Innovative Basic Robotechnical Mechanism for Implementation of Precisional Agriculture

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Abstract. In agriculture, the soil acts as a physical and biological environment that provides cultivated plants with life factors (water-air, food regimes, etc.), at the same time, the soil becomes the bearing surface for tillage agricultural machines. The increase in the productivity of agricultural energy causes the growth of their mass and the pressure on the soil of the running systems. Thus, in recent years, the mass of tractors per unit area of arable land has increased 3 times. Modern machine-tractor units are when growing crops passed through the field 5-15 times, which leads to the compaction of arable and subsurface of soil layers. In General, the running systems of machines are cover up to 80% of the field area, and on row crops (potatoes, sugar beet, etc.). The fields are exposed to 3-5 times the impact of units. The total area of their traces in the performance of the whole complex of field work is 100-200% of the field area. [1]

For most soils, the permissible specific pressure is 0.4-0.5 kg/cm² and the maximum is 1.0-1.5 kg/cm². However, energy-saturated wheeled tractors put pressure on the soil up to 3-4 kg/cm² or more. Soil compaction worsens its agrophysical properties, suppresses the activity of soil biota, causes poor-quality seeding and reduction of their field germination, reduces the moisture content of plants, as well as accelerates erosion processes.

Ultimately, all this leads to lower yields. In studies Matuzova G. V. and etc. [2] with an increase in the volume weight of the soil from the tractor engines from 1.05 to 1.49 g/cm³, the yield of green mass of Vico-oat mixture decreased from 218.3 to 116 C/ha almost 2 times.

The most important technical measures to reduce the compacting effect of agricultural machines on the soil include: the development of soil conservation systems of tractors (new types of caterpillar and pneumatic engines, elastic – ultra-low pressure tire) and agricultural machinery, non-tractor machines system (bridge, rope farming) and other constructive solutions.

Considered in the bridge system in the form of a self-moving platform is designed to perform in an automated mode a set of technological operations in the cultivation of crops, while providing a slight negative impact on the soil cover. The bridge technical complex is a platform approximately 10 x 30 m made of profiles. In short 10 - meter hollow profiles is moved by using a ratchet mechanism and 30-meter profile, which is equipped with roller bearings rail-beam, providing step-by-step movement of the platform on rigid supports in the form of concrete blocks and placed on
gravel-pebble pillows every 10 meters each or gravel-pebble drainage on reclamation systems. An automated technological module is mounted on 30-meter cross beams, which is moving along the long beams in an automated mode, performs the specified operations and according to these operations the platform is moved along the rail beams to the next cells. After reaching the edge of the rail-beams of the platform with the help of hydraulic cylinders, resting on a reinforced concrete beam-supports (or drainage system) is lifted, freeing the rail-beams, which with the help of ratchet mechanisms are moved to the next position. Subsequently, the hydraulic cylinders are supporting the platform in a balanced position to relax, the platform rests on the rail-beams, and the technological operation is repeated.

The bridge platform having a rigid base and an electronically-oriented system for adjusting the position of the technological module ensures the accuracy of the technological operations brought to each specific plant, the location of plant is recorded in the computer memory, as well as the application of the specified program at the level of small areas or individual plants of the norms of life support (moisture, fertilizers, chemical protection means, etc.).

Having a rigid support of movement positively solved the problems of reducing energy consumption for the module operation, moving the platform, reducing dependence on weather conditions, the state of the soil cover and human costs, etc. The bridge system in the proposed version can solves the problems of efficiency, aesthetics and attractiveness of agriculture as a production.

1. Introduction

One of the directions of technosphere safety is ecology and environmental protection, where the influence of technogenic factors on the safety of the technosphere in particular the soil, which is a technosphere in agriculture, is studied (investigated). In this paper we consider the system of bridge farming as a supportive way to reduce the anthropogenic impact on the soil cover.

One of the significant drawbacks of modern agricultural machines used in agriculture is their destructive impact on the soil structure, as a factor that determines the water-air and food regimes and in General the well-being of the habitat and life of the root system of plants and soil biota - the basis of soil fertility.

The large weight of modern units (up to 17 tons) with multiple passes up to 12 in the process of implementation of technologies of cultivation of agricultural crops and harvesting lead to soil compaction, destruction of its structure and ultimately reduce the yield.

2. Scientific significance of the issue with a brief review of the literature

Table 1. Influence of compacting action of tractors on soil and yield of green mass of Vico oat mixture [by Matuzova G. V., Bezuglova O. S. (2)].

| Number of tractor pass | Soil volume weight(g/cm³) before sowing at depth, cm | Yield, c/ha |
|------------------------|------------------------------------------------------|-------------|
|                        | 0-10 | 10-20 | 20-30 | 30-40 |                        |
| Tractor MTZ-50 (3-4 tons) |      |       |       |       |                        |
| 0                      | 1.02 | 1.13  | 1.39  | 1.40  | 218.3 ± 5.6            |
| 1                      | 1.02 | 1.25  | 1.41  | 1.42  | 179.9 ± 1.7            |
| 3                      | 1.32 | 1.34  | 1.43  | 1.47  | 153.3 ± 3.0            |
| 5                      | 1.49 | 1.50  | 1.52  | 1.53  | 116.6 ± 3.0            |
| Tractor T-74 (7 ton)    |      |       |       |       |                        |
| 0                      | 1.09 | 1.18  | 1.31  | 1.39  | 218.0 ± 4.1            |
| 1                      | 1.19 | 1.22  | 1.35  | 1.42  | 190.0 ± 2.9            |
| 3                      | 1.27 | 1.33  | 1.40  | 1.47  | 164.0 ± 2.9            |
| 5                      | 1.35 | 1.38  | 1.45  | 1.47  | 110.0 ± 1.4            |
So according to the research Matuzova G. V. and Bezuglova O. S. [2] the volume of soil mass at the depth of seed placement and root system at 5-fold passage of the MTZ-50 wheeled tractor increased by 1.5 times, which led to an almost twofold decrease in yield. Slightly lower, but sufficiently tangible negative impact on the specific mass of the soil and yield was observed on the caterpillar track T-74 (table 1). A similar pattern in their works noted Karapetyan M.A [3], Zakharova A.V [8] and others [4,5,6,7].

3. Problem statement
To solve the problems of reducing soil compaction, a number of structural upgrades of modern machines and mechanisms are proposed, which include paired and built wheels for wheeled tractors [8], broadened metal rubber and pneumatic caterpillar tractors [9], tractors with extended axles up to 12 m [10].

From technological systems the variants of performance of works on constant ridges [11,12], ridge technology of cultivation of crops [13] are offered.

The most radical systems that provide a significant reduction in the negative impact on the soil as a technosphere in agriculture include bridge systems, their movement provides for the device of rail tracks [14], cable devices [15] and others, up to unsupported tractors on an air cushion [4]. Among the bridges systems, the most interest system is represented, including a self-propelled bridge platform (Fig. 1) and some variants of the permanent support track (tracks) for moving the platform depending on the specific local soil and climatic conditions, reclamation of sites with concrete supports or use for the movement of closed gravel-pebble drains on reclamation systems.

4. Proposals and results of implementation
The principle and scheme of the device of the self-moving bridge platform are set out in patent № 263472 [16]. The bridge platform is a structure 10 x 30 m long, is made of channels (beams) (figures. 1). 10-meter hollow beams 1 are equipped with roller bearings 2 and moves 30-meter beam-support 3 by using a ratchet mechanism. On the long cross beams of the platform 5 is mounted by technological robot module 4, which is performing the operations specified by the program.

The scheme of the device and the equipment of a constant reference track are provided on figures 2 and 3. On the figure 2, variant of moving the platform on concrete blocks 1, which is laid on gravel pillows 2. Figure 3 shows a variant, where gravel-pebble drains are used under a constant track. This permanent track system is designed for reclaimed fields equipped with closed drainage.

![Figure 1. 10 x 30 m bridge platform.](image-url)
1- Short 10-meter hollow beams, 2- Roller bearings, 3- 30-meter retractable support beams, 4- Technological module, 5- Long 30-meter cross beams, 6- ratchet mechanism, 7- Wheel mechanisms for moving the platform on the road to the next field.

Figure 2. The scheme of the device and the equipment.
1-Concrete block, 2- Gravel cushion.

Figure 3. The scheme of the device and the equipment.
1-Gravel-pebble drainage.

The schematic diagram of the platform movement is provided on figure 4. The hydrocylinder 1 with support plate 2 based on concrete block 3 (or gravel drains) raise the entire platform 4, unloading of the beam-propeller 5, these beams and the rollers 6 under its own weight lay on the shelf longitudinal short beam 8 and then by ratchet mechanisms 7 are moved to the next plot (Fig. 5), where hydrocylinders 1 are slower and the whole system rests on the rollers 6 beams-propulsion 5, which in turn are stacked on concrete blocks (sand-gravel gauge-drains) 3. With the help of ratchet mechanisms 7, the complex moves to the next position (the plot of the plot), which is processed in a given mode by the technological module 8.
Figure 4. The schematic diagram of the platform.
1- hydro cylinder, 2- support plate, 3-concrete block, 4- platforms, 5- beam-propeller, 6- rollers, 7- ratchet mechanisms, 8- technological module.

Figure 5. The movement on the beams of the platform.

After the process module is completed, a new cycle begins.
The complex, after processing the next field 1 (Fig. 6), enters the inter-field road 2. The transverse movement of the platform to the new plot (field) occurs with the help of wheel movers 3. On the extended beams of the movers, the platform, moving to a new plot of 1 field, continues to perform the specified technology.
The considered bridge self-moving platform is a rigid structure that provides all the advantages that are inherent in the bridge system of Zhukov Y. A. AMAK [15] it’s a high techno sphere safety relative to the soil cover, providing conditions for the introduction of robotics with the execution of technological processes specified by the electronic program, with access to small areas and, moreover, to meet the vital needs of individual plants, with high efficiency of the unit, low energy consumption and high intelligence of labor.

At the same time, the system under consideration has a number of advantages in terms of the principle of the device, lower operating costs for the arrangement of the track. In particular, the device of the railway track and AMAK requires about 17.5 tons of rail steel per hectare of field, significant amounts of material for the installation of rail tracks and sufficiently material-intensive, high-tech devices of cable units, units on airbags and etc.

The device of the permanent track of the supposed patented bridge platform provides for more simplified versions of their equipment.

In the first variant on the non-reclaimed array platform is moved step by step concrete blocks 25 x 40 x 200 cm, which is laid on gravel-pebble cushions. The consumption of materials per 1 hectare of area is about 6 m³ of reinforced concrete and 30 m³ of gravel. On reclaimed land for displacement is used longitudinal system closed drainage, it made of gravel-pebble substrates with a depth of 0,7-1 m, placed 15-30 m depending on the mechanical composition of the soil [17], providing a stable reset perched significant drainage within the boundaries of the drainage paths (tracks), on which moves the bridge system. Turning lanes (Fig. 2) are paved roads, these are simultaneously serve to transport in term of providing the necessary materials (seeds, fertilizers, etc.), and export of the harvested crop.

5. Conclusion
Therefore, the modern agricultural machines are using the soil cover as a bearing surface, as a result of multiple passes provided by the technologies of cultivation of crops, their large weight significantly compacts the soil, which worsens its physical and chemical properties (water, air, food, etc. modes), the living conditions of soil biota, the root system of plants and, ultimately, reduces soil fertility. In order to reduce the negative impact of agricultural machines on the soil, to provide conditions for automation of technological processes, to reduce energy consumption, a number of technical solutions are proposed in
the form of improving the running systems and engines of agricultural machines, as well as various types of bridge systems. In this paper we consider the bridge system in the form of a self-moving technological platform 10 x 30 m moving on permanent supports in the form of rigid concrete block supports or gravel-pebble closed drains. With all the advantages of an analogue in the form of bridge systems on rail supports, the proposed option is less material-intensive, simpler in equipment and maintenance of technological design and permanent ways (track), quite productive up to 5 thousand hectares of area in the rotation of crops with different sowing periods (plantings). At the same time, the proposed version of the self-moving agricultural platform has all the positive properties of the rail analogue: high efficiency in energy consumption, high efficiency, creation of conditions for robotization and automation of technological processes, comfort and high intelligence of labor and high ecological compatibility.

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