MODERN AGRICULTURE

Bogusława BERNER, M.Sc. Eng.

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Koszalin University of Technology, Faculty of Mechanical Engineering,
Department of Mechanics, Automation and Construction
ul. Racławicka 15-17
75-620 Koszalin
e-mail: boguslawa.berner@tu.koszalin.pl

Bogusława Berner **ORCID: 0000-0003-2103-0535** **Researcher ID: Y-4607-2018**

FERTILIZATION AND SOWING FROM UNMANNED AERIAL VEHICLES

NAWOŻENIE I SIEW Z BEZZAŁOGOWYCH STATKÓW POWIETRZNYCH

***Summary**: In the paper, the modern technologies, utilizing unmanned aerial vehicles, drones, in sowing the seeds and distribution of fertilizers on the fields, have been described. Their construction, the examples of the application and the operating parameters have been presented. In the article, there have been also given the examples of the laboratory tests of the effect of the air stream, produced by rotor of drone – multicopter on the surface distribution of the sown seeds.*

***Keywords**: unmanned aerial vehicle, drone, precision agriculture, agricultural aviation, sowing*

***Streszczenie**: W artykule opisano nowoczesne technologie wykorzystujące bezzałogowe statki powietrzne, drony – do siewu nasion i rozsiewania nawozów na polach. Opisano ich budowę, przykłady zastosowania, podano parametry operacyjne. W pracy przedstawiono również wyniki badań laboratoryjnych nad wpływem strumienia powietrza wytwarzanego przez wirniki drona – multikoptera na rozłożenie na powierzchni rozsiewanych nasion.*

***Słowa kluczowe**: bezzałogowy statek powietrzny, dron, rolnictwo precyzyjne, agrolotnictwo, siew*

Introduction

The unmanned aerial vehicles, drones are used in agriculture, first of all, in spraying the plants, monitoring the cultivations and soil analysis. They may be also utilized in spreading of mineral fertilizers and sowing of the seeds. The advantage of the drone application in agriculture consists in the possibility of performing the operation in the specified parts of the field on the small surfaces of crops in a short time. Sowing of the plants with the application of drones may be applied in the organic (ecological) farming as well as in the traditional agriculture. Multi-rotary drones are the most popular constructions of drones which may be adapted to the performance of various types of work in agriculture. Their advantage includes the possibility of drone to stay in the air motionless or to move in any direction with the speed independent on the height level and load of the performed work. Together with the development of the precision agriculture, drones have become more and more popular, especially as the devices which supply information on the state of cultivated crops owing to the flights with the assembled hiperspectral high-resolution cameras. The drones with cameras are also helpful in the development of maps [1]; they supply information on the condition of the field and the demand of the plants on nutrients [2; 3]. The additional advantage of the drones consists in the possibility of moving over the fields without compaction of the soil, damage of the plants and without the necessity to use the tramline systems. In most of cases the drones are driven by electric batteries which do not cause the contamination of the environment and contamination of the plants and soil with the exhaust fumes which are produced during the traditional work with the use of agricultural tractors.

Sowing from drones

During the use of grasslands, a part of grasses is lost; thus, on the pastures, there are created the empty places, deprived of plants, which are exposed to the intensive development of weeds and not much valuable grass species. In consequence, the productivity of the grassland is decreased. It refers most frequently to the irregular, small areas of land, occurring in

different parts of the field, being difficult for repeated sowing of the plants on their area. The sowing of the plants, using the drill, suspended under the drone may be a solution for the discussed problem. The producers offer already the constructions of drones, destined for sowing the seeds [4]. The seed drill is used for aero-sowing of the seeds.

The Canadian company CFR – Innovations produces the small UGS-1 drills which were so designed as to be easily installed on the drone and not exert any destructive effect on the stability of the drone's flight (Fig. 1). For seed broadcasting from the drone, the seed drill with the rotating set of pipes was used; it may give an irregular distribution of the seeds in the field. As flying platforms for the drill, the hexacopter DJI S- 900 as well as octocopter DJI S-1000 are usually employed. The eight-rotor construction of DJI S- 1000 ensures better safety of flight. In the case of failure of a single rotor, or even two of them, the problems do not cause a threat to the stability of the drone's flight. The discussed machine has folded arms owing to which its transport is easy. It is equipped with electronic chassis which is hidden during the start. It is made from the best available materials, plates and pipes from carbon fibre 3 K, aluminium parts which are anodized and also, thick and light plates made from carbon fibre at the base of each engine.

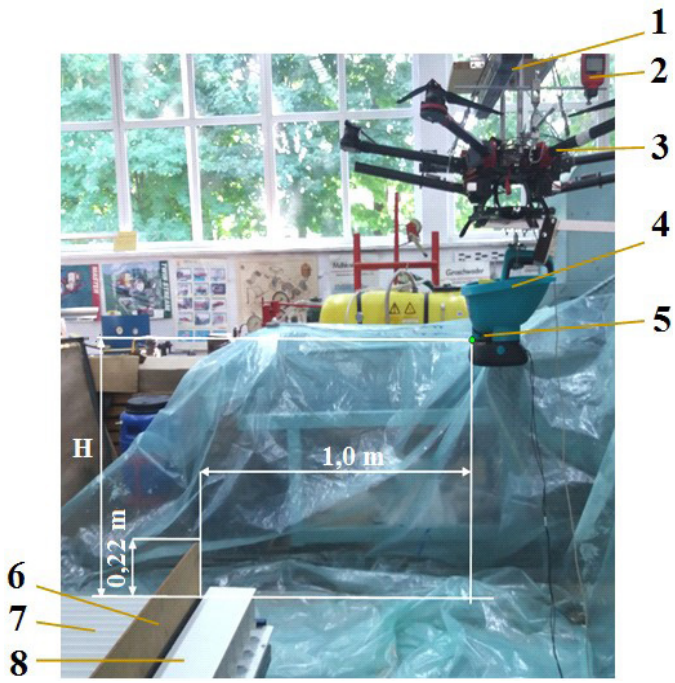
Fig. 1. DJI drone with the connected drill USG-1 during sowing [9]

IThe combination of electric manual seed distributor Scotts and rotary drone, as presented in Fig. 2 may be another example of drone spreader.

There are also developed non-professional constructions of the units, consisting in connecting the manual seed spreaders with the drones. The example of such device may be seen in the combination of electric-battery operated disc seed drill Greenmil and drone DJI 900 [5]. The seed drill, possessing the container of 2.7 dm^3 capacity was attached to the drone, equipped with the propellers with dimensions 15 x 5.2 inches (inch = 2.54 cm). The total weight of the drone with the seed drill amounted to 10.6 kg. There were performed studies on the influence of the air stream, generated by the drone rotors and necessary for generation of the thrust, enabling keeping the drone at the height over the surface of a field, on the transverse distribution of the seeds, falling on the groove patternator under the drone (Fig. 3).

Fig. 2. DJI Matrice 600 UAV with the connected manual electric seed drill Scotts [8]

Fig. 3. The research stand:1 – the holder, attaching the drone to the trolley, 2- tachometer, 3 – drone, 4 – seed spreader, 5 – spreading disc, 6 – vertical cover, 7 – groove patternator , 8 – horizontal cover [5]



The drone was moving on two heights: 1.0 m and 0.5 m over the groove patternator. The studies were conducted on the principle of comparing the transverse distribution of seeds, being spread from the seed drill at the operating rotors of the drone – with the air blow, and without the work of the drone's rotors – without the air blow. It was found that during the spreading of the seeds with the application of electric seed drill, installed under the drone, the air stream generated by the drone's rotors, necessary for maintaining the drone at the height of 0.5 m and 1.0 m over the groove patternator, had a significant influence on the transverse distribution of the falling rye seeds. The air blow changed the flight path of the seeds, spread with the use of rotating disc, and abbreviated their way of flight. It was also found that the velocity of the air deriving from the drone's rotors could blow and move the seeds which felt on the plane [6].

Drones are the remotely controlled devices, employing radio signal used by man with the aid of the broadcasting station. The flight of the drone may also occur on the earlier planned

Fig. 4. A map of the field generated with the application of Mission Planner software [9]

route, automatically, with the set course of auto-pilot and GPS coordinates. The flight will be fully automatic when the flight controller Pixhawk is employed. The drone may be guided by the enclosed controller during manually operated flight or using laptop or tablet with the application of free software Mission Planner during autonomic flight. Pixhawk has a function of safe ensuring of the drone and its automatic come back home in the cases when the device loses a signal or when the charge of batteries drops down. Owing to the system of the flight controller, the operator may program earlier the points and plan of the drone's flight (Fig. 4). In the future, the autonomic flight of the drone according to the route, programmed on the grounds of digital map of the field and planning the performance of sowing operations in the fixed points will be helpful in generation of seed drill robots [4].

Multifunctional flying platforms

German producer of spreaders for mineral fertilizers, Rauch company, offers the equipment for spreading a granulated mineral fertilizer and small seeds. The spreader for fertilizers is attached to the platform with the propellers and electric engines, being found on eight arms [10]. The total weight of the equipment together with the spreader is 80 kg. The weight of the load being present in the reservoir of the spreader is equal to ca. 30 kg (Fig. 5).

The discussed drone may work with the speed of 40 km/h. It may reach the places, situated at various height levels and perform the treatment over the territories with a variable inclination of the field surface.

The sets, offered by Zhuhai Yuren Agricultural Aviation are the example of construction of the set, designed for the needs of crop fertilization and sowing the seeds for agriculture. The

Fig. 5. Drone Agronator by Rauch: 1 – frame. 2 – reservoir, 3 – granulated fertilizer spreading disc [10]

mentioned company suggests two basic models of drones: Grain flyer 3 WDM8-20 and Flyer 3 WDM 4-10 [11]. Grain Flyer 3 WDM 8-20 is a rotor-based device which, together with the additional replaceable equipment (to be installed on it) is destined for performing different operations of the field. The discussed set is shown in Fig. 6. The platform is constituted by four-arm octocopter with double rotors on each arm. The carrying platform is equipped with the control system and batteries, ensuring power supply for the drone itself as well as for the equipment installed on the drone. Owing to the possibility of exchanging the equipment, the discussed set may be employed in operation of fertilizing with the granulated fertilizer, spreading the seeds, spraying the plants with the plant protection agents against the pests and application of liquid fertilizers as well as dissipation of powders. During the mentioned treatment, the drone control system enables control of the flight velocity and the rate of the employed liquid. The company offers also drone Grain Flyer 3 WDM 4-10 which is a considerably smaller unit. It was designed for the treatment on the small and medium fields.

The company Beijing TTA Aviation from China produces also the drones with the devices for distribution of granulated fertilizers and for sowing which cooperate with the drone (Fig.7). The same platform is destined for the following treatments: spraying of the crops, application of liquid fertilizers to the plants, sowing and spreading of granulated fertilizers. The reservoir of the drone has a big inlet which facilitates loading of the seed or fertilizer. Owing to it, we may avoid spilling of the sowing material during loading and also, its time is abbreviated. The internal waterproof constriction makes that cleaning of the reservoir is very easy. It is enough to pour water inside the reservoir in order to clean it. Owing to the possibility of a quick disassembly of the reservoir, serving for seed sowing and spreading of the fertilizers and being suspended on the drone, it is possible change its application as quickly as during 10 minutes. The parameters of the reservoir are as follows; the weight of the platform – 5 kg according to the data of the company; the total loading capacity – 20 kg, the dimensions of the reservoir: the length – 500 mm, the width – 500 mm and the height – 750 mm.

Drone by TTA is easy in service and is characterized by a stable and reliable operation. The construction of the spreading disc of the reservoir has been developed in such a way that the granulated is evenly distributed during its spreading. The width of spreading the fertilizers may be regulated by the choice of the rotary speed of the disc and the height of the drone's flight (Tab.1). The width of sowing the seeds is dependent of the height of the air raid. Together with the increase in the width of spreading, the yield of the equipment, as calculated per one flight, is increasing. It is connected with the amount of electric energy, accumulated in the battery. After filling the reservoir for each successive flight, it is also necessary to exchange the battery in the drone.

Fig. 6. Grain Flyer 3 WDM 8 -20 with the exchangeable adapters: 1 – drone, 2 – reservoir for spraying the liquid substances, 3 – reservoir for spreading, 4 – reservoir for powders' dissipation [11]

Fig. 7. Drone of TTA company, serving for spraying, and for sowing and spreading of fertilizers: 1 – drone serving for spraying, 2 – device for sowing and spreading of fertilizers, 3 – drone for sowing and spreading of fertilizers [12]

Tab. 1. The parameters of the work of TTA drone, serving for spraying, sowing and spreading of fertilizers [12].

Type of treatment	Size of granulate (mm)	Rotary speed	Height level of flight over the crops (m)	Width of performing the treatment (m)	Yield (ha/flight)	Time of flight (min/flight)
Sowing	**≤8**	High	1.0	10.0	1.00	6.0
		High	2.0	14.0	1.33	6.0
		High	3.0	18.0	2.00	6,0
Fertilization	**≤8**	Low	1.0	12.0	0.67	10.0
		Medium	1.0	17.0	0.87	8.0
		High	1.0	22.0	1.00	6.0
		Low	2.0	16.0	0.80	10.0
		Medium	2.0	20.0	1.00	8.0
		High	2.0	30.0	1.20	6.0
		Low	3.0	24.0	1.00	10.0
		Medium	3.0	28.0	1.33	8.0
		High	3.0	36.0	1.67	6.0

Summing up

When comparing the sowing of the seeds and spreading the fertilizers by the traditional method and that one with the use of drones, we may recognize that the main advantage of using the drone consists in the fact that the drone, flying over the crops, does not damage them, the soil is not packaged and the fertilizer is well distributed. The treatment of spreading may be performed over the growing plants during 10 minutes at the territory of 1.5 ha. Sowing and spreading of the fertilizers carried out by the traditional method is connected with the physical work of a farmer in the field. During the discussed operation, the plants may be easily damaged by heavy machines and the soil is packed what is unfavourable phenomenon. The discussed treatment being performed by ground machines is connected with high costs of work. Sowing and spreading of fertilizers, carried out with the use of drones in connected with a quick automatic spreading and easy operation of the equipment.

The advantage of the combination of drone and seeding machine (seed drill) includes also the fact that sowing may be performed in hard-to-reach places. The examples are the rice plots in China, situated at different land levels – the so-called terrace cultivations. Many pastures in Europe are also situated on the hills and on the uneven territory (in relation to the level) [7]. The drones enable the farmers to distribute the seeds quickly and effectively not only on the hills but also on the wet territories (wetland) and in other place where there is no possibility to reach by machines.

In the case of degraded pastures (places with a loss of plants), the drones facilitate a quick performance of sowing and fertilizing the discussed areas. They allow distributing the seeds quicker than by the application of ground seed drills on small areas situated in different places of the pastures. The drones used for sowing may distribute the seeds up to 40 times quicker than in the case of the application of manual spreaders.

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