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Research Article

Agriengineering Applications of Unmanned Aircraft Technologies for Remote Biostimulation of Grain Crops by Electromagnetic Pulses

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Abstract

The spreading of robotic unmanned aerial vehicle (UAV) technologies into agricultural bioengineering practice is promising for the industry development. The remote electromagnetic field (EMF) treatment by airborne "TOR" device mounted on the fixed-wing UAV had shown potentiality to biostimulate crops up to 14,000 hectares a day, which compares favorably with the similar device ground treatment productivity up to 300-500 hectares ceteris paribus.

To study EMF treatment effects generated by airborne "TOR" device for remote biostimulation of grain crops.

The seeds and sprouts of winter wheat of the Socrates variety (JSC "Shchelkovo Agrokhim") were selected for this study.

A EMF treatment device "TOR" was mounted on a robotic fixed-wing UAV "Os'-25" manufactured by "Concern GRANIT", JSC. "TOR" device generates weak non-ionized non-thermal wideband spectra EMFs with a pulse frequency in the range of 50-150 Hertz.

Experiments were carried out with dry seeds and seeds sown into the pots with soil. The dry seeds and crops in pots were exposed to "TOR" EMFs at UAV different flight altitudes. Control samples were not treated.

When dry seeds and pots with sown seeds located on the ground were exposed to an electromagnetic field from a UAV, metabolic processes were activated and cellular respiration increased. This was subsequently confirmed by gas chromatography in laboratory conditions. The EMF treatment from minimum altitude showed the most pronounced effect, presumably due to less signal scattering. As a result of wheat sprouts exposure to the "TOR" device EMFs, the average weight of the sprouts increased by approximately 30% compared to the control group.

The proven UAV based bioactivation EMF technology an increase the germination and development of agricultural crops.

Keywords: Robotic; UAV; EMF; Unmanned Technologies; Biostimulation; Electromagnetic Pulses; Agriengineering, Gas Chromatographys

Introduction

To ensure food security, to ehance agricultural production and efficient farming, various methods of increasing yields are currently in demand [1-3]. The technologies recently in use have a number of disadvantages: environmental stress, high costs, limited plant resistance to stress and pathogenic loads, depleted resources, and inability to apply them in diverse climatic conditions.

Magnetic and electric fields (hereinafter referred as EMFs) are safe physical factors that are tested and applied in real agricultural production. An increase in crop yields and product quality is achieved through a more complete implementation of the genetic and physiological potential of plants after EMF treatments at optimal expositions. When testing the EMF effects of the "TOR" device, it was shown that treatment with weak non-ionizing non-thermal EMFs increased the yield of various crops. Thus, treating potato tubers of several potato varieties with the "TOR" device before planting increased their yield by 20% [4], and grain crops by 40% was [5]. The effect of the "TOR" device EMFs on the quality of agricultural soils and seeds was demonstrated by gas chromatography methods [6]. In addition to mentioned methods like the remote pre-sowing treatment of dry seeds (tubers) and field treatment after sowing, another promising method was tested: EMF distant treatment with "TOR" device mounted on a robotic UAV. This area is promising because unmanned technologies in agriengineering allow to process agricultural lands, monitor crops, and have great technical advantages over traditional methods of agricultural practice [7].

In this paper, we evaluated the biostimulation method of spring wheat seeds by airborne "TOR" device combined with a UAV. Unlike ground-based treatment, the UAVs operation will allow for more uniform bioactivation of large agricultural lands.

Materials and Methods

The material for the study was dry seeds of winter wheat (Socrates variety, selected by "Shchelkovo Agrochim", JSC) and the seeds, sown in pots. The "TOR" device manufactured by "Concern GRANIT", JSC, was employed and mounted on the robotic UAV model "Os'-25" manufactured by the same vendor equipped with high-precision navigation system [Figure 1].

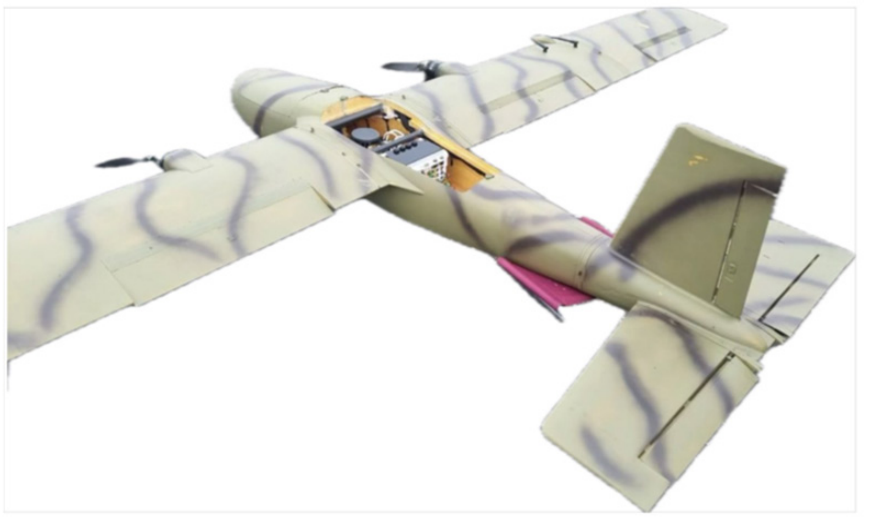

Figure 1: UAV model "Os'-25"equipped with the airborne "TOR" device.

The flight speed of the UAV is no more than 80 km/h, the commercial load is 5 kg, the takeoff weight in complete configuration is up to 28 kg, the flight duration without recharging is up to four hours.

The frequency of the EMF pulses of the "TOR device" was in the range of 50-150 Hz. The medical version of the device is registered with Roszdravnadzor of the Ministry of Health of the Russian Federation [8,9]. The total EMF exposure was 10 minutes above the experiment objects (dry seeds and pots with as-sown seeds). The overall exposure time is calculated as a number of UAV flights over the object multiplied on the time of "cone coating" crossing the object [see Figure 2]. The experiments were performed in March and April 2025, each test consisted of flights at two altitude levels.

Experiment 1 – dry seeds treated with EMFs of the "TOR" device mounted on the UAV from altitudes of 300 and 600 m; control seeds – no treatment.

Experiment 2 – seeds sown into pots with soil, treated with the EMFs of the "TOR" device mounted on the UAV from altitudes of 200 and 350 m; control pots with sawn seeds – no treatment.

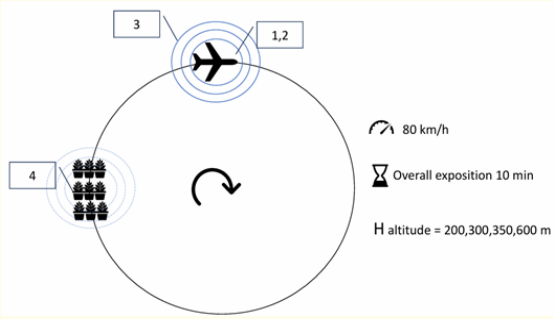

Figure 2: Treatment scheme: 1 – UAV, 2 – "TOR" device, 3 – "cone coating" with EMFs generated by the "TOR" device on ground, 4 – dry seeds and seeds sown in pots.

The experiment was repeated seven times with 50 seeds in each. The UAV flight trajectory scheme is shown in Figure 2.

Experiment 1. Chromatographic analysis of the content of H_2, CO_2, NH_2, O_2 gas emissions in control and experimental seeds was carried out on a TSVET-800 chromatograph by the 1st, 2nd, 6th, 8th and 15th days according procedure [7]. The relative change in the volume of gas released over a time period after the seeds metabolism start by adding water to the samples was calculated by the formula: (n-k)/k, where n is the volume of gas released, k is the volume of gas released in the control.

Experiment 2. Evaluation of sowing qualities (germination) and the gross weight of winter wheat seedlings of experimental and control samples.

Results and Discussion

Experiment 1. The release of H_2, CO_2, NH_2, O_2 gases in the samples after EMF treatment was greater than in the samples of the control group [Figure 3].

It shown in [Figure 3] that EMF treated seeds from the 300m altitude had a greater effect on seed metabolism than the treatment form 600m altitude.

The release of these gases by plant cells indicated qualitative morphological changes in the experimental sample. The increased carbon dioxide (CO_2) release indicated the greater activity of metabolic processes such as photosynthesis and cellular respiration. The increased release of hydrogen and ammonia (H_2, NH_3) indicat-

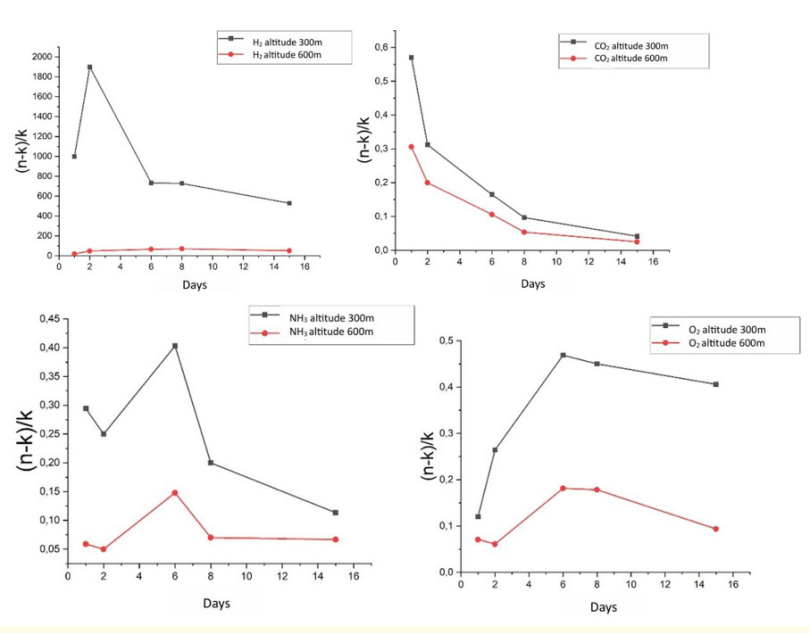

Figure 3: Dynamics in the content of H_2, CO_2, NH_2, O_2 in samples with EMF treated seeds over time relative to the gas content of in control samples (without EMF treatment).

ed a stressful state of the germinating seeds, as well as a metabolism acceleration in their cells. When exposed to EMFs, the breakdown of amino acids can be accelerated (during eustress), which temporarily increased the release of NH_3. In a healthy plant, EMF can stimulate nitrogen absorption, reducing NH_3 loss.

Thus, in seeds and sowings, after exposure to "TOR" device EMFs from altitudes of 300 and 600m, metabolic processes were activated and cellular respiration was enhanced. Increased release of gases: hydrogen, ammonia can be interpreted as a stress reaction of plants to the EMF effects. It was also observed that over time, the amount of emitted gases decreased and approached the control values.

Experiment 2. The differences between the control and experimental samples treated from different altitudes were revealed. The sowing qualities and the morphometric parameters of the studied seeds after EMF treatment changed especially noticeably [Figure 4].

The photo in Figure 4 shows EMF treated samples having a more developed root system than the control one, and a number of experimental sproutings increased by almost 10% for both altitude options [Figure 5] *vs* control.

(Figure 6)

Figure 4: Winter wheat seedlings: the control group; experimental groups treated from altitudes of 200m and 350m.

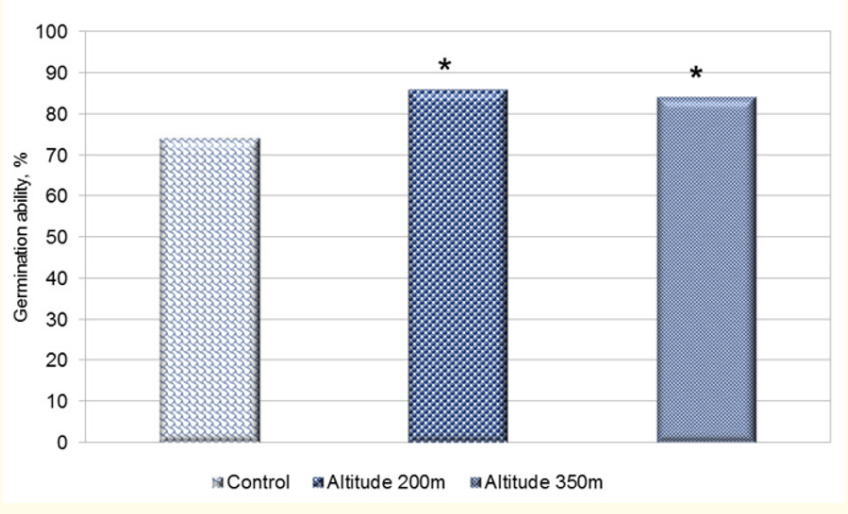

Figure 5: Germination of winter wheat seeds of the control group and two experimental ones EMF treated from altitudes 200m and 350m, respectively; * - $p < 0.05$ - compared to the control.

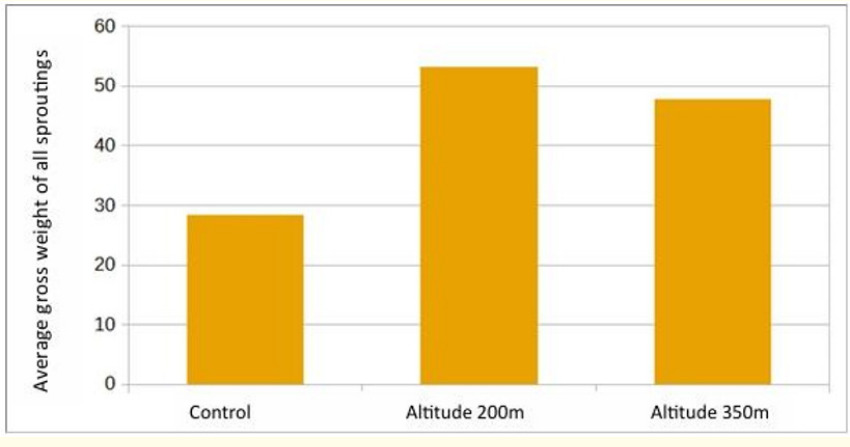

Figure 6: Gross weight of 15th-day winter wheat sproutings of all groups; * - $p < 0.05$ - compared to the control.

The average gross weight of wheat sproutings from both experimental groups increased by 30% relative to the control [Figure 6]. The EMF treatment from a UAV flight altitude of 200m provided a more pronounced effect, probably, due to the less signal scattering. At the 350m altitude, the effect was weaker, but it also had shown the statistical significance.

Conclusion

The research demonstrated high efficiency of the EMF cereal crops treatment by "TOR" device [10] from the UAV as in the investigation [10], where cereals had been remote EMF treated terrestrially. The results of observations were confirmed by measuring the wheat seeds metabolism products by the gas chromatography method. The research demonstrated the potential of "TOR" device mounted on the UAV, for remote crops bioactivation. The direct gas chromatography method revealed the greater gas release (H_2, CO_2, NH_3, O_2) in the samples with EMF treated seeds *vs* the control.

The EMF treatment positive effect on the seed germination rate, as well as on the sproutings gross weight, was also confirmed and allowed plants to form a more developed root system. The results obtained require more in-depth studies, but the positive EMF distant bioactivation of plants with UAVs is obvious.

Bibliography

1. Tilman D., *et al*. "Agricultural sustainability and intensive production practices". *Nature* 418.6898 (2002): 671-677.

2. Foley JA., *et al*. "Solutions for a cultivated planet". *Nature* 478.7369 (2011): 337-342.

3. Cassman KG. "Ecological intensification of cereal production systems: Yield potential, soil quality, and precision agriculture". *Proceedings of the National Academy of Sciences* 96.11 (1999): 5952-5959.

4. Elena V Bondarchuk., *et al*. "Weak pulsed electromagnetic fields enhance potato yield and immunity". *Potato and Vegetables* 4 (2023): 35-40.

5. Igor F Turkanov., *et al*. "The effect of remote treatment with weak non-thermal pulsed electromagnetic fields on the growth and yield of grain crops". Proc. Orenburg State Agrarian University 110.6 (2024): 158-164.

6. Svetlana Yu Khashirova., *et al*. "Gas chromatographic analysis of agricultural soils and seeds treated with weak non-ionizing non-thermal electromagnetic fields (EMFs)". Proc. Komi Science Centre 77.1 (2025): 120-126.

7. Chunhua Zhang John M Kovacs. "The application of small unmanned aerial systems for precision agriculture: a review". *Precision Agriculture* 13.6 (2012): 693-712.

8. Oleg V Fatenkov., *et al*. "Efficacy of a Pulsed Electromagnetic Field in Accelerating COVID-19 Clearance: Phase II Clinical Trial Results". *Acta Scientific Medical Sciences* 9.7 (2025): 123-131.

9. "Device for suppressing the vital activity of pathogenic microorganisms and viruses by electromagnetic radiation". Patent RU2765973 by 07 Feb. 2022. Patent India 557514 by 07 Jan.2025.

10. Igor F Turkanov., *et al*. "Effects of Remote Barley Seed Treatment with Weak Non-Thermal Pulsed Electromagnetic Fields on Plant Development and Yields". *Seeds* 4.35 (2025): 1-18.