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THE INFLUENCE OF INNOVATIVE TECHNOLOGIES ON THE DYNAMICS OF LAND USE INDICATORS OF UKRAINIAN AGRICULTURAL ENTERPRISES

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Abstract

The article examines the innovative activities of agricultura lenterprises on the territory of Ukraine, in particular the use of unmanned aerial vehicles (DJI Agras T30 multicopter). The policy of the leading Ukrainian company Ukrland farming in the field of balanced land use and effective development of the agro-industrial complex was studied. The criteria used in the development of the plant nutrition system have been formed. Advantages were formed in the performance of works on the application of nutrients and plant protection with the help of the Agras T30 multicopter. Proposals were made to increase the level of resource-saving activities of agro-industrial complexes due to the use of alternative methods of agricultural production, namely organic farming, biointensive mini-farming, biodynamic farming, ecological agriculture, EM technologies, established agriculture with low resource intensity, precision agriculture. The existence of an economic-mathematical model of the influence of the use of innovative technologies, in particular, the use of the DJI Agras T30 multicopter, on the dynamics of indicators of the efficiency of the cultivation of cultivated areas of agricultural enterprises has been formed and substantiated.

Key words**:** *agricultural production, innovative activity, unmanned aerial vehicles, balanced land use*

INTRODUCTION

The agro-industrial complex of Ukraine is one of the most important segments of economic development. That is why the effective functioning of this area should be implemented through the introduction and spread of innovative activities.

Considering that the innovation process goes through a series of stages from the development of an innovative product to its approval and introduction into wide production, currently innovative activity in Ukraine is unbalanced according to the stages of the innovation process, the participants of which are little informed and interested in each other, especially this concerns the production of agricultural products and its consumption.

Ukrainian agricultural products are known in almost 200 countries of the world. It occupies leading positions in global markets in terms of export volumes, namely: sunflower oil - 1st place, corn, oilseeds - 3rd place, barley - 4th place, wheat - 6th place, etc. Further entry into the world economic space, strengthening of processes of globalization and liberalization of trade requires adaptation to constantly changing conditions, and, accordingly, further improvement of agrarian policy [7]. The study of the trends and regularities of the functioning of agricultural enterprises showed that one of the main reasons for the low innovation activity of domestic agricultural enterprises is the lack of mechanisms and tools of interest in introducing innovations into agricultural production. While in the difficult current conditions, agricultural enterprises independently carry out innovative activities, taking into account the limited financial resources for solving scientific and technological problems [8]. Until February 24, 2022, th agro-industrial complex, in

particular, the corporate segment, was characterized by a high level of technical progress, an increase in labor productivity, as well as a significant scale of production and export. Starting from January to April 2022, Ukraine exported agricultural products in the amount of 7,420 billion dollars, which exceeded last year's figures by 3% [14].

In the conditions of hostilities, the primary task of the Ukrainian agricultural sector became the reliable supply of agricultural products and food to the population. Farm business and individual peasant farms havep layed a key role in the preservation and development of local markets and food supply chains. Of course, in the coming year, state measures are planned for financial support of the agrarian sector of the economy, taking into account the active implementation of innovative technologies in the context of increasing labor productivity and land use efficiency.

The purpose of the article is to substantiate the essence of theoretical and applied aspects in the process of applying modern technologies on the basis of agricultural enterprises and the formation of a mathematical model that allows determining the dynamics of indicators of the efficiency of cultivation of the cultivated area for a certain period of time [13].

MATERIALS AND METHODS

The basis for theoretical and methodological research was the main economic and macroeconomic laws, the theory of mathematical modeling, as well as the works of Italian, Austrian, Malaysian, and British scientists who work in the field of improving innovative solutions for the purpose of ecologically, economically, ethically, and socially viable production of agricultural products.

Scientific methods of cognition based on a systematic approach to solving the problem were also applied.

The statistical base of the study was made up of the official data base and reports of the State Statistics Service of Ukraine, the agrarian company "Ukrland farming", the official web site about agribusiness LATIFUNDIST.COM. In particular, the data were used to present the main indicators of agricultural land use to calculate the actual economic efficiency as a result of the application of innovative technologies during the sowing campaign.

In the course of scientific research, a complex system was used, including general scientific and special research methods. The conceptual apparatus and the essence of the innovative activity of agricultural enterprises on the territory of Ukraine are theoretically substantiated [12].

With the help of system analysis and synthesis, the principles of the potential development of the field of agro-industrial complex with the use of drones were revealed. Using the method of economic-mathematical modeling, a model of the influence of the use of innovative technologies, in particular, the use of the DJI Agras T30 multicopter, on the dynamics of the efficiency indicators of cultivation of agrarian enterprises was formed and substantiated.

RESULTS AND DISCUSSIONS

A modern tool for the agricultural sector, which is used almost all over the world, and is also gradually penetrating the Ukrainian technology market, is an unmanned aerial vehicle, or in other words, a drone.

Unmanned aerial vehicles are used both to solve everyday needs and to conduct secret military operations, as well as in various types of economic activity (industry, forestry, ecology, space research, inspection of inaccessible or dangerous places, etc.).

One of the most promising areas of application of unmanned aerial vehicles is agriculture itself. According to forecasts of the International Association of Unmanned Systems (AUVSI), they can have the greatest impact precisely in agricultural production, that is, be economically feasible in this area 6 [6].

When using agricultural land, drones can perform various functions, including monitoring and transportation (Table 1).

Table 1 Potential possibilities of agricultural land use when using the main functions of unmanned aerial vehicles

Function monitoring	***Determining the level of nitrogen content in the soil and plant tissues;*** ***Monitoring the condition and development of crops;*** ***Forecasting yield;*** ***Calculation of humidity indices and vegetation indices;*** ***Determination of the actual sown area, the area of the land plot and its boundary;*** ***Inventory of land plots;*** ***Observation of the state of plants at various stages of their development.***
Transport function	*Ensuring the necessary level of plant protection and nutrition;* *Spraying with special solutions of sown areas;* *Crop protection and safety in the field;* *Pollination of plants.*

Source: made by the authors [3].

With the help of drones, agricultural enterprises will be able to receive the necessary information about the condition of productive lands. In addition, such information can be accumulated at such a frequency that the owner needs for further analysis of production processes in dynamics.

The active use of drones by agricultural producers ensures the optimization of production costs due to the reduction of energy costs, the minimization of the use of seeds, fertilizers and water resources [11].

According to the expert data of drone services, the saving of fertilizers and toxic chemicals with the correct use of drone data is up to 30%, and the saving of seed material, depending on the terrain, can reach up to 15%.

Based on the experience of farmers of the French OCEALIA Group, thanks to the use of drones, the yield level increased by an average of 10%. The profit from the use of "drones" in the US agricultural sector is estimated at 75 billion US dollars by 2025 due to the creation of new jobs and optimization of existing processes [4].

The advantages of involving drones in the production process of agricultural activity are that aerial photography from them is more detailed than a space photo.

In addition, drones allow filming even in cloudy weather, which cannot be said about aviation and satellites. The advantage is also that you can get pictures during the flight, which can be adjusted even in real time. The results of aerial photography make it possible to place plots on the cadastral record [5].

The Ukrainian agrarian company "Ukrland farming", which is included in the rating of the TOP-20 most successful investors of Ukraine according to the version of the investment portal InVenture, is gradually implementing programs regarding the use of innovative technologies during the sowing campaign and the direct production of its own agricultural products.

Ukrland farming cooperates with the international organization International Sustainability and Carbon Certification, and complies with the requirements of the ISCS voluntary certification system. Also, the enterprise is characterized by quality indicators of the production of ecologically clean, organic products in compliance with the relevant criteria in relation to suppliers of goods and services [13].

The relevant structural subdivisions of the enterprise organize monitoring and compliance with all environmental safety measures.

The fundamental directions of the company's operation are balanced land use and effective development of the agro-industrial complex.

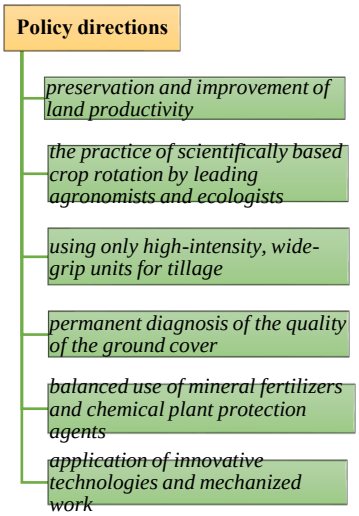

Fig. 1. Policy directions of the company "Ukrlandfarming" in terms of balanced land use and implementation of innovative technologies

Source: made by the authors based on the source [13].

The use of land resources as the main means of production in the implementation of

agricultural activities requires an optimized approach to preserving and increasing the level of soil fertility. In particular, the development of plant nutrition systems is influenced by a number of natural factors, in which experts are guided by a number of criteria

It is worth noting that the company's specialists combine various methods of plant protection, in particular: organizational and economic, mechanical, physical, agrotechnical and biological with chemical [2].

Such a rational approach to the chemical method of plant protection allows reducing significantly the negative impact of pesticides on the integrity of the natural environment. Thus, land plots on which agricultural crops are grown are characterized by a high level of safety and a reduction in the number of risks related to environmental pollution by minimizing or reducing to zero emissions of negative substances into the atmosphere.

Lets analyze the functioning of the plant nutrition and protection system with the help of a drone - DJI Agras T30, which is most often used for the needs of agricultural land use and is used by specialists of the agricultural company Ukrlandfarmin.

DJI Agras T30 lifts 30 liters of a special solution into the air, which allows you to process up to 16 hectares of land per hour.

Thanks to the ability to transform the DJI Agras T30, it is suitable for working in orchards and processing hard-to-reach places in tree crowns.

DJI Agras T30 is a transforming agrocopter. It can be used both for spraying plant protection products and for spreading granular fertilizers and seeds [1].

DJI Agras T30 flight features:

1. Unprecedented flight safety under any conditions

2. Agras T30 independently recognizes and flies around unexpected obstacles.

3. Equipped with a spherical radar system for avoiding obstacles, thanks to which the copter is free of blind spots.

4. The RTK module provides centimeter positioning accuracy.

5. T30 Since the dark time of the day is optimal for the operation of the copter; it was equipped with a system of 8 searchlights.

Four of them are frontal, and four more are necessary for the operation of the rear camera, so that the operator can observe the results of the work in real time [1].

Special measures to feed and protect agricultural crops, which are carried out with the help of the DJI Agras T30 multicopter, are characterized by fine-droplet spraying. It should be emphasized that the main difference from traditional methods of tillage is the minimal use of water.

The initial stage of work is the determination of the contour coordinates of an oriented field or fields. After that, it is necessary to agree on an individual plan of the performed works, which necessarily includes such characteristics as: area, location of the object and weather conditions. An important point is the detailed analysis and forecasting of certain meteorological elements, in particular, the speed and direction of the wind, precipitation, etc. [10].

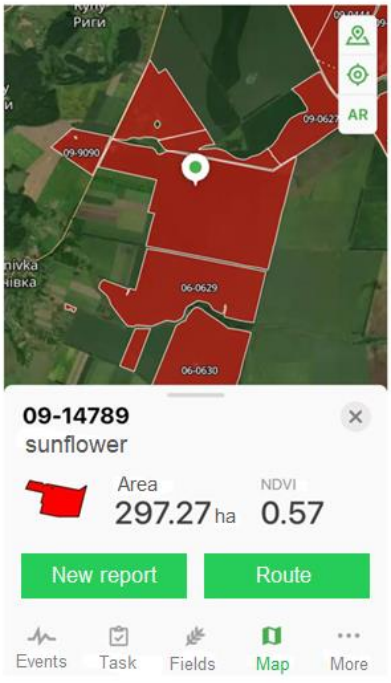

Fig. 2. Map with an individual task with clearly defined identifiers, parameters on the territory of the Poltava region of the Lohvytskyi territorial community
Source: Data from the DJI Agras T30 multicopter control panel.

According to Figure 2, it is possible to analyze a map with an individual task, in

particular, an image with a field identifier - 09-14789, an area - 297.27 ha, a vegetation index NDVI - 0.57 and a specifically defined agricultural crop - sunflower.

The next stage is the immediate start of work by a special flight team. Thus, depending on the features of the land plot, it is possible to process from 20 to 100 hectares of the sown area in one work shift (Fig. 3).

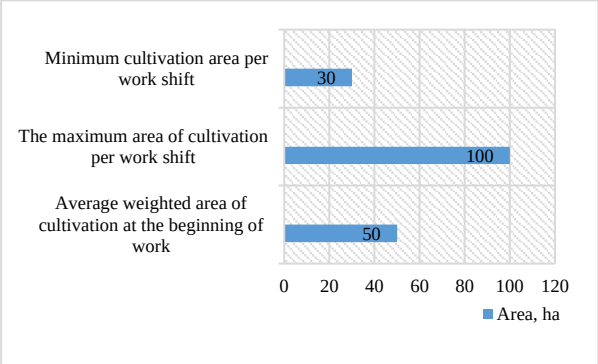

Fig. 3. Analysis of cultivated area for one work shift (ha)

Source: Developed by the authors based on the results of the DJI Agras T30 multicopter during the sowing campaign in the Poltava region.

The average area of the cultivated field at the initial stage of work is about 50 hectares. In the future, depending on the spatial characteristics of the field, for example, if the field is flat without humps and depressions, the cultivation of the sown area can reach up to 100 hectares per work shift, with a maximum speed of the multicopter of 25.2 km/h. If the territory of the field is more relief or has a number of restrictions, for example, power lines, then the cultivation area reaches 30 hectares. Again, on the condition that with this or that field it is necessary to first go around its perimeter, be it 10, 40, 100, 200 hectares of area to clarify the coordinates and only after that start work [9].

Using the apparatus of economic-mathematical modeling, we will express the model of the influence of the use of innovative technologies, in particular, the use of the DJI Agras T30 multicopter, on the dynamics of indicators of the efficiency of the cultivation of cultivated areas of agricultural enterprises.

Let's denote Pz (t) - cultivated area, per shift, hectare.

The change of this value can be expressed by the following formula:

$$Pz(t) = -Pz(t) * kw - Pzr(t) + 0.02 * Pvr\max(t) \quad \text{.....(1)}$$

where: kw is the coefficient of influence of weather conditions, which is in the range from 0 to 1 and shows which area may be under-cultivated if the weather conditions are negative.

On average, during the flight, due to unfavorable weather conditions, it is possible to process only a quarter of the planned area.

Pzr(t) is the area actually processed per shift;

0.01-0.05 – a coefficient that shows what proportion of the area is processed per shift (7 hours);

Pzrmax(t) is the maximum possible area that can be processed in 1 flight.

Important attention should also be paid to the calculation of costs for maintenance and repair of the multicopter, which can be determined by the formula:

$$cpr = \begin{cases} \dfrac{Pz(t) * kpqn}{kpq}, if\ t \in [7;10] \\ 0, if\ t \notin [7,10] \end{cases} \quad \text{.....(2)}$$

where: kpq is the coefficient of efficiency of costs for field cultivation, which shows how much area can be provided by a unit of money under the conditions of using a certain amount of spraying material;

$kpqn$ is the depreciation rate, which shows how much of the share wears outdaily, transferring its value into potential yield.

By combining all the above-mentioned equalities, restrictions, and initial conditions, we will obtain a model of the influence of the use of innovative technologies on the dynamics of indicators of the efficiency of cultivation of cultivated areas of agricultural enterprises:

$$Pz(t) = -Pz(t) * kw - Pzr(t) + 0.02 * Pvr\max(t)$$

$$Pzr\,max(t) = \begin{cases} 0, if\ t \notin [100] \\ Pv\ if\ t \in [100] \end{cases}$$

$$cpr = \begin{cases} \dfrac{Pz(t) * kpqn}{kpq}, if\ t \in [7;10] \\ 0, if\ t \notin [7,10] \end{cases} Por(t) = \begin{cases} 0\ if\ t \neq 7 \\ Pz(t), if\ t = 7 \end{cases}$$

.....(3)

With the help of an economic-mathematical model, the indicators of the efficiency of cultivation of cultivated areas with the DJI Agras T30 multicopter were calculated based on spraying operations in three work shifts (Table 2).

Table 2. Values of model parameters

Parameter	***Indicators of work shifts***		
	shift 1	***shift 2***	***shift 3***
Total area for cultivation, ha	*111*	*104*	*26*
Area under cultivation, ha	*31.6*	*51.6*	*23,4*
Factor of influence of weather conditions	*0.000685*	*0.000685*	*0.000685*
The maximum potential area that can be processed by a multicopter	*100*	*100*	*100*
A ratio that shows what proportion of the area is processed per shift	*0.02*	*0.05*	*0.02*
Actual cultivated area for 1 flight lasting 7 hours	***33.5***	***56.6***	***25.3***

Source: Made by the authors based on the results of the DJI Agras T30 multicopter during the sowing campaign in the Poltava region.

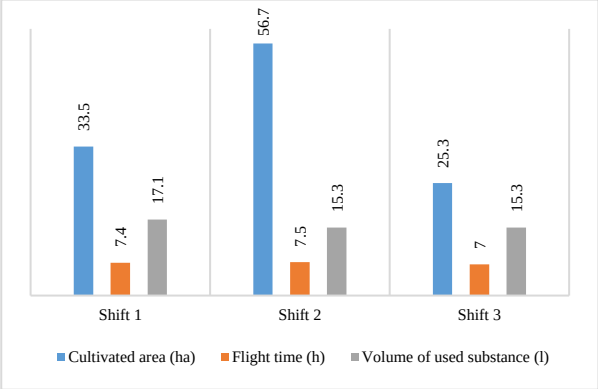

Fig. 4. Comparative analysis of the results of the Agras T30 multicopter and indicators that reflect the level of efficiency of agricultural land cultivation in the Poltava region

Source: Made by the authors based on the results of the DJI Agras T30 multicopter during the sowing campaign in the Poltava region.

On the example of one of the largest Ukrainian agricultural companies, "Ukrlandfarming" activities, a comparative analysis of the results of the Agras T30 multicopter and indicators reflecting the level of efficiency of agricultural land cultivation in the territory of Poltava region with the least ecological and economic losses during the period of 3 different work shifts was carried out.

From the analysis of the multicopter operation data for three work shifts, it follows that the most effective results of cultivation of the planned land area are observed for work shift 2. After all, with the application of 15.3 liters of spraying substance, more than 50 hectares of the cultivated area were processed in 7.5 hours. At the same time, the same amount of material was spent during the 3rd working shift, but 25.3 hectares of the plot were processed, which is more than 30 hectares less compared to the 3rd working shift and 8 hectares less than the 1st working shift.

All final indicators are affected by many factors, starting from the period of the day during which the multicopter flight was carried out, weather conditions, restrictions in the form of artificial or natural objects on the territory of the sown area. In the case considered in the article, the difference in indicators in the result of the drone was influenced by factors related to the different configuration and topography of the cultivated areas. In particular, the work shifts differed by the speeds that were programmed during the operation of the multicopter. After all, fields with hills, valleys and a noticeable difference in the height of plants force you to rely on the clear operation of the radar. In order for the multicopter to work as efficiently as possible, its speed was reduced, which minimized the risk of the copter falling or colliding with plants. On flat fields, you can work at a speed of up to 23 km/h. On fields with difficult terrain, the speed was no more than 10-12 km/h.

However, regardless of a number of factors, there is no need to attract additional material, technical and human resources to perform such types of work, thereby reducing the time and cost, which leads to an increase in the profitability of growing agricultural crops.

CONCLUSIONS

The advantages of using innovative technologies in agricultural land use, in particular, when performing work on the

application of nutrients and plant protection with the help of the Agras T30 multicopter, are:
reduction of harmful effects on plants and ground cover;
more efficient and economical use of protective equipment; plants per 1 ha of sown area;
more automated activities without the use of heavy machinery;
high quality of technological operations;
increasing the productivity indicators of cultivation of the sown area.
That's how the use of unmanned aerial vehicles allows to reduce the level of capital costs for technical means of processing. After all, a single multicopter is capable of replacing several ground vehicles at once. Accordingly, operating costs for fuel, water for working solutions, and logistics are reduced.
There is no need to attract additional material, technical and human resources to perform such types of work, thereby reducing the time and cost, which leads to an increase in the profitability of growing agricultural crops.
The formed and substantiated economic-mathematical model of the dynamics of the efficiency indicators of cultivation of the sown area for a certain period of time allows us to establish that the use of innovations, in particular the DJI Agras T30 multicopter, and technical and economic developments in the practice of agricultural enterprises increases the effectiveness of their activities during the sowing campaign.
It is worth to mention that in the future, with the help of intensive technologies of agricultural production, it is possible to increase the production of gross products, improve its quality, reduce resource consumption, which will contribute to increasing the efficiency and profitability of agricultural activity.

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