tractor and the harrow as necessary to increase the vertical load on a tractor or harrow with an inventive level, high industrial applicability and novelty, which will allow solving the task of increasing the efficiency of the MTU (Figure 1-2).

Fig. 1. MTU diagram with installed device.

Fig. 2. General view of the MTU with the installed device

When carrying out studies on optimization and redistribution of weight in the scheme of a machine-tractor unit, an energy tool was taken as the object of research - a wheeled tractor of class 1.4 and a disc harrow BDT-3, as the most often used in peasant farms of the region with a small volume of sowing capacities, the offered device was installed at the MTU.

Within the study, the well-known and separate methods were used with application of specialized programs for mathematical processing, experimental modeling and methods of statistical and regression analysis [9, 10]. Within the experiment, the following parameters were measured: adhesion weight, distance traveled, rotational speed of the driving wheels of the power plant, tractive effort, weight of the harrow's working body, and the quality of the treatment performed.

The above parameters were measured using specialized instruments and equipment. Processing the obtained values was carried out using well-known methods of mathematical statistics and information technology.

3 Results

Theoretical and experimental studies on use of a machine-tractor harrow unit, carried out on the basis of the Far Eastern GAU, Amur Region, the city of Blagoveshchensk, the Russian Federation and the peasant farms of the region, have shown the validity and correctness of the chosen method for increasing the redistribution of weight within the

machine-tractor unit in order to increase the traction-coupling properties of the energy means and additional loading of weight on the working body of the harrow.

It was found that use of the offered device made it possible to redistribute the mass of the MTU (Figures 3 and 4).

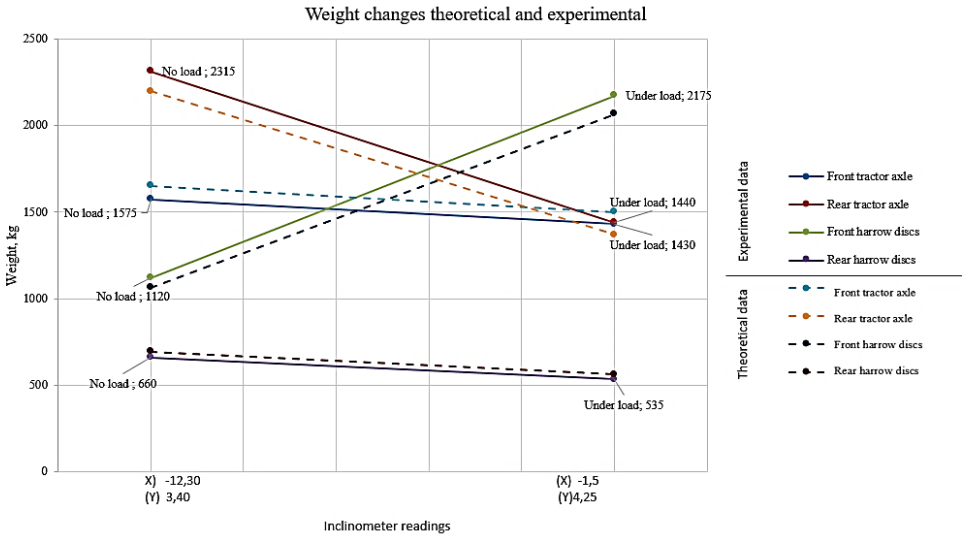

Fig. 3. Results of experimental studies on the redistribution of mass when the device is operating inside the MTU

Analyzing the data obtained (Figure 3), the following conclusions can be drawn that when the device was operating in order to reload the harrow sections, the following redistribution of mass within the MTU scheme occurred: the load on the rear axle of the tractor decreased from 2,315 kg to 1,440 kg; on the front axle of the tractor, 1,575 kg decreased to 1,440 kg; on the front sections of the harrow increased from 1,120 kg to 2,175 kg; on the rear sections of the harrow decreased from 660 kg to 535 kg. The above data and the results of graphical displays allow to conclude that use of the offered device allows to redistribute the mass in the MTU system and thereby adjust its technological properties and energy indicators during soil cultivation.

In order to check the parameters of the additional loading of the tractor, studies of the offered design were also carried out in the mode of weight redistribution from the harrow to the tractor running system (Figure 4).

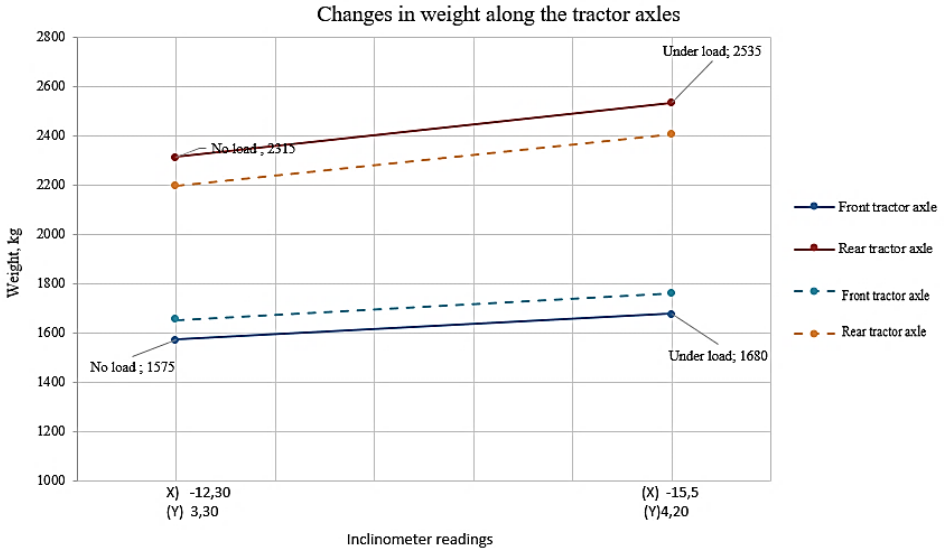

Fig. 4. Results of experimental studies on the redistribution of mass when the device is operating in the tractor reloading mode

Therefore, an increase in the vertical load on: the front axle of the tractor — by 105 kg; rear axle of the tractor — 220 kg.

Based on the results obtained above, it can be concluded that the redistributed vertical load makes it possible to increase the traction and coupling properties of the tractor, reduce the amount of slipping, increase the speed characteristics of the MTU and expand its technological characteristics.

As the studies have shown, the results of theoretical and experimental data are within the confidence interval of 3.5-5 %, which indicates the reliability of the theoretical justification.

4 Discussion

As a result of solving the compromise problem, the following acceptable values are justified, all other things being equal. At the maximum depth of soil treatment, the lowering angle of the hitch is 27-12 degrees, the width of the disc harrow is 2.4-2.8 meters, the speed of the unit is 9-10 km/h.

At the maximum lowering angle of the hitch, the processing depth is 18-20 cm, the speed of the unit is 4-7 km/h, the width of the disc harrow is 2.9-3.0 meters. At the optimum value (6-8 km/h) of the unit's speed, the movement depth is 13.5-17 cm, the width of the disc harrow is 2.4-3.0 meters, the angle of lowering of the lift is 27-16 degrees. With the maximum working width, the lowering angle is 27-17 degrees, the soil treatment depth is 13-17 cm, the speed of the unit is 11-12 km/h.

The comparative economic tests carried out showed that use of the MTZ-80 tractor and the BDT-3 harrow with an installed harrowing device made it possible to increase the productivity per hour of the main working time by 14.2 % and reduce the fuel consumption per unit of cultivated area by 8.6 % compared to with MTZ-80 and BDT-3 tractors operating in the serial version.

An analysis of the results of traction tests indicated that there was a redistribution of the components of the power balance in both the serial and experimental tractors.Therefore, a decrease in the power spent on slipping was recorded for an experimental tractor in

comparison with a serial one from 15.18 % to 10.25 %. On the basis of the data obtained, it can be concluded that use of the offered device makes it possible to increase the traction and coupling properties in comparison with a serial tractor due to the redistribution of the coupling weight in the MTU scheme.

The fuel and energy assessment showed that use of 1.4 class tractor with a device for redistributing the MTU weight during harrowing allows reducing energy consumption by 32.93 MJ/ha compared to the serial version and obtaining an annual economic effect on harrowing in terms of the ruble equivalent in the amount of 38.6 rubles/ha.

5 Conclusion

Based on the above, in comparison with the results previously obtained by the authors [11, 12, 13, 14], it can be concluded that the offered device for redistributing the adhesion weight in the harrow system is a highly efficient design that implements original ideas and has a design novelty intended for increasing the efficiency of mechanization means in the agro-industrial complex. Study materials are widely used in the technology of plant growing, used in the Federal State Unitary Enterprise Sadovoe, SOYUZ LLC of the Seryshevsky District, KFH S.V. Kovaleva. Ivanovsky district, farm ZARECHNOE, Mikhailovsky district, farm A.V. Osipov . Blagoveshchensky district of the Amur region.

Implementation of the results obtained in production has made it possible to increase the efficiency when using wheeled tractors of the 1.4-2 class and the BDT-3 harrow to obtain significant economic benefits for the enterprise.

Based on the results of the work, the team of authors responsibly declares that there is no conflict of interest, information data and results were obtained as a result of the activities of the entire research group. Wherein, the spent material resources are not attracted funds and belong personally to the co-authors.

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