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# Research of the unit for intrasoil fertilizing of soil with simultaneous sowing

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**The purpose.** To prove an opportunity of effective application of the combined machine-tractor unit for intrasoil complex fertilizing of soil with simultaneous sowing grain crops. **Methods.** Use of machines in agriculture, mathematical modeling based on higher mathematics and theoretical mechanics. **Results.** The developed and proved new constructive-technological scheme of the combined machine-tractor unit for intrasoil complex fertilizing of soil with simultaneous sowing grain crops which consists of wheel aggregating tractor and seeder for entering into soil of the basic doze of fertilizers, and seeder of grain crops with the device for simultaneous entering into soil of starting doze of fertilizers. **Conclusions.** The developed and tested in field conditions combined unit for intrasoil complex fertilizing of soil with simultaneous sowing grain crops has shown advantages in comparison with existing similar units

***Key words:*** *machine-tractor unit, seeder, mineral fertilizers, constructive-technological scheme, mathematical model, differential equations.*

**Formulation of the problem.** Numerous agronomic studies have shown that the introduction of mineral fertilizers simultaneously with the sowing of cereals and other crops, when the starting doses of fertilizers are introduced at the level of the bed for the seed, and the main dose of fertilizers is introduced below the level of seeding with displacement in the horizontal plane, allows you to achieve fertilizer savings by 30 -45%. Thus, it is obvious that the combination of the sowing of cereals and other crops with the main fertilizer of the soil is a resource-saving measure. In connection with this, there is a need for the development and research of such a combined machine-tractor unit that would allow hanging with the simultaneous introduction of mineral fertilizers with starting and main doses.

**Analysis of recent research and publications.** The work of the combined machine-tractor aggregates is devoted to the published works [1-8, 10]. The methodology of theoretical investigations of such aggregates, that is, the method of constructing their calculated mathematical models is sufficiently widely represented in the writings of Academician Vasylenko P. M. [1-4].

Numerous theoretical and experimental studies have proved that the agrotechnical and operational-technical performance indicators, as well as the productivity of combined machine-tractor aggregates, to a large extent, depend on the nature of their plane parallel motion. Therefore, the study of flat parallel motion of various combined machine-tractor aggregates must be carried out both in the comparative assessment of existing and in the design of fundamentally new ones. The main method of theoretical studies of this kind of movement of machine-tractor aggregates is the construction of their calculated mathematical models based on the compilation of differential equations using the initial equations in the form of the Lagrange of the second kind [4].

**The purpose of the study.** To substantiate the possibility of efficient use of a combined machine-tractor unit for intra-soil complex mineral fertilization of soil with simultaneous sowing of grain crops.

**Research methods.** In conducting research used methods of machine use in agriculture, methods of mathematical modeling, based on higher mathematics and theoretical mechanics.

**Research results.** On the basis of previous preliminary design work and experimental research [11] a new combined machine-tractor unit was created for intra-soil complex mineral fertilization of soil with simultaneous sowing of grain and other crops.

In fig. 1 presents a new design diagram of a combined machine-tractor unit, which consists of a wheeled integrated tractor behind which two seeders have been installed successively.

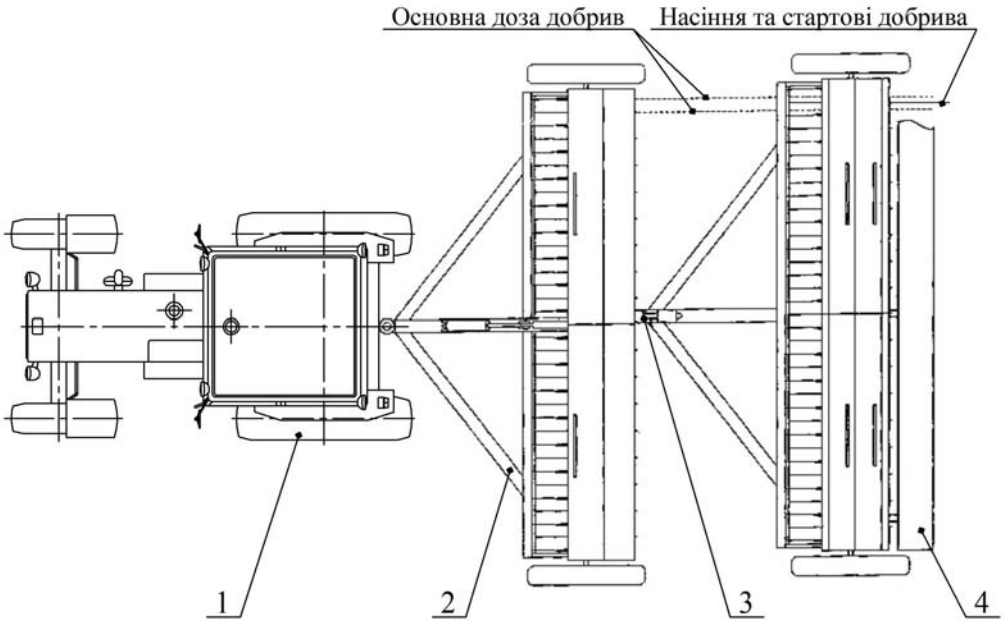


*Fig. 1. Combined aggregate of intrinsic soil. Mineral fertilization of soil with simultaneous sowing: 1 - wheeled aggregate tractor; 2 - seeders for introducing into the soil the main dose of mineral fertilizers; 3 - coupling device; 4 - a seeder of grain crops with a device for the simultaneous introduction into the soil of the starting dose of mineral fertilizers*

Due to this implementation of the unit for inland soil complex mineral fertilization, simultaneously with the sowing of agricultural crops, it is first provided that the main dose of mineral fertilizers is introduced into the soil to a greater depth (60-150 mm), and then in the middle of the spacing of the introduced main dose of fertilizers, seeds are sown together with the starting dose of mineral fertilizers to a lesser depth (20-60 mm). At the same time, the initial dose of mineral fertilizers provides effective nutrition of seedlings of cereals, which determines their accelerated growth and development, and as the growth of these plants, until the ripening of the harvest of their roots, is fed by fertilizers of the main dose, which are at a greater depth and therefore in a moist soil that ensures their dissolution and effective use by plants.

For the theoretical study of this combined machine-tractor unit, above all, its equivalent scheme was developed (Fig. 2).

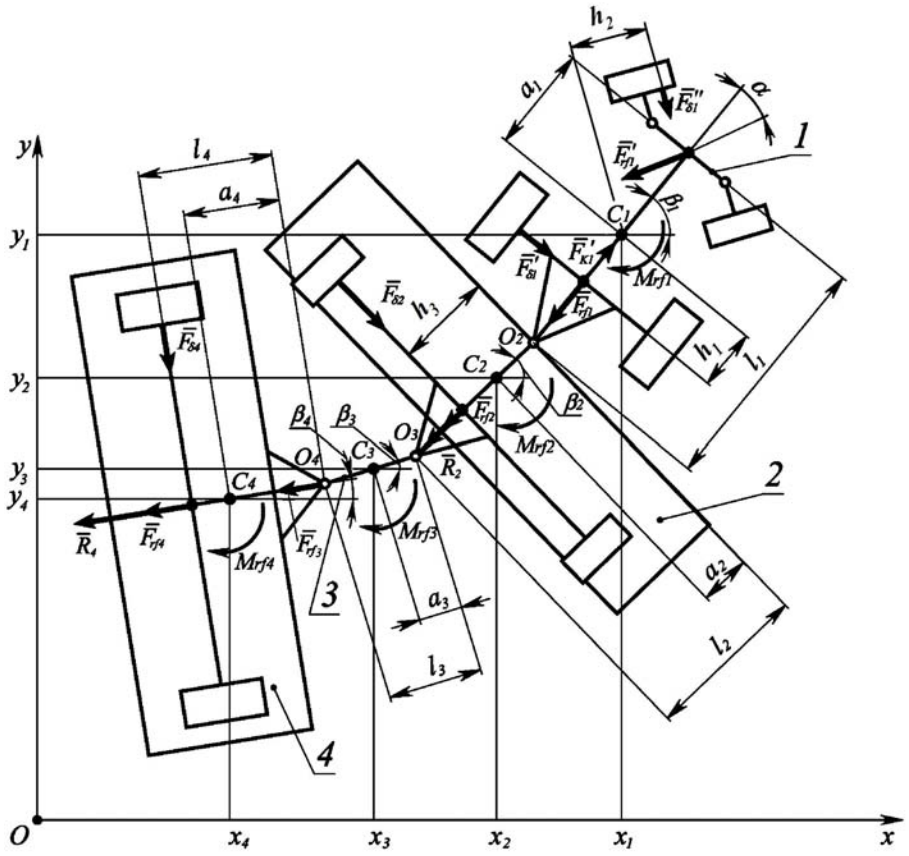


*Fig. 2. Equivalent scheme of the combined aggregate for intrinsic mineral fertilizer application with simultaneous sowing of grain crops*

Further, on the basis of the initial equations of dynamics in the form of the Lagrange II of the genus, the operations provided for their use and the finally obtained system consisting of six differential equations describing the plane-parallel motion of the dynamical system under consideration in the horizontal plane of the following form are performed:

$$
\left.
\begin{aligned}
&m_1\ddot{x}_1 + \sum_{i=2}^{4} m_i\ddot{x}_i = \sum_{i=1}^{4} F_{xi},\\
&m_1\ddot{y}_1 + \sum_{i=2}^{4} m_i\ddot{y}_i = \sum_{i=1}^{4} F_{yi},\\
&I_1\ddot{\beta}_1 + (l_1 - a_1)\sum_{i=2}^{4} m_i\left(\ddot{x}_i \sin\beta_1 - \ddot{y}_i \cos\beta_1\right) =\\
&= M_{c_1} - M_{0n1} + (l_1 - a_1)\left[\sin\beta_1 \sum_{i=2}^{4} F_{xi} - \cos\beta_1 \sum_{i=2}^{4} F_{yi}\right],\\
&I_2\ddot{\beta}_2 + m_2 a_2\left(\ddot{x}_2 \sin\beta_2 - \ddot{y}_2 \cos\beta_2\right) + l_2\left[m_3\left(\ddot{x}_3 \sin\beta_2 - \ddot{y}_j \cos\beta_2\right) +\right.\\
&\left.+ m_4\left(\ddot{x}_4 \sin\beta_2 - \ddot{y}_4 \cos\beta_2\right)\right] = M_{02} - M_{0n2} +\\
&+ l_2\left(\sin\beta_2 \sum_{j=3}^{4} F_{yj} - \cos\beta_2 \sum_{j=3}^{4} F_{yj}\right),\\
&I_3\ddot{\beta}_3 + m_3 a_3\left(\ddot{x}_3 \sin\beta_3 - \ddot{y}_3 \cos\beta_3\right) + l_3 m_4\left(\ddot{x}_4 \sin\beta_3 - \ddot{y}_4 \cos\beta_3\right) = M_{03} -\\
&- M_{0n3} + l_3\left(\sin\beta_3 F_{y4} - \cos\beta_3 F_{y4}\right),\\
&I_4\ddot{\beta}_4 + m_4 a_4\left(\ddot{x}_4 \sin\beta_4 - \ddot{y}_4 \cos\beta_4\right) = M_{04} - M_{0n4}.
\end{aligned}
\right\} \quad (1)
$$

The first three equations of the system of differential equations (1) describe the motion of an aggregating tractor along the axes $Ox$, $Oy$ and the equation of rotation of the tractor around its center of mass. The last three equations of system (1) describe the turns of the sections of the combined machine-tractor unit, respectively: rotation of the first seeder, coupling device and grain crop seed.

The solution of this system of differential equations with the help of a PC will determine the pattern of motion of each component of the aggregate in a horizontal plane, which will enable to determine the optimal kinematic and structural parameters of this combined unit for intra-soil mineral fertilization of the soil with simultaneous sowing.

**Conclusions**

1. The combined machine-tractor unit developed and tested in field conditions for intra-soil complex mineral fertilization of soil with simultaneous seeding of grain crops has shown advantages in comparison with existing analogous aggregates.

2. Received, on the basis of theoretical studies, a system of differential equations describing the plane-parallel motion of this combined unit will be used in the future for numerical solution on the PC and obtaining its optimal kinematic and constructive parameters.

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