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Recultivation of fallow lands with soil moisture regulation

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Abstract. The technologies for implementing the tasks of involving fallow lands in agricultural turnover and increasing the fertility of agricultural lands in the long-term period of economic activity are highlighted. Insufficient informativeness of the use of yield maps to assess the fertility of fields has been revealed. It is proposed to use field relief maps to establish the dynamics of violation of the water-air regime of the soil. It is proved that in the process of involving fallow lands into circulation, it is necessary to introduce a technological operation of microtopographic analysis of the degree of soil moisture. An algorithm for enabling the operation of levelling of field surface (removal of relief) using modern positioning systems has been developed. It was revealed that the levelling of the field with a laser level allowed to reduce yield fluctuations by 20% within the crop acres of the field and increase yield by 25-30%. Disadvantages of positioning accuracy with the use of laser and satellite positioning have been established. It is proposed to transfer digital information transmission modules to network clusters with the choice of the best digital data transmission channel by including an uninterrupted positioning module with digital data transmission over a 434 MHz and 864 MHz radio channel with a range of up to 600 meters to other modules for providing digital positioning information to the machine. The plan of implementation of the concept of digital field formation on the basis of the field experimental station of the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy is presented, with the aim of creating a frontier for the sustainable development of closed-life cycle technologies through the introduction of innovations using multiplicative interaction of mechatronic systems and telematics for agricultural technology.

1 Introduction

The problem of rational use of the land fund is becoming more acute due to various circumstances that do not allow the creation on a permanent basis of land conservation services that implement the principle of "do no harm" to the environment in the format of preserving natural identity. In turn, the number of abandoned lands, although beginning to

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decrease, but the low rates of involvement in the turnover of abandoned lands require the search for new technological solutions [1, 2].

As noted in the regulatory documentation, a technogenic impact is considered a violation of land, leading to a violation of the soil cover, the hydrological regime of the terrain and other qualitative changes. The term "disturbed lands – lands that have lost their original economic value due to their violation and are a source of negative impact on the environment" in general remains relevant, but requires additions and explanations when considering abandoned lands. The cessation of man-made impacts on land plots for a short period of time allows nature to clean itself, of course, in the absence of a critical man-made impact, and recover by creating vegetation cover with the adaptation of the remnants of man-made traces. All this can be clearly traced on abandoned agricultural plots, the so-called fallow lands. Of course, in cases where the territory is polluted with chemical elements, construction and other materials, garbage, it is often extremely difficult to realize the restoration of the environment itself, although delving into the mechanism of this process, we can say that for a sufficiently long period of time, the effect of environmental transformation appears [3, 4].

The purpose of the research is to identify effective technologies for recultivation of lands that have been subjected to man-made impacts in the long term to ensure uniformity of humidification by profiling the surface.

2 Materials and methods

The task of land reclamation in the classical format of its solution is considered to be "a set of works aimed at restoring the productivity and economic value of disturbed lands, as well as improving environmental conditions in accordance with the interests of society", which causes a contradiction between the "interests of society" for a given time period and the long-term effectiveness of ensuring a high-quality environment.

For example, in [5] the author notes the influence of economic and political trends on the validity of extensive land reclamation work. It is proved that regardless of the long-term and cost-effectiveness of land reclamation measures, these types of work should be transferred to the legal plane, as an additional burdensome component to the main types of economic activity.

There are two stages of land reclamation: technical and biological. At the same time, the technical stage is preparatory work to create conditions for subsequent biological reclamation, or rather restoration of soil fertility [6].

The quality of the territories is also affected by the relief, the configuration of which can influence the occurrence of both wind and water erosion sites. As a rule, the cause of these areas is an overabundance of wind load or water formed after rains on compacted land and with a structural composition that does not ensure its absorption.

It is obvious that the relief of fallow lands is an intersected space with a high level of surface unevenness. In turn, it should be noted that profile instability is also characteristic of agricultural lands in constant circulation, where places with dead wood and increased watering are concentrated, which is clearly visible on aerial survey maps of fields (Fig.1).

Fig. 1. An example of a field map using satellite positioning.

The analysis of photography shows bright spots of places exposed to wind erosion. Technologically, this problem is solved by installing additional irrigation, which can cause flooding in other areas of the field. Potentially watered areas on the plane, although characterized by small washouts, are eliminated quickly enough. It has been scientifically proven that the formation of water effluents that cause erosion increases by 20% with a decrease in the wooded area of the surrounding area.

An important factor in combating water erosion when performing land reclamation is the formation of relief and roads, the horizon of which would not allow the formation of runoff flows outside the designated areas, which can be drainage trenches, ponds or water-absorbing structures [7, 8].

3 Results and discussion

It is recommended to carry out work to remove excess moisture 1-2 times a year, but there are some problems.

As shown in Fig. 2, in fields with uneven terrain, there are areas with bald spots due to lack of moisture and areas filled with water, because the soil is not able to absorb it.

Fig. 2. Soil waterlogging example.

The technical means of saturating the soil with air and removing excess water are aerators and scarifiers, which are installed as additional working equipment for basic equipment [9, 10].

Modern means of digital sensing make it possible to create a map not just of "Fields", but to identify areas with different moisture absorption.

For this purpose, within the framework of the Digital Field project, a plan for assessing soil fertility has been developed, including monitoring of moisture zones as an addition.

Technically, it is proposed to carry out measures for watering the site or its drainage to be carried out point-by-point, in areas identified by aerial video monitoring.

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3.1 Technology and technical means for land reclamation with leveling of the field relief

When recultivating lands whose fallowness does not exceed 4-5 years, it is recommended to use heavy disc harrows or disc plows DPN-7 or PNF-5-26 with disk headers BDM 4*4 or "Ruby" 9 for processing [10].

Considering that disking should be carried out repeatedly in order to remove weeds, plant crop material into the soil and mix it. The number of diskings, depending on the degree of turfness, can increase to 3, while each subsequent processing should be carried out at an angle of 35-45° to the previous passage.

In the future, loosening of the lower layers of the soil and pruning of rhizomes should be carried out, rippers, heavy cultivators or a similar tool should be used.

After completing these works, the next step is to prepare the soil for sowing. It is proposed to perform preliminary work on the digital processing of the field with the control of the relief and zones according to the moisture level indicator.

To do this, it is necessary to perform terrain mapping [10, 11].

The relief of the field is built according to the grid according to the levels of field levelling and to carry out profiling work leveling the surface.

Obviously, the initial stage will require additional costs, but in the long term it will eliminate the uneven ripening of crops, increasing the percentage of similarity, simplify irrigation control by eliminating the uneven distribution of moisture and nutrients, etc. There is a leveller or scraper for these purposes.

The choice of the type of leveller depends on the level of the leveled surface, but it should be clarified that for agricultural fields, it is not recommended to use heavy scrapers capable of moving 10-15 m^3 of soil due to the danger of soil over-compaction.

In turn, lightweight levellers only level the surface. Manufacturers produce various models of agricultural scrapers equipped with steel blades made of tungsten alloys.

The inclusion in the set of profilers of digital laser leveling systems combined with aerial survey maps allows to create a surface at the level of finishing.

An interesting solution is a complex multifunctional machine capable of performing several operations at once in one pass: a ripper – preliminary loosening; a scraper blade – cutting and distributing soil over the surface; a laser level – control of the surface profile along the levelling horizon; a harrow and a seed hopper – harrowing and sowing.


a) b)


c) d)

Fig. 3. Levellers for leveling fields: a) long base D-719; b) trailer P-2.8; c) scraper SP-4.2; d) scraper "Kholmogor 3700".

3.2 Microtopographic analysis of the degree of soil moisture

Considering the experience of various agricultural organizations, it is necessary to highlight the developments presented at the Trimble Agriculture CIS seminar, which was attended by Russia, Belarus, Kazakhstan, Uzbekistan, Azerbaijan, Kyrgyzstan, Armenia and other countries. Of particular note are developments in the field of soil moisture control using modern digital field levellers, such as the Trimble Field Level II system (https://glavpahar.ru/articles/planirovka-poley-s-sistemoy-trimble-field-level-ii), according to the developers, the extension of agronomic terms of work in the field has been ensured, the efficiency of fertilizer application has increased, the uniformity of crop ripening and, accordingly, additional productivity (Fig. 4).


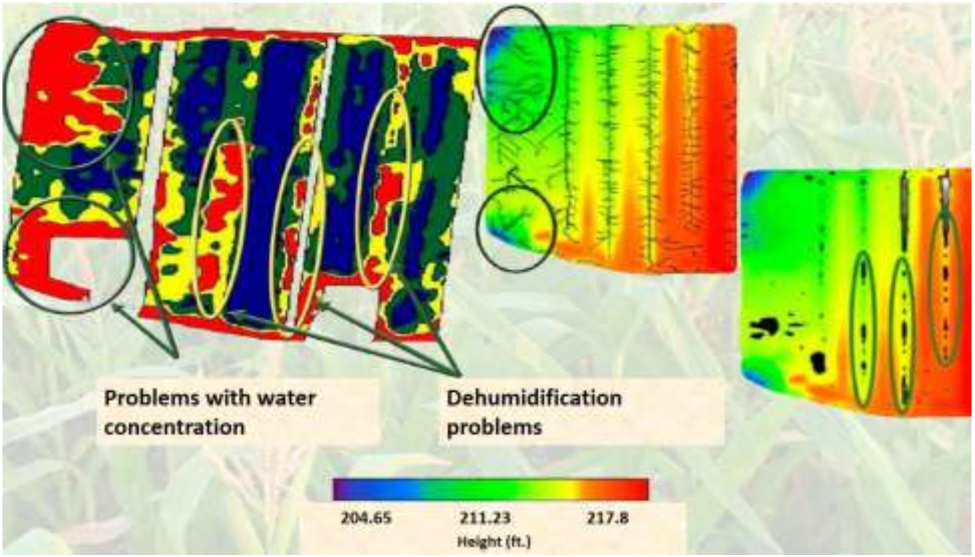

Fig. 4. Results of the implementation of field profiling technologies with microtopographic surface analysis.

According to [11], leveling the field with a laser level required a cut of the fertile soil layer of no more than 9 cm, the volume of displaced soil did not exceed 1.5 thous. m^3, which made it possible to reduce yield fluctuations by 20% within the cultivated area of the field and increase yield by 25-30% (example of corn sowing).

Typical structural solutions of laser plane planning are carried out by circular scanning of the surface with a laser beam and using software Plane Laser System, the receiving device on the working organ receives the signal and corrects its position relative to the soil surface. The key disadvantage of this technology is the high sensitivity of the Plane Laser System to dust, temperature and wind, time of day and distance.

Trimble offers to combine the levelling system according to satellite coordinates, the base station of this system is able to pick up the satellite signal, correct it and transmit it within a radius of 3 km to the leveller's working body.

The control module transmits a command to the leveller's hydraulic valve, and the knife cuts the surface to a predetermined depth.

It should be noted that increasing the reference points of the location of the base stations along the perimeter of the cultivated areas of the fields or using mobile, pre-erected signal reception stations in the areas of involvement in the turnover of fallow lands increases the accuracy of positioning, and installing 2 antennas on the leveller's working body will ensure greater accuracy of the tilt of the tool, control of movement along the slope in any direction, correction of smoothness a slice.

The studies conducted by the authors show that the installation of laser alignment shows positive results, but as noted above has significant drawbacks. Also, manufacturers, as an alternative, proposed to carry out work on satellite coordinates, but even in this case it will be quite difficult to receive an uninterrupted signal in rural areas, especially in places where work is carried out on the reclamation of fallow lands [12].

To solve the stated problem, the authors propose to combine digital information transmission modules into network clusters with the choice of the best digital data transmission channel by including an uninterrupted positioning module with digital data transmission over a 434 MHz and 864 MHz radio channel with a range of up to 600 meters to other modules for providing digital positioning information to the machine. The diagram of the module for uninterrupted digital data transmission is shown in Fig. 5.

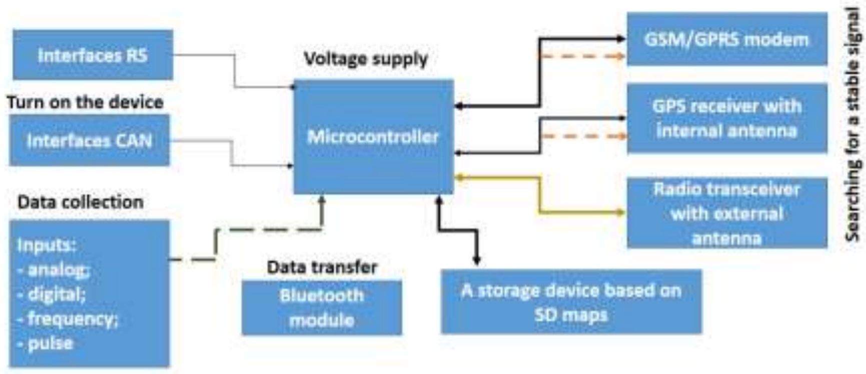

Fig. 5. Algorithm of the module of uninterrupted positioning with digital data transmission.

The conducted analytical studies are one of the stages of the implementation of the complex scientific and practical work of scientists and production structures of the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy using the resource potential of the field experimental station to create a "Digital field" [13, 14].

3.3 The Digital Field concept on the basis of the field experimental station of the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy

The aim of the research within the framework of the project is to create a frontier of sustainable development Digital Field in the concept of closed life cycle technologies by introducing innovations using multiplicative interaction of mechatronic systems and telematics.

To achieve this goal , the following tasks are solved:

1. Assessment of component mutual sufficiency of technologies for the implementation of sustainable development tasks in the functioning of the agro-industrial complex with the allocation of multiplicative interaction of mechatronic systems and telematics [15, 16].
2. Formation of the concept of a closed life cycle of all levels of the agro-industrial complex system, with the inclusion of resource-saving technologies for the secondary use of recyclable processed products [17, 18].
3. Development of a hardware and software complex for monitoring, diagnostics and remote control of an object, based on a sensor self-regulating network of radio modules, in the absence of GSM network coverage (hereinafter referred to as the SRNRM Package).
4. Creation of a cloud environment of the Digital Field Data Bank with a flexible, adaptive self-development module, up to the level of justification for "decision-making" with predicate regulation of the efficiency of the life cycle.

4 Conclusions

Insufficient informativeness of the use of yield maps to assess the fertility of fields has been revealed.

It is proposed to use field relief maps that will allow to establish the dynamics of violation of the water-air regime of the soil.

It is proved that in the process of involving fallow lands into circulation, it is necessary to introduce a technological operation of microtopographic analysis of the degree of soil moisture.

An algorithm for enabling the operation of levelling of field surface (removal of relief) using modern positioning systems has been developed.

It is recommended to install a laser alignment system for positioning the planner knife or scraper, which will ensure smooth operation.

The plan of implementation of the concept of digital field formation on the basis of the field experimental station of the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy is presented, with the aim of creating a frontier for the sustainable development of closed-life cycle technologies through the introduction of innovations using multiplicative interaction of mechatronic systems and telematics for agricultural technology.

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