

# Comparative Experiment on the Use of Unmanned and Ground-Based Technologies of Fertilizer and Crop Protection Products on Winter Barley

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**Abstract.** The results of a comparative experiment of the use of an agricultural drone Agras T10 and ground agricultural machines (Amazone ZA-X Perfect fertilizer spreader, Amazone UF-901 sprayer) for the application of nitrogen fertilizers and plant protection products (herbicides, insecticides and fungicides treatment) are presented. Yield of experimental and control plots, economic efficiency of unmanned and ground technologies are determined. Calculation of economic efficiency of unmanned technology showed that its productivity is 4 times less. While using this technology with differentiated fertilizer application the winter barley yield increased by 3,6 % while the amount of fertilizer application decreased by 2 %. Consumption of fuel and lubricants decreased by 1.4 times, metal consumption by 26.7 times.

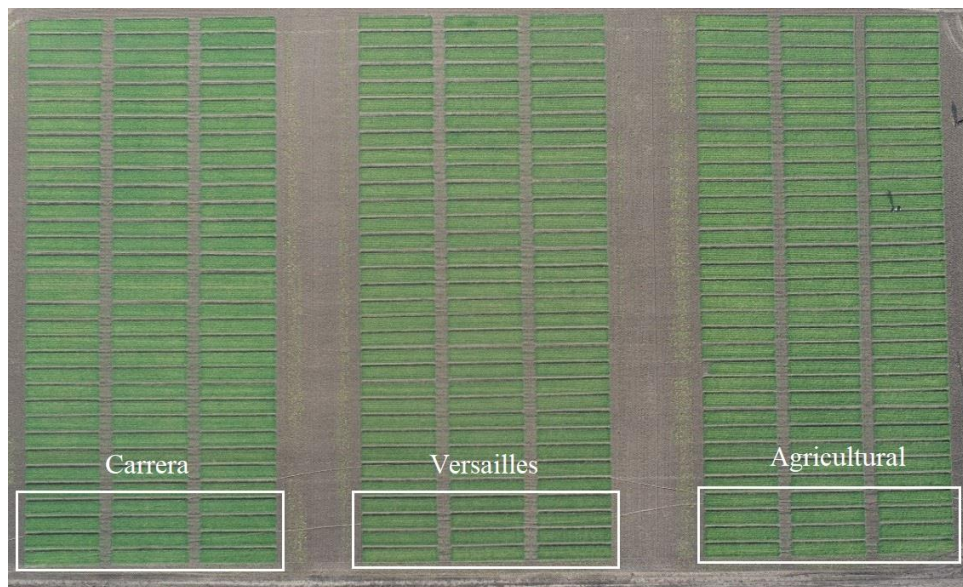
In recent years, many farms have begun to use drones and agricultural drones to monitor fields and cultivate crops [1, 2, 3, 4, 5].

The purpose of the conducted research was a comparative analysis of the use of unmanned and ground technologies of fertilizers and plant protection means (treatment with herbicides, insecticides and fungicides) in winter barley cultivation.

Each winter barley variety was sown in plots in triplicate with four variants (Figure 1). The size of each plot averaged 9×1.4 m. Three winter barley varieties participated in the experiment: Agricultural, Versailles, Carrera.

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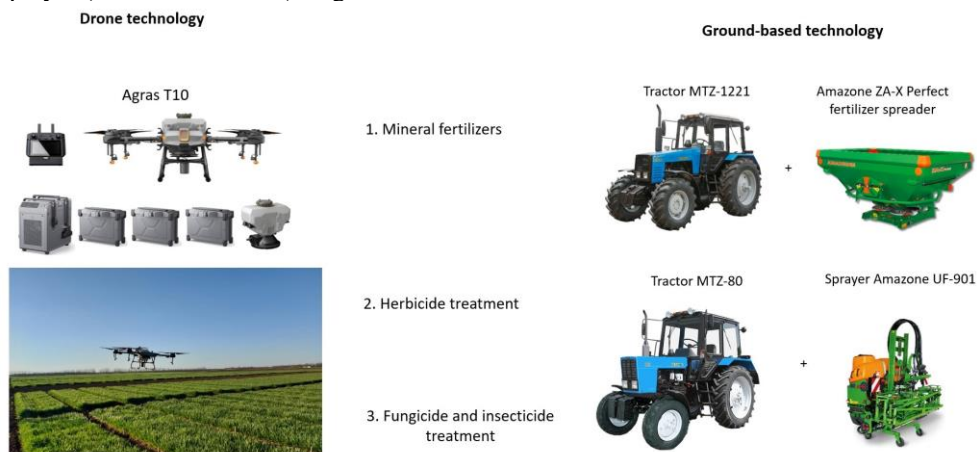
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**Fig. 1.** Winter barley varieties in the experimental field (Kurchenko N. Yu. orthophoto).

Experimental winter barley varieties were sown on 08.10.2021 by T-25 tractor with a Klen-S seeder. Before sowing, seed dressing was carried out by Winterstiger Hege 14 wet dressing machine. The precursor on the experimental field was winter rape, the seeding rate of which was 4.5 million seeds per hectare.

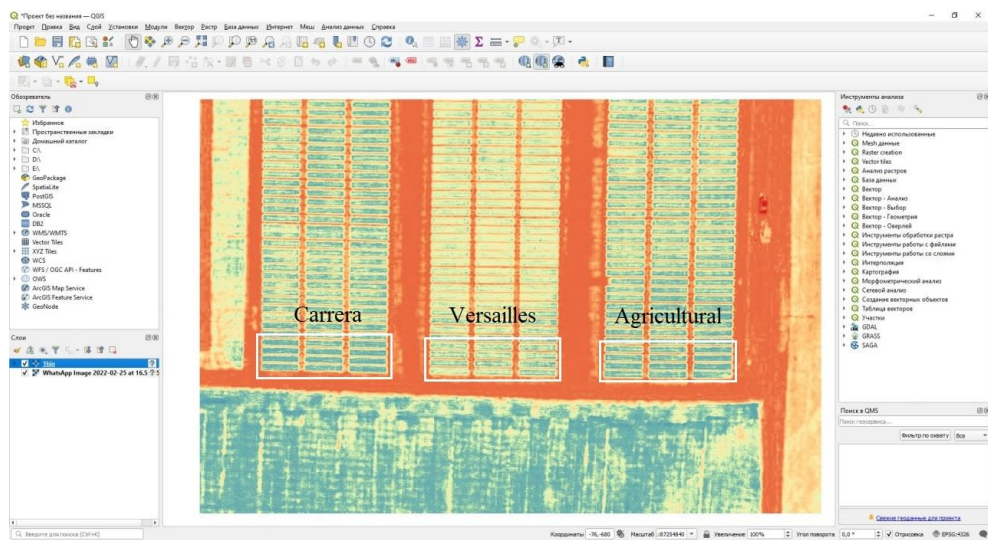
In the course of the experiment we compared an unmanned technology for the application of nitrogen fertilizers, crop protection products (unmanned aerial vehicle Agras T10) and a ground technology using a spreader (Amazone ZA-X Perfect) fertilizers and a sprayer (Amazone UF-901) - figure 2.



**Fig. 2.** Technical solutions in comparable unmanned and ground technologies.

Before feeding with ammonium nitrate, a Phantom 4 Pro drone overflight was carried out with obtaining an orthophotomap with further conversion into a vegetation index "Bioindex". The vegetation index "Bioindex" was obtained by processing the image

obtained from an unmanned aerial vehicle, which has three color channels (red, blue, green) - figure 3.



**Fig. 3.** Map of "Bioindex" of experimental plots (AIS data).

We divided the obtained plots with strong and weak plant development. Average dose of fertilizer was 100 kg/ha, then differentiation of fertilizer in different plots, depending on the state of crops by "Bioindex" was made.

Doses of ammonium nitrate were varied:

- Agricultural variety: 80 kg/ha; 100 kg/ha (control); 120 kg/ha;
- Versailles variety: 80 kg/ha; 93 kg/ha; 100 kg/ha (control); 107 kg/ha;
- Carrera variety: 80 kg/ha; 93 kg/ha; 100 kg/ha (control); 120 kg/ha.

Fertilizers on the studied plots were applied on 9.03.2022 by Agras T10 drone.

On March 9, 2022, MTZ-1221 tractor with Amazone ZX-A Perfect spreader applied 100 kg/ha of ammonium nitrate on barley production fields.

Then on 7.04.2022 we treated plots with herbicide also using Agras T10 unmanned aerial vehicle (Fig.5). Dosage of the solution was 7.5 l/ha (the drug Axial - 1 l/ha, Derby - 0.07 l/ha).

On production sowing 7.04.2022 was carried out processing MTZ-80 tractor with a field sprayer Amazone UF-901 herbicide dosage 200 l / ha.

Plots of winter barley were treated with fungicide and insecticide by drone on May 13, 2022 also by agricultural drone Agras T10 (fungicide + insecticide: Elatus Ria 0.5 l/ha + Eforia 0.2 l/ha).



**Fig. 4.** Treatment of winter barley plots.

Treatment area of the experimental plot was 468 m<sup>2</sup>. The control plots were treated on 7.04.2022 with MTZ-80 tractor with Amazone UF-901 field sprayer with 200 l/ha herbicide dosage.

Harvesting was carried out on 21.06.2022 with the TERRION 2010 combine.

At the average dose of application of 100 kg/ha the yield was: variety Agricultural - 11.4 t/ha; variety Versailles - 11.0 t/ha; variety Carrera - 11.7 t/ha.

The average yield depending on the dose of fertilizer application by varieties was (Figure 5):

- Agricultural variety: 80 kg/ha ammonium nitrate application dose (yield 11.5 t/ha); 100 kg/ha (11.4 t/ha); 120 kg/ha (11.3 t/ha);

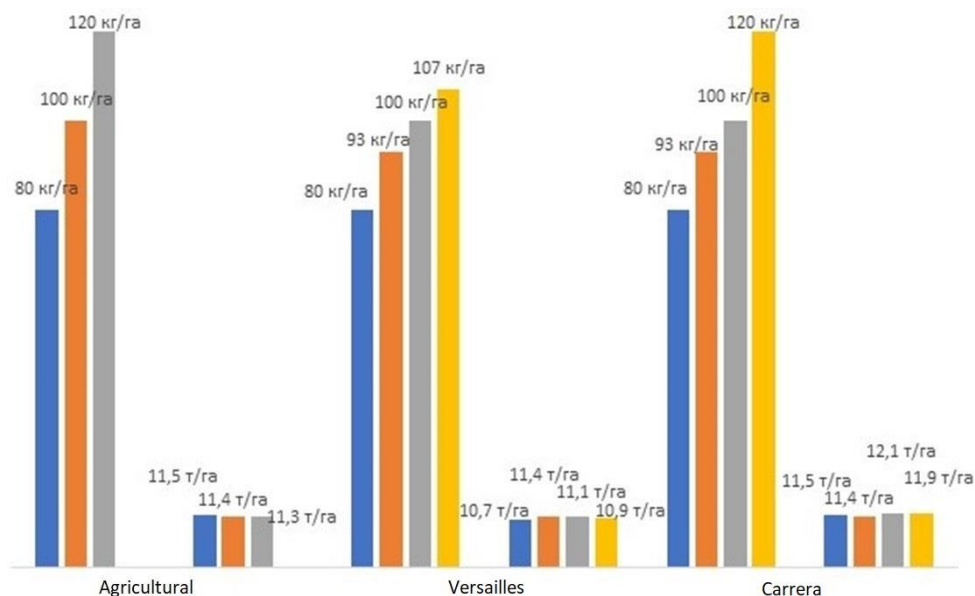
- Versailles variety: 80 kg/ha (10.7 t/ha); 93 kg/ha (11.4 t/ha); 100 kg/ha (11.1 t/ha); 107 kg/ha (10.9 t/ha)

- Carrera variety: 80 kg/ha (11.5 t/ha); 93 kg/ha (11.4 t/ha); 100 kg/ha (12.1 t/ha); 120 kg/ha (11.9 t/ha).

For the variety Agricultural, the difference between the maximum and minimum values in the dose of application was 50%, and in the yield no more than 2%, so a change in the dose of application had no effect on the yield.

For the variety Versailles, the difference between the maximum and minimum values in application rate was 34 % and in yield 6.5 %.

For the variety Carrera, the difference between the maximum and minimum values in the application rate was 50 % and the yield 6.1 %.



**Fig. 5.** Treatment of winter barley plots.

Let us compare the yield obtained by the compared technologies (unmanned and ground-based). Yield increase using drone technology averaged 3.6 %; in the variety Versailles - 8.9 %, Carrera - 6.4 %. In the variety Agricultural reduced by 1.8 %.

When calculating the cost-effectiveness of the existing version of the ground technology to apply fertilizers and crop protection products for the proposed option - unmanned technology.

As a result of the research the unmanned technology of materials application during winter barley cultivation was tested with the obtained data on the yield at each plot and the cost of materials.

The calculation of economic efficiency of the unmanned technology showed that its productivity is 4 times less. While using this technology with differentiated fertilizer application the winter barley yield increased by 3,6 % while the amount of fertilizer application decreased by 2 %.

Consumption of fuel and lubricants decreased by 1,4 times, metal consumption - by 26,7 times. Additional capital investments when using ground technology is 4771 thousand rubles.

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