ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 1 , January 2021

Anthropogenic Impact Assessment of Undercarriages on Soil

Tukhtabaev MirzohidAkhmadjanovich, NuriddinovAkmaljonDavlatalievich, XidirovUlug'bekXabibullayevich

PhD, Associate professor of the department of Transportation logistics and services, Transport faculty, Namangan Engineering-Construction Institute, Namangan, Uzbekistan
Deputy Dean of the Transport faculty, Namangan Engineering-Construction Institute, Namangan, Uzbekistan
Lecturer of the department of Transportation logistics and services, Transport faculty, Namangan Engineering-Construction Institute, Namangan, Uzbekistan

ABSTRACT: In article are brought results of theoretical and experimental studies on substantiation of parameters of the of a row crop tractor tires, which affect the reduction of soil compaction. Soil compaction and the depth of the track left by the tire in the soil were investigated, depending on its parameters. In experimental studies carried out in laboratory conditions, the areas of tire square prints on rigid base were determined and the maximum pressure values in the contact zone were calculated for soil conditions. The influence of vertical load and internal tire pressure on soil density and track depth of the 18.4R38 tire was determined.

KEYWORDS: cultivator tractor, row space, front wheel, rear wheel, loading, leading tire, directing tire.

I. INTRODUCTION

The choice of tires for agricultural machinery for compacting effect on soil and the development of ways to prevent it occupies one of the leading places in the world. Considering that, on a global scale, today various agricultural crops are grown on an area of 900 million hectares.Including cotton growing on 32-34 million hectares, and at the same time 70-90 percent are compacted under the influence of wheels due to the passage of tractors on the field, then the use of tires in the wheels of tractors, which ensure reduction of soil compaction, is considered an important task. At the same time, when using machine-tractor aggregates (MTA) with a large mass, much attention is paid to the development of methods and solutions that reduce their negative impact on the soil, including soil compaction (1–4).

In the world, research is underway aimed at developing scientific and technical solutions to reduce soil compaction under the influence of tractor wheels during the cultivation of agricultural crops [5–8]. In this direction, one of the important tasks is to reduce deformation and compaction of the soil under the influence of tractor tires, as well as to reduce the negative effect of the tire on soil fertility when interacting with it. In this aspect, the development of rational methods and means of reducing soil compaction based on the choice of optimal types and parameters of tires for the wheels of row-crop tractors and the study of their impact on the soil is in demand (9–12).

II. RESEARCH RATIONALE AND METHODS

The aim of the study is to select the optimal tires for cotton growing tractor and reduce soil compaction based on the study of their impact on it.

In the research, the laws and rules of theoretical and agricultural mechanics, mathematical statistics, and strain gauge methods were applied.

One of the most pressing issues today is the reduction of existing arable land to meet the food needs of the country population, making it unsuitable for cultivation[13], and the annual decline in soil fertility of these areas[14]. This is due to the inefficient use of previously cultivated fields and non-compliance with agro-technical requirements, as well as the continuous application of chemical fertilizers to increase productivity, which has led to a decrease in the amount of humus in the soil. As a result, a decrease in the amount of humus led to a deterioration of its structure and a decrease in its fertility, making the soil unusable.

It is known that the territory of the country is located in a hot and dry region, and the need for water during the cultivation of agricultural crops is very high, and the cultivated areas are mainly sandy loam. Especially in the summer months, frequent watering of crops and short-term cultivation of the land after irrigation with agricultural machinery is required, which leads to excessive soil compaction [14]. If the soil is not loosened, the water will evaporate quickly

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 1 , January 2021

when the sun is hot, and the roots of the seedlings will not receive enough nutrients and minerals in the compacted soil and will not develop well due to the high tendency of the sandy soils to condense.

In recent years, the use of large-scale, wheeled agricultural machinery to increase productivity in agricultural production has been increasing. This leads to a sharp increase in the soil density of the cultivated fields under the influence of the wheels as a result of the aggregates entering the field for repeated tillage (1,15). Therefore, the search for ways to prevent and reduce soil compaction from man-made impacts is a pressing issue.

The soil of cotton growing areas is divided into heavy, medium and light soils by mechanical composition. In cotton growing, more than 65% of the land fund consists of light and clear gray-gray soils, which are included in heavy soils [16]. Due to the low amount of humus and granularity in the irrigated arable lands of Central Asia [17], the soil is very prone to compaction when treated with machine-tractor aggregates.

III. PROPOSED METHODOLOGY AND DISCUSSION

When choosing tires, the main indicators are the average $q_{av\cdot soil}$, and their maximum q_{max} pressure on the soil.

These indicators, taking into account the tire imprints left on a rigid (non-deformable) base in a static state, based on the methods given in GOST 26953-86, are determined by the following formulas:

$$q_{av.soil} = \frac{Q}{F_k K_1} = \frac{q_{av}}{K_1} \tag{1}$$

and

$$q_{max} = q_{av.soil} K_2 = q_{av.} \frac{K_2}{K_1}, \tag{2}$$

where: $q_{av.soil}$, q_{max}– average and maximum tire pressure on the soil, Pa; Q – normal load on the tire, N; F_k – the area of the tire track imprints on a solid (non-deformable) base, m^2; K_1 – coefficient depending on the outer diameter of the tire; K_2– coefficient of uneven pressure distribution on the tire track in the longitudinal direction; K_1 and K_2 – coefficients are taken from GOST 26955-86.

Calculations using these formulas showed that with a vertical load Q = 21 kN, the average $q_{av.soil}$, and the maximum q_{max} pressure on the soil in a tire 15.5-38 is 124.9 kPa and 187.3 kPa, in a tire 16.9R38 81.8 kPa and 122.6 kPa, in the 420/85R38 tire 79.8 kPa and 119.7 kPa, in the 18.4R38 tire 75.8 kPa and 113.7 kPa. It can be seen that among the existing ones, the 18.4R38 tire exerts the least pressure on the soil.

The depth of the wheel rut in the soil. The depth of the wheel tire left in the soil should be minimal when performing soil cultivation, sowing and other activities with a tractor used in agriculture, in particular cotton growing. Taking into account the intra-tire pressure and volumetric crushing of the soil, the depth of track left by tire of the wheel is determined by the following expression

$$h = K_{P_w} \sqrt[3]{\frac{Q^2}{q_1^2 \left(d + mV_M^2\right)^2 B^2 D}}, \tag{3}$$

where K_{P_w} – the coefficient taking into account the influence of the intra-tire pressure, $K_{P_w} = 0{,}2412 P_w^{0{,}3262}$; P_w – internal pressure of the tire, Pa; Q – the rated load on tire, N; q_1 – the static coefficient of volumetric soil crushing; d – dimensionless coefficient; m – the coefficient of proportionality, s^2/m^2; V_M – movement speed, m/s; B – tire profile width, m; D – the outer diameter of the tire, m.

Calculations made according to expression (3) show that the depth of the track left on the soil with the same vertical loads is 6.41 cm in the 18.4R38 tire and are less than 15.5-38 tires by 20.6%, 16,9R38 tires by 7.2%, 420/85R38 tires by 4.51%.

Determination of soil compaction under the influence of wheel tire. Density compaction of soil under the influence of the tire depends on depth of track left in the soil at different intra-tire pressures, vertical loads and different speeds of the tractor and is determined by the following expression

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 1 , January 2021

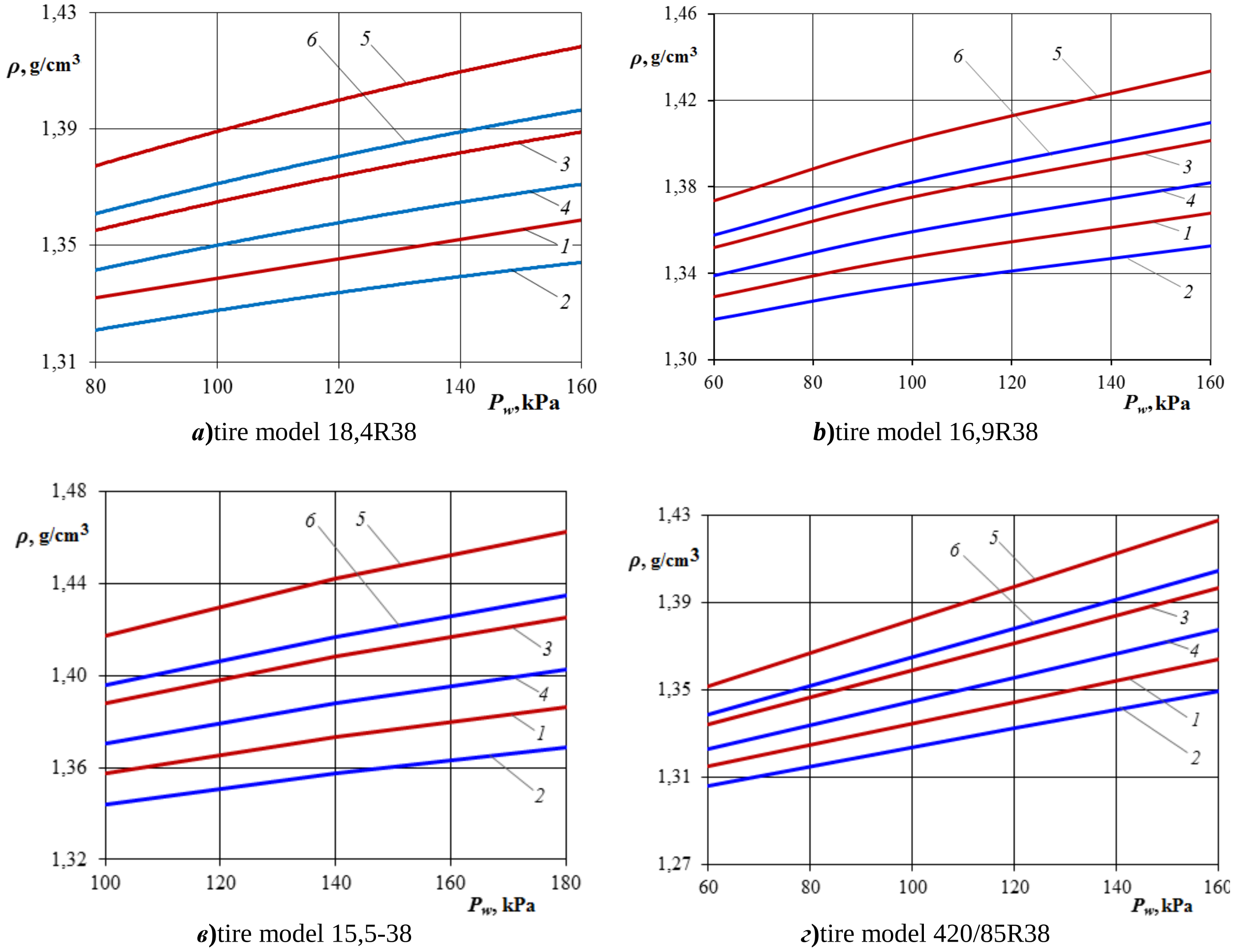
$$\rho = \frac{\rho_o H_1}{H_1 - 0{,}2412 P_w^{0{,}3262} \cdot \sqrt[3]{\dfrac{Q^2}{q_1^2 \left(d + mV_M^2\right)^2 B^2 D}}}. \qquad (4)$$

where H_1 – the depth of expansion of soil deformation, m; ρ_o – soil density before the wheel passage, g/cm^3; ρ – the density of the soil after passing the wheel, g/cm^3;

According to expression (4), graphs of changes in soil compaction for various tires are constructed depending on their intra-tire pressures at different speeds of the aggregate and vertical loads to them (Fig. 2).

Analysis of the graphs presented (Fig. 2) shows that soil compaction increases on all tires with an increase in internal pressure and the corresponding loads from the minimum permissible values to the maximum at low (5.6 km/h) and increased (8 km/h) tractor speeds. However, compaction of the soil on different tires has different meanings.

At speed of the aggregate V_M = 5.6 km/h on an 18.4R38 tire with vertical load of Q = 11.3 kN and a minimum permissible intra-tire pressure, soil compaction was 1.32 g/cm^3. Under the same conditions, on the 15.5-38 tire, soil compaction was 1.36 g/cm^3, on the 16.9R38 tire, 1.33 g/cm^3, and on the 420/85R38 tire, 1.32 g/cm^3. It is clear from this that soil compaction will be greater on 15.5-38 and 16.9R38 tires than on 18.4R38 and 420/85R38 tires.



1, 3, 5 - at 5.6 km/h; 2, 4, 6 - at 8 km/h; 1, 2 - 11.28 kN; 3, 4 - 15.30 kN and 5, 6 - 19.32 kN.

Figure 2. Dependence of soil density ρ on tire pressure P_w at different speeds of the aggregate and vertical loads on tires, which can be installed on a cotton-growing tractor

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 1 , January 2021

At the above operating speed of the aggregate and vertical load, soil compaction with the 18.4R38 tire is 1.36 g/cm^3 at the maximum permissible intra-tire pressures, which is 1.5-2.3% lower than the 420/85R38, 16.9R38 and 15.5-38 tires.
At the same time, it was found that at a aggregate speed of 8.0 km/h and a minimum permissible intra-tire pressure, soil compaction on an 18.4R38 tire is 1.32 g/cm^3, and at a maximum permissible intra-tire pressure - 1.34 g/cm^3. Similar indicators are on the tire 15.5-38 1.34 g/cm^3 and 1.37 g/cm^3 on the tire 16.9R38 1.32 g/cm^3 and 1.35 g/cm^3, on the tire 420/85R38 1.31 g/cm^3 and 1.35 g/cm^3.
Analysis of the above results shows that with an increase in intra-tire pressures, an increase in soil compaction is observed in the 18.4R38 tire by an average of 0.035 g/cm^3, in 15.5-38 tire by 0.05 g/cm^3, in 16.9R38 tire by 0.04 g/cm^3, in the tire 420/85R38 at 0.036 g/cm^3. Moreover, at higher speeds the tires compact the soil by 0.04 g/cm^3 less than at lower speeds (5.6 km/h).
Based on the results of the above theoretical studies, it was found that tires 18.4R38 are 1.42–3.76% less soil compacted than other existing tires.

IV. EXPERIMENTAL RESULTS

In experimental studies carried out in laboratory conditions, the areas of tire prints on a rigid foundation were determined and the maximum pressure values in the contact zone were calculated for soil conditions.
The influence of vertical load and internal tire pressure on soil density and track depth of the 18.4R38 tire was determined. According to the results of experimental studies at low speeds (5.6 km/h), the depth of the wheel tracks left in soil is greater than at higher (8 km/h) speeds (Fig. 4). At the same time, the increase in vertical loads also led to an increase in the depth of the tracks.
At lower speeds (Fig. 5, curves 1, 3 and 5) of the tractor, the effect of the intra-tire pressure on soil density on the tire tracks was greater than at higher speeds (Fig. 5, curves 2, 4 and 6).

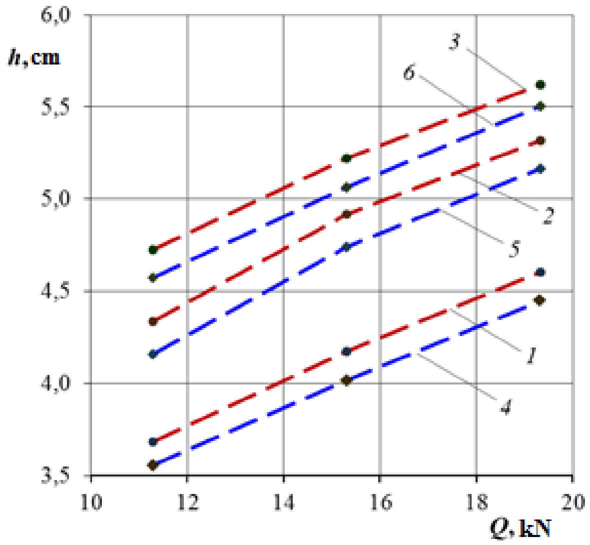


Fig. 4. Dependence of the tracks depth *h* on vertical load *Q* for various speeds (1, 2; 3 - 5.6 km/h; 4; 5; 6 - 8.0 km/h) and intra-tire pressures P_w (1, 4 - 80 kPa; 2, 5 - 120 kPa; 3, 6 - 160 kPa)

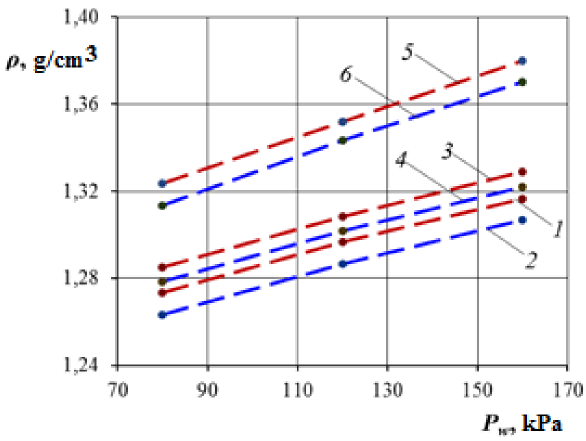


Fig. 5. Dependence of soil density *ρ* on internal tire pressure P_w for different speeds (1, 3; 5 - 5.6 km/h; 2; 4; 6 - 8 km/h) **and vertical load *Q***

As a result, with an increase in the internal pressure in the 18.4R38 tire from 80 kPa to 160.0 kPa and the vertical load on it from 11.28 kN to 19.32 kN, soil compaction increased, and when the speed of the unit changes from 5.6 to 8.0 km/h soil compaction decreased.
Consequently, a decrease in the internal pressure of an 18.4R38 tire to the minimum permissible (80 kPa) reduces soil compaction by an average of 0.06 g/cm^3, and the depth of tracks to 28%.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 8, Issue 1 , January 2021

V. CONCLUSION

Research-based selection of rational tires for cotton tractor reduces soil compaction, increases productivity and improves performance. The installation of tires with a profile width of more than 15.5 inches and less than 18.4 inches on the drive wheels of a promising four-wheeled cotton-growing tractor with a spacing of 90 cm provides loads on them not exceeding the values permissible according to GOST.

When using the tire 18.4R38, selected for the driving wheels of a four-wheel row crop cotton-growing tractor, with an internal pressure of up to 150 kPa, it makes it possible to reduce soil density by an average of 0.06 g/cm^3, and track depth by 28.8%.

REFERENCES

[1]. Talibaev A., Tukhtabaev M., Obidov R., Temirov J., & Khamzaev M., Innovative production of raw cotton technology. International Journal of Advanced Research in Science, Engineering and Technology (IJARSET), Volime6, no 9, India, 2019.
[2]. Tukhtabayev M.A. To select optimal tire sets for cultivator tractors // European science review. No.11-12, Vienna, 2017,pp. 147-149.
[3]. Nuriddinov A., Nasritdinov A., Normirzaev A. Development of aggregates for the main and pre-sowing soil cultivation for sowing catch crops. Scientific and technical journal Fergana Polytechnic Institute, No. 3, Fergana, 2015,pp. 53-56.
[4]. Normirzaev A., Nuriddinov A., Bayboboev N.G., Nasritdinov A. Energy-saving combined unit for tillage, Bulletin of the Ryazan State Agrotechnological University. No. 3, Volgograd, 2014, pp. 42-45.
[5]. Tukhtabaev M.A. Tire Selection of cotton tractor on effect of soil compaction: Abstracts of PhD, TIQXMMI, Tashkent, 2019, p. 41.
[6]. Hideo Sakai, Tomas Nordfjell and others. Soil Compaction on Forest Soils from Different Kinds of Tires and Tracks and Possibility of Accurate Estimate // Croat, j. for. eng., 29(1). pp.15-27. Denmark, 2008.
[7]. Buliński J., Sergiel L. Effect of wheel passage number and tyre inflation pressure on soil compaction in the wheel track, Ann. Warsaw Univ. Life Sci. SGGW, Agricult, №62. pp. 5-15. Warsaw, 2013.
[8]. Damanauskas V., Janulevičius A., Pupinis G. Influence of extra weight and tire pressure on fuel consumption at normal tractor slippage, Journal of Agricultural Science, Vol.7, No.2. pp. 55-67. Canada, 2015.
[9]. Sergienko V.A. Machines for inter-row processing. In the book, Handbook of mechanization of cotton growing. Uzbekistan Publishing House, pp.106-121. Tashkent, 1981.
[10]. Tukhtabayev M.A. Resource-saving technology for saving of soil fertility. Scientifically grounded systems of dry farming in modern conditions: Materials of the International scientific-practical conference dedicated to the 30th anniversary of the system of dry farming in Volgograd region, May 17, 2016. Volgograd GAU, pp. 43-45. Volgograd, 2016.
[11]. Mamadjanov S.I., Tukhtabaev M.A., Obidov R., Umirzaqov Z.A. Perspective Technology to Improve Arid Pastures, International Journal of Recent Technology and Engineering (IJRTE), Volume-9 Issue-1, May. India, 2020. DOI:10.35940/ijrte.A1496.059120
[12]. Tukhtabayev M.A. Applying for wide coverage four wheel machine-tractor aggregate in row-spacing.Modern trends in the development of the agrarian complex: Materials of the international scientific-practical conference, FGBNU: PNIIAZ, pp. 1263-1266. Solyonoye Zaymishe, 2016.
[13]. Temirov S. U. Substantiation the Parameters of Universal Operating Element on Row Crop Cultivator, International Journal of Advanced Research in Science, Engineering and Technology (IJARSET), 6(2), pp. 8154-8156. India, 2019.
[14]. Tukhtaboev M., Tulanov I. Scientific basis for the selection of tires for agricultural tractors. Monograph: Tamaddun, p. 104. Tashkent, 2016.
[15]. Tukhtaboev M.A. Traction characteristics of TTZ 1030 cultivator tractor tire at low air pressures. Mechanical problems, No.2. pp. 83-85. Tashkent, 2013.
[16]. https://stat.uz/uploads/doklad/2017/doklad2017-uz-yanvar-iyun.pdf
[17]. Umbetaev I., Kostakov A. «The effect of inter-row processing on the accumulation of cotton roots» The Way of Science. International scientific journal. No. 7 (29), pp. 31-32. Volgograd, 2016.

AUTHOR'S BIOGRAPHY

Mirzohid AkhmadjanovichTukhtabaev,

PhD,Associate professor of the department of Transportation logistics and services, Transport faculty, Namangan Engineering-Construction Institute (NamECI)

Nuriddinov Akmaljon Davlatalievich,

PhD,Deputy Dean of the Transport faculty, Namangan Engineering-Construction Institute (NamECI),