RESEARCH ARTICLE | JUNE 17 2025

Case study of factors influencing damage to cotton crops under cultivation care conditions

Adilbek Akhmetov ; Sherzodbek Akhmedov; Shavkat Abdurahmonov; Anvarjon Dadahodjaev

AIP Conf. Proc. 3286, 050003 (2025)
https://doi.org/10.1063/5.0281097

Case Study of Factors Influencing Damage to Cotton Crops Under Cultivation Care Conditions

Adilbek Akhmetov[1, a)], Sherzodbek Akhmedov[2], Shavkat Abdurahmonov[2], and Anvarjon Dadahodjaev[3]

[1]*Design Technology Center for Agricultural Engineering, Tashkent, Uzbekistan*
[2]*"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan*
[3]*Namangan Institute of Engineering and Construction, Namangan, Uzbekistan*

[a)] Corresponding author: tractor-v@mail.ru

Abstract. To care for crops without damaging plant sprouts, a safe distance must be maintained from the wheels of the tractor and the working parts of the agricultural machine to the root system of the plant rows, which is determined by the size of the protective zone. Despite the installation of protective zones, in some cases, when caring for crops, damage to individual plant sprouts occurs. Research has established that such damage to plant sprouts occurs in two cases. In the first case, due to the location of the seeds during sowing, and therefore their subsequent germination relative to the axis of symmetry of the seed row, and in the second case, due to the lateral movement of the guide wheels under the influence of a change in the direction of the traction force, depending on the physical and mechanical properties of the soil. In this case, the amount of deviation of the seedlings relative to the axis of symmetry of the seed row after sowing the seeds remains unchanged throughout the entire growing season, which must be taken into account when determining the size of the protective zone. While the influence of the second factor on plant damage can be adjusted. Therefore, in order to eliminate damage to plant sprouts, both of these factors must be taken into account.

Keywords: cotton, seeds, plant sprouts, deviation, protective zone, lateral deformation of the tire, lateral wheel slip.

INTRODUCTION

Since the soil and climatic conditions of the republic are dominated by high temperatures during the cotton cultivation period, several irrigations and inter-row treatments of cotton crops are carried out to maintain the soil moisture necessary for the growth and development of cotton [1, 17-20]. In addition, a number of technological operations for caring for cotton, including protecting it from pests, diseases and weeds, is one of the key tasks in obtaining high yields of raw cotton.

All types of cotton cultivation operations (sowing, inter-row cultivation, volumetric formation of cotton bushes, chemical protection, defoliation and desiccation, machine harvesting) must be successfully carried out by units with a wide range of machines [2] and efficiently perform all the necessary operations for the above-mentioned work without damaging the cotton plant.

During the growing season, when caring for cotton plants [3, 4], in order to protect them from damage, a protective zone is provided [5, 6], the value of which, depending on the technological operation being carried out and the working parts used, is set in the range from 7 to 15 cm [7].

MATERIALS AND METHODS

Despite the adjustment of both cultivators and sprayers and other types of machines taking into account the protective zone, in some cases, damage to individual plant sprouts and their root systems occurs [8], knocking down of fruit elements [9], which ultimately leads to a decrease in yield. This occurs mainly due to the excessive deviation of some plant sprouts from the straightness of the rows of plants [10], as well as due to the deviation of the tractor guide wheels due to lateral deviation from the straightness of movement [11].

Thus, violation of a pre-established protection zone occurs in two cases, i.e. in case of excessive deviation of some plant sprouts from the straightness of the rows, and in case of deviation of the tractor guide wheels due to lateral

VI International Scientific Conference Construction Mechanics, Hydraulics & Water Resources Engineering (CONMECHYDRO 2024)
AIP Conf. Proc. 3286, 050003-1–050003-7; https://doi.org/10.1063/5.0281097

deviation from the straightness of the movement of the unit. Below we will consider each case separately.

RESULTS AND DISCUSSIONS

The origin of the deviation of sprouts from the straightness of the arrangement of plant rows can be explained by two significant factors that depend on the technological process of sowing cotton seeds and the technical condition of the sowing unit.

Despite the precise straight sowing of seeds by the sowing unit, their seedlings appear with some deviations from these lines. Preliminary studies of the sowing process, as well as a literature review [12, 13] of this process, showed that such deviation of seedlings is mainly due to the following factors:

- due to the type of arrangement of seeds during sowing [14] relative to the axis of symmetry of the seed row;
- due to the profile of the field and the content of the soil fraction of the surface layer of soil located above the sown seeds [10];
- due to gaps in the steering drive connections [15];
- due to the qualifications of the driver and other factors [11].

Here, the first factor depends on the different probability of the location of the seeds during sowing relative to the axis of symmetry of the seed row, and the second factor depends on the content of the soil fraction raked by the seeder and filled with the sown seeds. Consequently, both factors are probabilistic in nature and significantly affect the deviation of seedlings from the straightness of the rows and the setting of the size of the protective zone.

Of the listed factors, the last two factors can be eliminated by improving the qualifications of the driver and adjusting the gaps in the steering drive connections.

Our field studies to study the deviations of cotton sprouts from the straightness of the row (Fig. 1) showed that the initial source of their deviation from the straightness of the row is the location of the seeds during sowing relative to the straightness of the row.

When sowing, cotton seeds relative to the row are located in very different positions, chaotically, but with all this, among them there are the following five characteristic cases of its location (Fig. 1):

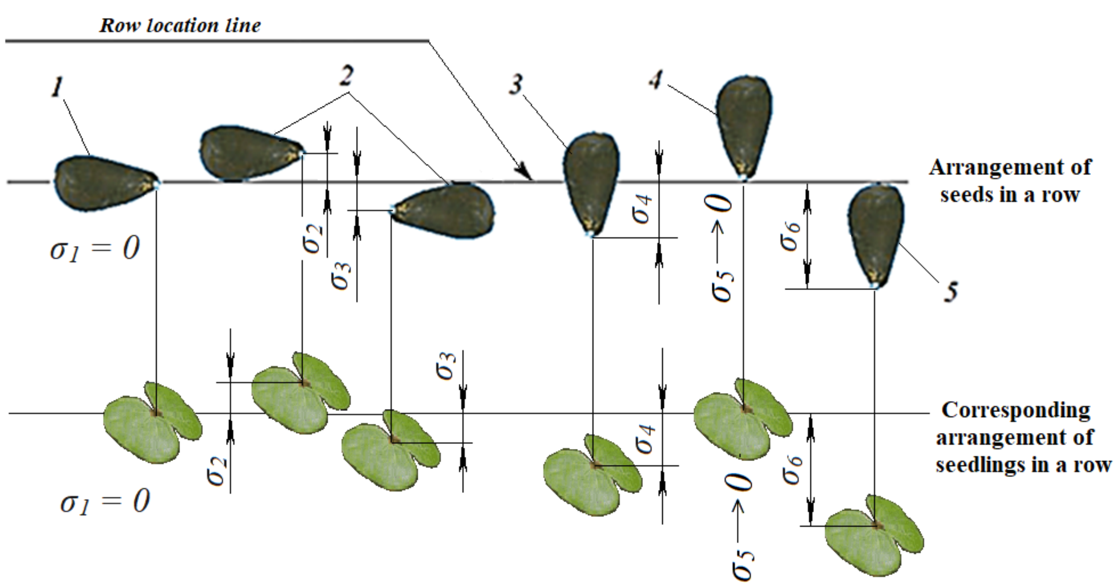

FIGURE 1. Typical cases of the location of cotton seeds and their seedlings depending on the straightness of the row.

1. The location of the seeds is longitudinal and it coincides with the axis of symmetry of the row location line. In this case, the descent of the root occurs along the axis of symmetry of the row as a result of which the deviation of the seedlings from the straightness of the rows will be practically equal to zero, i.e. $\sigma_1 = 0$.

2. The seeds are also located longitudinally, but in one direction or another relative to the axis of symmetry of the row location line. In this case, the descent of the spine occurs with some deviation from the axis of symmetry of the row in one direction or another by an amount of σ_2 or σ_3.

3. The seeds are located transversely relative to the symmetry axis of the row location line and the descent of the root occurs with some deviation σ_4 from the row symmetry axis in one direction or another.

4. The seeds are also located transversely, but in one direction or another relative to the axis of symmetry of the row location line and its root is directed towards the row location line. In this case, the descent of the root occurs as close as possible or directly along the axis of symmetry of the row as a result of which the magnitude of the deviation of the seedlings from the straightness of the rows will be minimal, tending to zero, i.e. $\sigma_5 \rightarrow 0$

5. The seeds are also located transversely, but differ from the previous one in that the root is directed in the opposite direction of the row location line and the descent of the root occurs with the greatest deviation σ_6 from the axis of symmetry of the row in one direction or another.

To check the validity of the judgments made, as well as to determine the practical deviation of sprouts from the straightness of the arrangement of rows of plants, field experimental studies were carried out on the cotton fields of the “TCT cluster”.

At the same time, the determination of the deviation of sprouts from the straightness of the arrangement of plant rows was determined as follows.

Considering that cotton cultivation in the republic is carried out with a four-row system of machines, to cover the butt row spacings, measurements of deviations of plant sprouts from the straightness of the rows were carried out on five adjacent row spacings. Selectively, in one of the field sections, on five adjacent row spacings of cotton crops, a 20 m long twine was stretched in the middle of the furrow of each row spacing (Fig. 2).

FIGURE 2. The process of measuring deviations of plant sprouts from the straightness of the row.

Next, by measuring the distances from the center of the twine to each plant located both on the right and on the left row of each row spacing and subsequent static processing [16, 17] of the obtained measurements, their standard deviation was determined, which is the amount of deviation of plant sprouts from a straight line.

Analysis of the results of static processing of experimental data (Fig. 3) showed that due to the different arrangement of seeds in the nest relative to the axis of symmetry of the row, the amount of deviation of the sprouts from the straightness of the arrangement of plant rows is in the range of ±2.02-4.27 cm, which should be taken into account when determining the size of the protective zone.

Thus, the deviation of seed germination relative to the axis of row location depends on the technological process of sowing and its value after seed germination during the growing season practically does not change, and it is taken into account when setting the value of the protective zone.

In contrast to the deviation of seedlings relative to the axis of the row location, the deviation of the tractor guide wheels due to the lateral deviation of the tractor wheel from the straightness of the movement of the unit is unpredictable, and during the growing season it has a different meaning in each case of the unit passing between the rows.

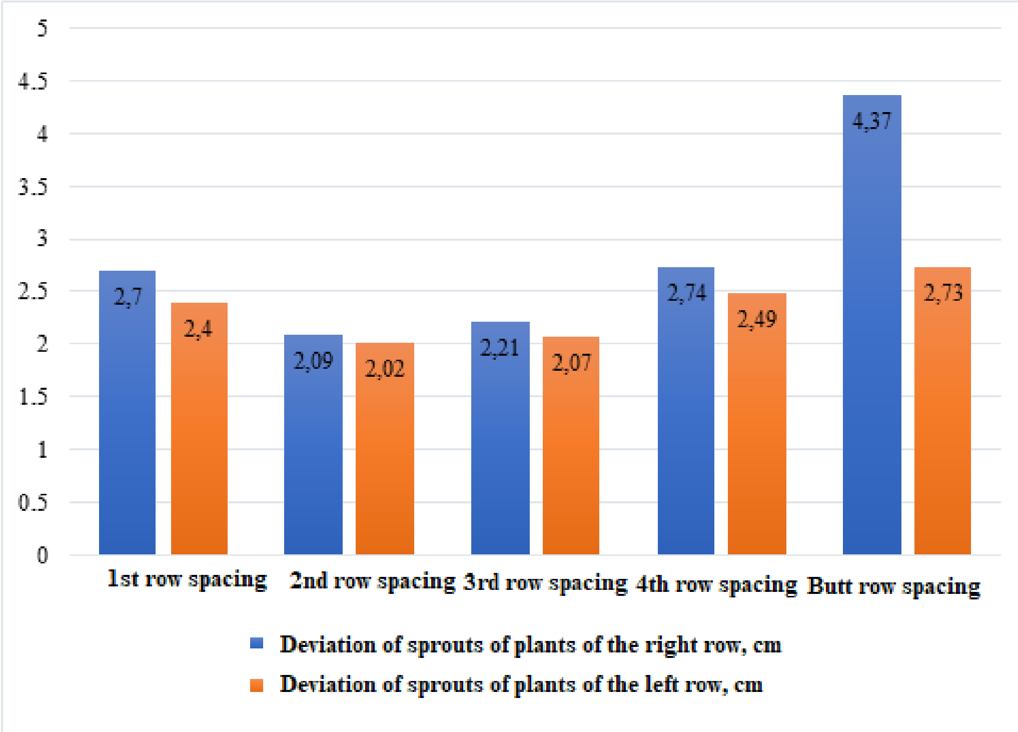

FIGURE 3. Deviation of plant sprouts from the axis of symmetry of the row, cm.

To determine the factors influencing the amount of lateral deviation of the tractor wheel from the straightness of the unit, we will consider this case separately below.

During operation of the unit for inter-row cultivation of crops, due to the variability of the physical and mechanical properties of the soil, the direction of the resulting traction resistance force constantly changes relative to the center of gravity of the tractor in one direction or another, thereby causing the appearance of lateral forces $P_б$.

Analysis of the influence of external factors on the deformation of the tractor guide wheel tire shows that when a vertical load G_n and a lateral force $P_б$ (Fig. 4), the soil reacts to these forces with vertical R_n and horizontal F_c with reaction forces. Under the influence of these forces, the tire is deformed. Moreover, those parts of the tire that are closer to the surface of contact with the soil, the more they are deformed.

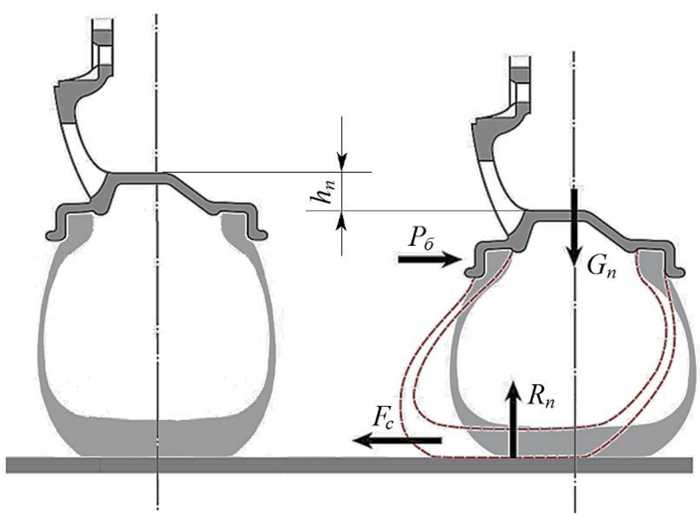

FIGURE 4. Tire deflection when the wheel rolls under the influence of vertical load and lateral force.

Let's take a certain point 1 in the middle of the symmetry axis of the wheel tire (Fig. 5). The closer to the surface of contact with the soil this point, due to the deformation of the tire, moving to the side opposite to the direction of the lateral force, will take position 2.

Having come into contact with the soil surface, due to deflection and deformation of the tire, it will move to position 3, and subsequently to position 4. In position 4, the tangential stress of the tire reaches its maximum value under adhesion conditions. Before leaving contact with the soil surface, the point under study will take position 5 and at point 6 returns to the middle plane of rotation of the ΠB wheel, i.e. to the starting position.

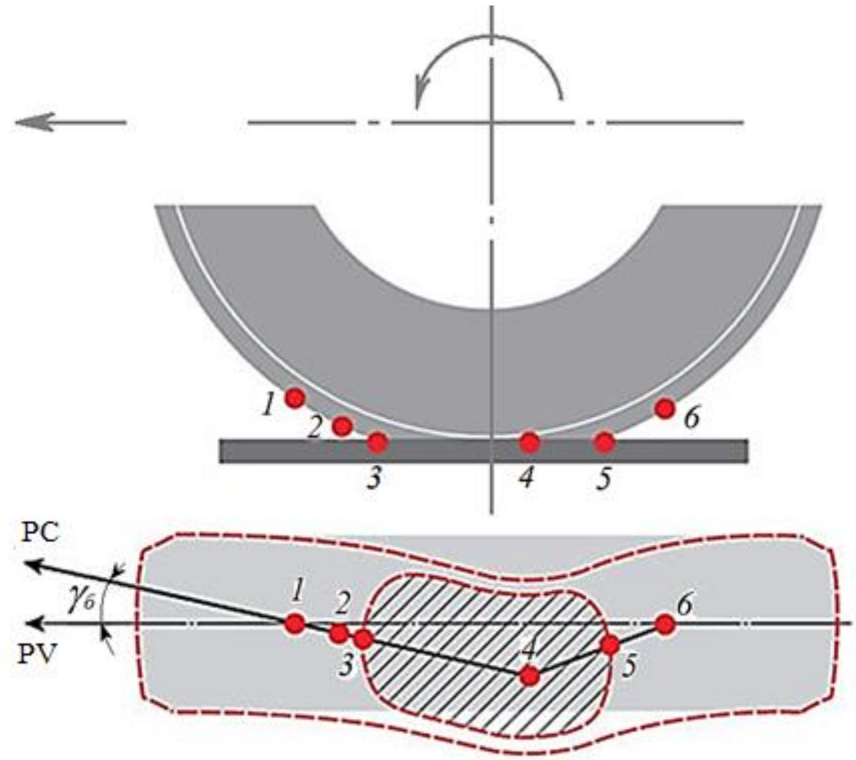

FIGURE 5. Scheme for determining wheel slip.

Thus, the point under study moves to the side by a certain amount during one revolution of the wheel, i.e. rolls a little to the side. In this case, the trajectory of the studied point in section 1-4 does not coincide with the plane of rotation of the wheel, and it shows the directions of the real movement of the wheel, and the plane passing along this trajectory is the rolling plane of the PK wheel. The angle between the plane of rotation of the wheel PV and the plane of its rolling PK shows the value of the wheel slip angle.

It should also be taken into account that cotton plantations in the republic are located both on the plain, where the surface of the fields is flat, and in the foothills, where fields with various slopes predominate. If on the plain the direction of irrigation does not have a significant effect on water erosion, then on the foothills with a slope the direction of irrigation has a significant effect on water erosion of the soil, therefore, to prevent water erosion, here sowing is carried out in a transverse direction to the slopes of the area. Therefore, in foothill areas, the amount of lateral slip of the tractor wheel is also significantly influenced by the weight of the tractor.

Conducted laboratory and field studies have shown that when the unit operates on flat terrain, lateral wheel slip occurs mainly due to the lateral force arising from a change in the direction of the unit's traction force and its maximum value does not exceed 0.6 kN, at which the maximum value of tire deformation is affecting the lateral wheel slip is 18.4 mm.

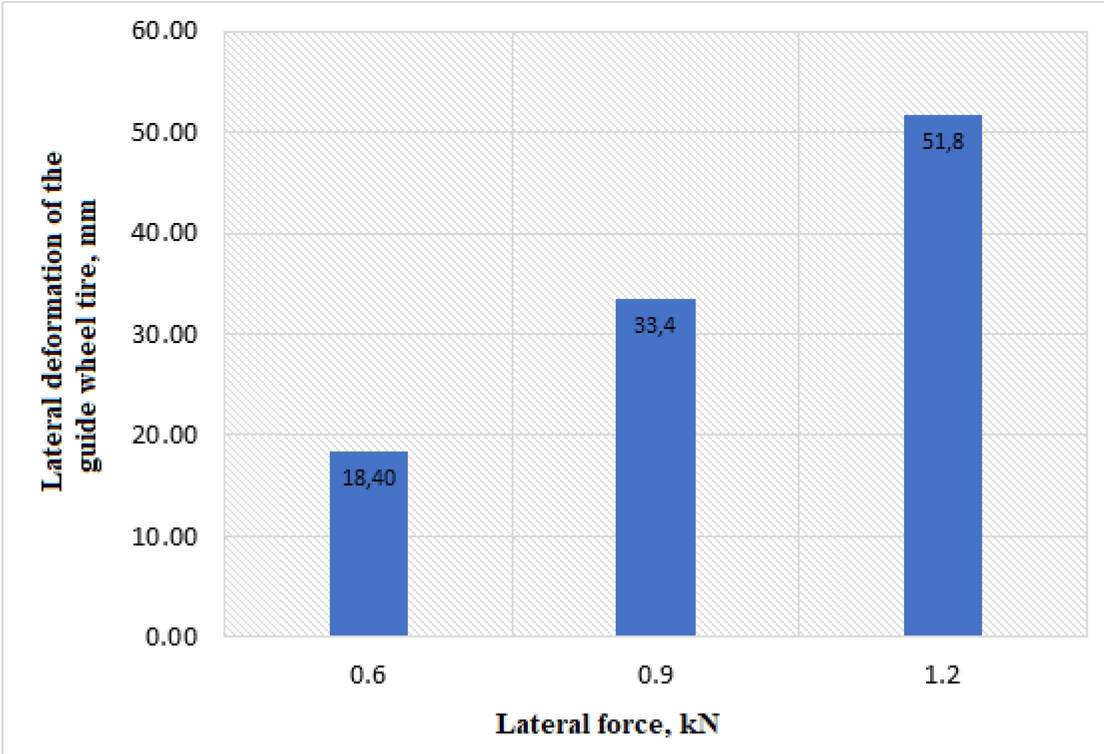

FIGURE 6. Diagram of the influence of lateral force on tire lateral deformation.

In contrast to flat terrain, when the unit operates on foothill terrain with a slope, lateral wheel slip occurs under the influence of both a change in the direction of the traction force of the unit and under the influence of the mass of the unit. Moreover, if the influence of mass on the amount of lateral slip of the tractor wheel remains almost at the same level, then changes in the direction of the traction force of the unit, depending on the slope of the field, either increases this value or decreases it. Moreover, if the lateral component of the traction force is directed towards the high side of the slope, then the amount of lateral slip of the tractor wheel decreases, while the lateral component of the traction force is directed towards the low side of the slope, then the amount of lateral slip of the tractor wheel, on the contrary, increases.

Observation of changes in the magnitude of the lateral slip of the tractor wheel at the maximum lateral component of the traction force of the unit showed that in the above cases, its maximum value of the lateral slip of the tractor wheel is 51.8 mm, and the minimum is 33.4 mm.

Thus, summarizing the above, it can be noted that under the influence of a change in the direction of the traction force created by an agricultural machine (for example, a cultivator), the tractor's guide wheels move sideways in one direction or another, depending on the direction of the lateral component of the traction force, and in some cases also on the mass tractor. Therefore, the amount of lateral slip together with the width of the tractor wheel tire must also be taken into account while observing the established protection zone.

CONCLUSION

The results of the studies established that damage to plant sprouts occurs in two cases. In the first case, due to the location of the seeds during sowing, and therefore their subsequent germination relative to the axis of symmetry of the seed row, and in the second case, due to the lateral movement of the guide wheels under the influence of a change in the direction of the traction force, depending on the physical and mechanical properties of the soil. In this case, the deviation of the seedlings relative to the axis of symmetry of the seed row after sowing the seeds remains unchanged throughout the entire growing season, which must be taken into account when determining the size of the protective zone. Whereas the influence of the second factor on plant damage can be corrected. Therefore, in order to eliminate damage to plant sprouts, both of these factors must be taken into account when inter-row care of crops.

REFERENCES

1. Avtonomov A. I., Kaziev M. Z., Shleikher A. I. Cotton growing - 2nd ed., revised. and additional. (Moscow, Kolos, 1983).
2. M. T.Bairov, Mamajanov S. M., Olmasov M. N. Agricultural machinery. Cars /Catalog/. (Tashkent, 2016).
3. Khudiyarov B. Yu., Saparov A. P., Khodzhayeva N. K. Methods for processing cotton row spacing // Young scientist. No. 17 (464). - pp. 169-174. (2023). https://moluch.ru/archive/464/101947/.
4. Akhmetov A. A. Universal-rowed crop tractors for row-to-row processing of cotton-plant crops. (Tashkent, Science, 2017)
5. Kambarov B. A., Osipov O. S. Mechanization and electrification of agriculture. (2015).
6. Kamalov M. K., Samandarov A. Kh. Analysis of cross-row maneuverability of an agricultural universal row-crop tractor // Eurasian Journal of Technology and Innovation. Vol. 1(6), pp. 51-54. (2023).
7. Sui, R., & Thomasson, J. Mechanization, sensing, and control in cotton production. Agricultural Automation: Fundamentals and Practices, 125. (2013).
8. Carmi, A., & Shalhevet, J. Root Effects on Cotton Growth and Yield 1. Crop science, 23(5), 875-878. (1983).
9. Akhmetov, A. A., Kambarov, B. A., Isokova, Z. X., & Xatamov, B. A. Fitability of the high-clearance tractor with the 4K4 wheel arrangement at the row spacing. In IOP Conference Series: Earth and Environmental Science, Vol. 1112, No. 1. IOP Publishing. (2022).
10. Akhmetov, A. A., Akhmedov, S. A., Kambarova, D. U., & Ostanov, S. S. Influence of seed positioning during sowing on the amount of deviation of plant sprouts from the straightness of rows. In IOP Conference Series: Earth and Environmental Science, Vol. 1284, No. 1, IOP Publishing. (2023).
11. Kambarov B.A. Stability of straight-line motion and controllability of wide-grip cotton MTAs based on an energy vehicle with a 4K2 propulsion circuit. Modern achievements of science in environmental management: Collection of reports of the International Scientific and Practical Conference of the Federal State Budgetary Institution PNIIAZ. – Moscow: Publishing house "Bulletin of the Russian Academy of Agricultural Sciences", pp. 247-250 (2014).
12. Kolchinsky Yu. L. Study of some factors influencing the stability of straight-line motion and controllability of a three-wheeled row-crop tractor for wide-row cotton crops. (1969).
13. Dvortsov E. F. Study of factors determining the accuracy of copying a cotton row by the working parts of mounted units. (Tashkent, 1960).
14. Grishchenko, N. V., & Trubnikov, V. N. New technology and machine for corn cultivation. Agrarian Bulletin of the Urals, (12 (79)), pp.7-8. (2010).
15. Kambarov B. A. Main parameters of the steering linkage of a cotton-growing tractor. In International Agroengineering. Scientific and technical journal of KazNIIMESKh. No. 1. pp. 67-73. (Almaty, 2013).
16. Karmanov, F. I., Ostreykovsky V. A. Statistical methods for processing experimental data using the Mathcad package. (Moscow, 2019).
17. Dospehov B. A. Methodology of field experience (with the basics of statistical processing of research results). (Moscow, Alliance, 2011).
18. Shermukhamedov A. A., Astanov B. J. Mathematical model of dynamic characteristics of a hydraulic drive with distributed parameters taking into account the influence of the temperature factor. In AIP Conference Proceedings 2612, 060012 (2023) https://doi.org/10.1063/5.0121022
19. Shermukhamedov, A., Astanov, B., & Tojiboev, S. Modeling of Thermal Processes in Flow-Through Hydraulic Drives. In International Scientific Conference Fundamental and Applied Scientific Research in the Development of Agriculture in the Far East (pp. 486-495). Cham: Springer Nature Switzerland. (2023). https://doi.org/10.1007/978-3-031-36960-5_55
20. Shermukhamedov, A., Annakulova, G., Astanov, B., & Akhmedov, S. A. Mathematical modeling of a hydraulic hitched system of gantry tractor with high clearance used in horticulture and viticulture. In IOP Conference Series: Materials Science and Engineering, Vol. 1030, No. 1, p. 012152. IOP Publishing. (2021). Doi.10.1088/1757-899X/1030/1/012152