Efficiency of using drones in agricultural production

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Abstract. The article deals with the issue of economic efficiency of the use of drones in agricultural production. There is an opinion about their inefficiency, which is refuted by the study. The purpose of the study is to determine the effectiveness of the use of agricultural drones (using the example of U-30L-6 (BROUAV) in comparison with other technological options. The use of agricultural drones allows not only to reduce the cost of manufactured products, but also to increase crop yields by reducing losses during cultivation, as the number of passes of wheeled vehicles across the field during the growing season is reduced. Among the options considered (trailed sprayer, self-propelled sprayer, agrodrone), the use of copters took the second place in terms of production costs. But due to a decrease in the spraying rate and losses from trampling, the economic effect of using agricultural drones is the highest (3417.34 rubles/ha), which is more than twice as high as when using a self-propelled sprayer.

1 Introduction

The improvement of agricultural technologies is one of the factors in providing the growing population of the Earth with agricultural products [1-6]. Despite the widespread advertising of organic farming, traditional technologies still retain an important place in providing food for the population of all countries [7-9]. This is because the approach that tries to insert elements of organic farming into traditional technologies does not work. Therefore, the role of traditional farming is to be maintained for a long period [10].

At the same time, technologies and equipment used in agriculture are developing. New campaigns, technological options, equipment, plant protection products and fertilizers are emerging, based on the latest achievements of science and technology [11-13]. One of the new directions is the use of agricultural drones (Fig. 1).

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Fig. 1. Processing of crops with the U-30L-6 (BROUAV) agrodrone.

2 Materials and methods

The purpose of the study is to determine the effectiveness of the use of agricultural drones (using the example of U-30L-6 (BROUAV) in comparison with other technological options. As part of this, it is necessary to perform the following tasks: - determine the list of technological operations that can be performed using agricultural drones; - identify strong and weaknesses of agricultural drones as technological equipment; - calculate the costs of technological operations; - conduct a comparative analysis of the effectiveness of the use of agricultural drones and other options for technological equipment.

In the course of the study, monographic, abstract-logical methods, modeling, and the method of expert assessments were used.

3 Results

A few years ago, drones were used in agriculture on only 2% of all land in the country, in recent years this figure has been growing rapidly, thanks to the wide capabilities of the device [14-16]. Technological equipment and high accuracy of operations, allows the use of quadrocopters for an impressive list of jobs:

1. Sowing seeds.

This technology is only in its infancy and is currently used only for small-seed crops due to the low payload of drones [17-19].

2. Adding of the trichogramma.

Trichogramma are very small insects that parasitize other pests and thus help to fight them. Due to its size, it is ideal for drone spreading. One device is capable of applying Trichogramma to an area of up to 2,000 hectares per day. It is used mainly in the framework of organic farming technology.

3. Spraying the crop.

Spraying with the help of drones is effective on small fields, or when treating problematic foci in the fields. To identify problem areas, a preliminary flight of a drone with a camera installed is used. With continuous processing of large fields, it is effective to use drones in conjunction with several units at the same time. The productivity of processing fields with one device per day is up to 80 hectares. The drone can see weeds in the field up to the bush, even distinguish their types. Then data on their total number is entered into the database, and subsequently into the “brain” of the drone. The sprayer introduces chemicals pointwise. The consumption of expensive drugs, as well as fertilizers, is reduced by 25-35% [20-23].

4. Watering plantations in limited areas.

5. Delivery and spreading of fertilizers.

Drone fertilization is less popular than pesticides processing due to higher application rates. It is effective to use microfertilizers for drone application. At the same time, on large areas, it is necessary to conduct a preliminary analysis of the field to build maps of differentiated application. Since it is not advisable to use drones for continuous application. The productivity of fertilizer application by one drone is up to 50 hectares per day.

6. Fog generation.

In this case, a special system for generating fog is installed on the drone, which improves the quality of crop processing. However, due to the weight of the fog generation system, the work efficiency is reduced. The productivity of processing fields with one device per day when generating fog is up to 30 hectares [24, 25].

The main advantages of agricultural drones include:

Reduced time costs. Tests and practical use of drones have shown that due to the wide spray area, they can process 4-6 hectares in 20 minutes of flight.

Functionality. UAVs equipped with a capacious liquid tank and sprayer are able to transport pesticides or fertilizers to any point in the field and hard-to-reach places, and carry out their precise dosage and uniform spraying.

Financial savings. Reducing the cost of operating ground special equipment and fuels and lubricants.

Maneuverability. Agricultural drones are able to quickly respond to obstacles and go around them, so they can be used in fields with complex terrain and contours.

Wide possibilities. For efficient operation, drones have different route building modes and a variety of spray systems. In addition, agricultural drones can automatically record stop points, return to the starting point and continue spraying from the area where they previously completed work.

The ease of use of the drone, which anyone can handle with a little training.

The use of an unmanned complex allows, in the presence of the same equipment (tractors, seeders, combines), to increase the yield by up to 20% and reduce costs by up to 15% [26-30].

The increase in yield is formed due to the accuracy of processing, the absence of overlap during the processing of plant protection chemicals. In addition, according to scientific research, 3-6% of the entire sown area of the field perishes under the wheels of wheeled vehicles [31-34].

There are two possible approaches to determine the efficiency of the use of agricultural drones:

- when services are provided by a third party;
- when purchasing agricultural drones.

First option.

In the conditions of the Samara region, the prices for the provision of services with the help of agricultural drones depend on the area of processing.

Price of treatment (herbicides, etc.) with agrodrones:

- up to 100 ha - 900 rubles/ha;
- from 100 ha to 400 ha - 850 rubles/ha;
- from 400 ha to 800 - 750 rubles/ha;
- from 800 ha - 650 rubles/ha.

The price of applying granular fertilizers by agricultural drones:

- up to 100 ha - 1100 rubles/ha;
- from 100 ha to 400 ha - 950 rubles/ha;
- from 400 ha to 800 ha - 850 rubles/ha;
- from 800 ha - 700 rubles/ha.

The price of applying microfertilizers is the same as for the treatment of plant protection chemicals [35-38].

For example, with a winter wheat yield of 30 cwt/ha, up to 6% of the crop can be saved. At a price of 9,500 rubles/t (feed wheat), additional production will be 1.8 cwt/ha (1,710 rubles/ha).

When applying the cheapest fertilizer (ammonium nitrate - 20,000 rubles/t) as top dressing in the amount of 1 cwt/ha, it will save about 0.3 cwt/ha (600 rubles/ha) due to the precise application of fertilizers. When using more expensive types of fertilizers (diammofoska, ammophos), the savings increase by 2-3 times. The same applies to pesticide treatment [39-40].

Table 1. Calculation of savings in pesticide treatment.

Herbicide	Price, rub./unit	Application rate, units/ha	Consumption		Economic effect, rub./ha
			units/ha	rub./ha	
Banwell WS, l	2748.0	0.15-0.8	0.3	824.4	247.32
Gardo Gold SC, l	1386.0	3.0-4.5	4	5544	1663.2
Derby 175 SC, L	15684.0	0.05-0.07	0.07	1097.88	329.364
Logran WDG, kg	59142.0	0.0065-0.01	0.01	591.42	177.426
Peak WDG, kg	33540.0	0.015-0.025	0.025	838.5	251.55
Reglon Forte WS, l	2208.0	1.0-2.0	2	4416	1324.8
Aktara WDG, kg	23094.0	0.06-0.15	0.1	2309.4	692.82
Alto Super EC, l	3150.0	0.4-0.5	0.5	1575	472.5
Amistar Gold SC, l	5340.0	0.75-1.0	1	5340	1602
Horus WDG, l	16686.0	0.2-0.7	0.35	5840.1	1752.03

Table 2. Comparative analysis of the use of drones in the processing of crops (on the example of the drug AMISTAR gold SC).

Indicator	Meaning
The cost of processing 1 hectare with wheeled vehicles, rub. (excluding the cost of pesticides)	400
The cost of processing 1000 hectares with wheeled vehicles (excluding the cost of pesticides), thousand rub.	400
Pesticide cost per 1 ha, rub.	5340
The cost of a pesticide per 1000 ha, thousand rub.	5340
Total costs for the processing of 1000 hectares of crops with wheeled vehicles, thousand rub.	5740
The cost of services for the processing of 1 ha with an agrodrone (the volume is more than 800 ha), rub.	650
The cost of services for the processing of 1000 hectares with an agrodrone (the volume is more than 800 ha), thousand rub.	650
Pesticide cost per 1 ha (including 30% savings), rub.	3738
The cost of a pesticide per 1000 ha (including 30% savings), thousand rub.	3738
Total costs for processing 1000 ha of crops with an agrodrone, thousand rub.	4388
Benefit from the use of an agrodrone per 1000 ha, thousand rub.	1352

Second option. When acquiring agricultural drones for ownership, it is possible to determine the comparative effectiveness of various technological options for processing crops with plant protection products based on the calculation of technological maps.

Let us consider the comparative efficiency of using various technological options for treating crops with pesticides on the example of winter wheat (Table 3). The initial data for

calculations were determined using a program for calculating technological maps in crop production, developed at the Samara State Agrarian University [41-43].

Table 3. Comparative efficiency of the use of agricultural drones when spraying winter wheat crops with chemical plant protection products.

Indicator	KhTZ-16131+UG 3000 Special (basic version)	Tuman-2M	Agrodrone U-30L-6
Productivity of winter wheat, cwt/ha	26.32		
Reducing losses from trampling (3%), cwt/ha	-	-	0.8
Cost of additional production, rub./ha	-	-	899.52
Processing costs, rub./ha	1598.31	227.79	493.13
Pesticides savings, rub./ha	-	-	1412.64
Economic effect, rub./ha	-	1370.52	3417.34

Calculation of savings of pesticides when processing with U-30L-6 agrodrone is presented in Table 4.

Table 4. Calculation of savings in pesticide treatment.

Pesticide	Price, rub./unit	Consumption		Economic effect, rub./ha
		units/ha	rub./ha	
Herbicide Banvel WS, l	2748.0	0.3	824.4	247.32
Insecticide Aktara WDG, kg	23094.0	0.1	2309.4	692.82
Fungicide Alto Super EC, l	3150.0	0.5	1575	472.5
TOTAL				1412.64

Among the technological options considered, the most costly is the use of the KhTZ-16131 + UG 3000 Special tractor. This option is chosen as the base one. The cost of tank mix treatment will amount to 1598.31 rubles/ha. The option of using a sprayer based on Tuman-2M is the most attractive in terms of direct operating costs (227.79 rubles/ha) due to the high processing speed and large processing width. As a result, this option provides an economic effect equal to 1370.52 rubles/ha compared to using a tractor. The third option (agrodrone U-30L-6) is effective taking into account the synergistic effect - it loses to Tuman-2M in terms of the cost of processing crops, but saves the used plant protection products (1412.64 rubles/ha) and reduces crop losses from trampling (899 52 rubles/ha). As a result, the effect of the agrodrone in comparison with the use of a tractor will be 3417.34 rubles/ha.

4 Conclusion

The use of modern approaches allows us to improve agricultural technologies at a completely new technological level. Reduction of unit costs is the most important criterion when choosing new technological options. The use of agricultural drones allows not only to reduce the cost of manufactured products, but also to increase crop yields by reducing losses during cultivation, as the number of passes of wheeled vehicles across the field during the growing season is reduced. Among the options considered (trailed sprayer, self-propelled sprayer, agrodrone), the use of copters took the second place in terms of production costs. But due to a decrease in the spraying rate and losses from trampling, the

economic effect of using agricultural drones is the highest (3417.34 rubles/ha), which is more than twice as high as when using a self-propelled sprayer.

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