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THE INFLUENCE OF AIR STREAM GENERATED BY DRONE ROTORS ON TRANSVERSE DISTRIBUTION PATTERN OF SOWN SEEDS

Summary

The paper presents the results of research on the influence of the air stream produced by produced by the drone on the transverse distribution pattern of the rye seeds. The seeds were spread by a small electric seeder with capacity of 2.7 dm^3 with a spreading disc. The distribution of seeds on a groove patternator was analyzed. The height of the sowing disc position above the patternator surface was 0.5 and 1.0 meter. The influence of the air stream from the drone rotors on the change of transverse distribution pattern of the seeds falling into the table grooves was confirmed.
***Key words**: drone, seeding, rye*

WPŁYW STRUMIENIA POWIETRZA WYTWARZANEGO PRZEZ WIRNIKI DRONA NA ROZKŁAD POPRZECZNY WYSIANYCH NASION

Streszczenie

Przedstawiono wyniki badań wpływu strumienia powietrza wytwarzanego przez drona na rozkład poprzeczny wagi nasion żyta osiadających pod dronem. Nasiona wysiewane były za pomocą małego elektrycznego siewnika z tarczą rozsiewającą o pojemności zbiornika 2,7 dm^3. Analizowano rozkład nasion na stole rowkowym. Wysokość umieszczenia tarczy siewnika nad powierzchnią stołu wynosiła 0,5 i 1,0 m. Stwierdzono wpływ strumienia powietrza pochodzącego od wirników drona na zmianę rozkładu masy nasion opadłej w rowki stołu.
***Słowa kluczowe**: dron, siew nasion, żyto*

1. Introduction

Drone seeding can be used both in organic as well as in conventional agriculture, but the unquestionable advantage of unmanned aerial vehicles (UAV), authorizing them for use in organic farming, is the lack of soil compaction/trampling when using them in field work. In most cases, they are powered by electric batteries, thus not causing environment pollution and contamination of plants and soil with exhaust gases, especially dioxins arising during the combustion of diesel oils in farm tractor engines.

Empty spots in the field, most often in winter crops caused mainly by weather conditions during plants wintering, are the problem of farmers. Then there are plant-free, non-productive sites that are exposed to the intensive development of weeds. These are usually irregular small surfaces of the soil, "scattered" in various parts of the field, difficult to reach for repeated sowing. Sowing the seeds with a drone seeder can be the solution to this problem. Manufacturers already propose drones for sowing seeds [1]. An example is a manual electric spreader Scotts coupled with a drone DJI [4]. The CFR company also produces small spreaders of granulated UGS-1 fertilizers, which are also suitable for seed spreading [5]. The load capacity of the device does not exceed 3 kg of the seeding material. It is equipped with a rotary spreader that allows spreading the granulate to a width of 12-23 meters. The device is equipped with a system adjusting the dose of seeds and fertilizer granules. Switching on and off the spreader is remotely controlled by the drone operator.

The advantage of drone - seeder coupling is that seeding can also be used on hard-to-reach areas. An example is the small plots in China located additionally at different heights - terraced crops. For drone seeding, seeders with rotating disks are used most often, which give irregular distribution of seeds in the field [3]. Another no less important advantage of coupling drones with seeders consists in the possibility of using the autonomous drone flight according to the route programmed on the basis of the digital map of the field and seeding at marked points. On this basis, autonomous robots - seeders [2] can be created in the future.

2. Aim of study

The aim of the work was to examine whether during seeding with a broadcast seeder mounted under the drone, the air stream from the drone rotors and necessary to create thrust to keep the drone high above the field surface, can significantly affect the transverse deposition of falling seeds.

3. Material and research methods

The rye seeds were spread with the seeder mounted under the drone. The measured seed parameters are presented in Table 1. The DJI S 900 drone was used for the tests. The electric Greenmil seeder was attached to the drone chassis at the bottom, with battery supply. The seeder had a tank with a capacity of 2.7 dm^3. The total weight of the drone and the seeder was 10.6 kg.

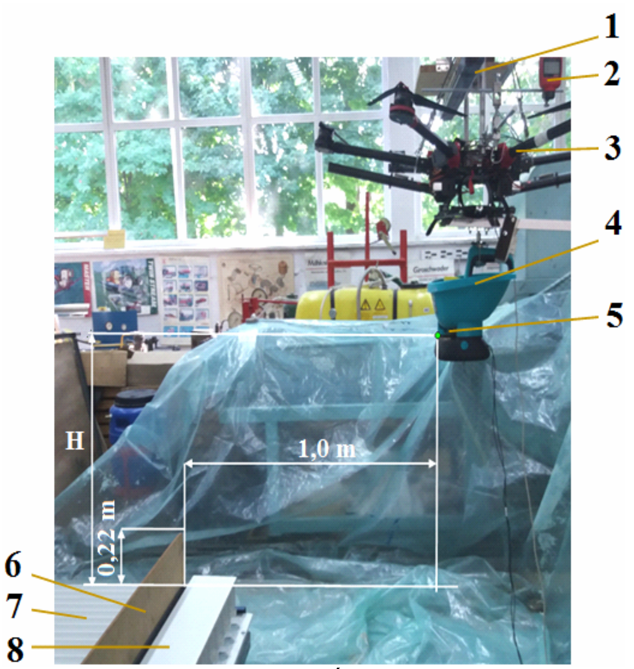
The drone was equipped with 15x5.2" folded propellers. The propeller engines were powered by the current from the mounted on the drone Lipo 12000 mAh 22.2 V battery. The propellers rotated in pairs in opposite directions to one another. The tests were carried out under laboratory conditions. The closed laboratory eliminated the influence of external conditions such as gusts of wind causing changes in the angle of the drone position in relation to the surface of the field, changes in the altitude and direction of the flight.

Table 1. Rye seed parameters
Tab. 1. Parametry nasion żyta

Moisture content wet basis [%]	1000 seed weight [g]	True density [$g \cdot dm^{-3}$]	Bulk density [$g \cdot dm^{-3}$]
12.07	33.22	1095.98	75.20

Source: own work / Źródło: opracowanie własne

The drone was fixed rigidly to the boom mounted on the trolley, which moved on a high horizontal chassis, based on its ends on stands. The boom facilitated changing of the height of the drone above the laboratory floor surface, and at the same time over the objects over which it was moved. In order to prevent unequal rotation speed of individual drone engines, in the drone control system the influence of gyroscope and barometer on the operation of the rotors was blocked.



Source: own work / Źródło: opracowanie własne

Fig. 1. Test stand: 1 - bracket mounting the drone to the trolley, 2 - tachometer, 3 - drone, 4 - seed spreader, 5 - spreading disk, 6 - vertical cover, 7 - groove patternator, 8 - horizontal cover
Rys. 1. Stanowisko badawcze: 1 - uchwyt montujący drona do wózka, 2 - obrotomierz, 3 - dron, 4 - rozsiewacz nasion, 5 - tarcza rozsiewająca, 6 - pokrywa pionowa, 7 - stół rowkowy, 8 - pokrywa pozioma

The deposition of seeds falling from under the drone was assessed using a low groove patternator, applied to measure the transverse distribution of liquids under the atomizers. The groove patternator was used to ensure obtaining high accuracy of the transverse distribution of the spread seeds. The width of the slots in the groove patternator was 5 cm and the height of the slot walls was 7 cm. The drone with the seeder moved over the patternator at a speed of $1.0 \text{ m} \cdot \text{s}^{-1}$. Prior to starting the measurements, the drone was placed away from the table, so that the seeds spread by the seeder disc did not fall on the table. The measuring stand is shown in Fig. 1. Because the space between the supports of the chassis on which the trolley with the drone moved was limited, and the seeds reached the table surface before the start of the measurements, a vertical 0.22 m high screen was placed on the table preventing depositing of the seeds into the grooves when the drone was not moving and the spreading disk was rotating. The rotational speed of the spreading disc of the seeder was approx. 700 rpm^{-1}. Each time before the trolley with the drone and the seeder started moving, the seed hopper was filled up with seeds to a constant level.

The research was carried out on the basis of comparing transverse distribution of seeds spread by a seeder with working drone rotors - with air stream and without working drone rotors - without air stream. The rotational speed of the drone rotors when moving over the table equaled 5.000 rpm^{-1}. Such rotational speed of the drone rotors was determined as necessary to create a thrust that could overcome the weight of the drone along with the seeder. The rotational speed of the rotors was controlled by means of the UT 372 optical tachometer. The tests were carried out for two heights of the seeder disc over the groove patternator: H = 0.5 m and H = 1.0 m.

The seeds from the patternator grooves were collected into containers mounted under each slot and then weighed. The seeds were collected for measurement after two routes of the drone seeder. Five repetitions were made for each of set experiment parameters.

To illustrate the transverse distribution of spread seeds, based on the results obtained from each experiment, for each slot, the qi value was calculated – the percentage of the weight of the seeds collected from the groove in relation to the total weight of seeds collected from all grooves according to formula 1.

$$qi = \frac{100 \cdot m_i}{\sum m_i}, \tag{1}$$

where:
qi – share of seeds weight in the i-th groove in relation to the weight of seeds in all table grooves [%],
m_i – mass of seeds collected in the i-th groove [g].

The coefficients of variation of the seeds mass distribution on the groove patternator according to formula 2 were also evaluated.

$$m_{sr} = \frac{\sum m_i}{n} \tag{2}$$

where:
m_{sr} − average mass of seeds in one groove [g],
m_i − the mass of seeds collected in the i-th groove [g],
n − grooves number.

The coefficients of variation of the seeds mass distribution on the groove patternator according to formula 3 were also evaluated.

$$CV = \frac{\sqrt{\frac{\sum_{i=1}^{i=n}(m_i - m_{sr})^2}{n}}}{m_{sr}} \cdot 100\%, \tag{3}$$

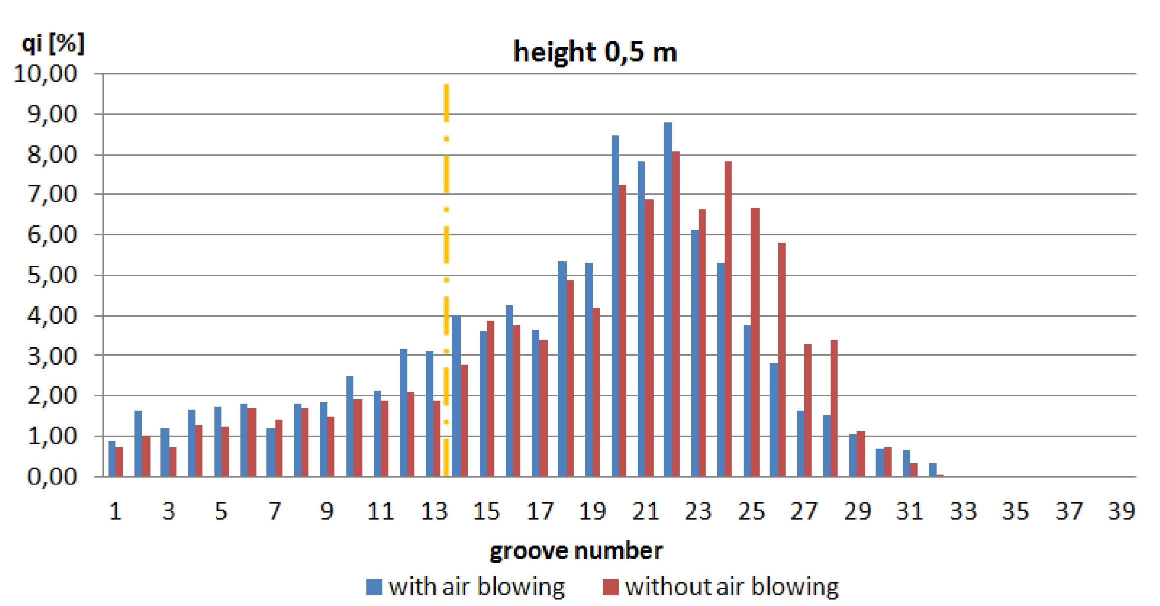
where:
CV − coefficient of variation of the transverse distribution of seeds on the groove patternator [%],
m_i − the mass of seeds collected in the i-th groove [g],
m_{sr} − average mass of seeds in one groove (according to formula 2) [g],
n − grooves number.

4. Results and discussion

On the basis of the weight of seeds deposited in the grooves of the patternator, using formula 1, the qi - percentage share of seeds weight in the i-th groove in relation to the weight of the seeds in all table grooves was calculated. The results are shown in Figs. 2 and 3.

The brown color on the graphs indicates the distribution of the weight of the seeds with not working rotors of the drone and the blue color- with the air stream, with the working drone rotors. In addition, the position of the rotation axis of the spreading disk in relation to the groove patternator is marked in orange on the graphs. The design of the seeder and the method of seed spreading caused that the seeds were not deposited symmetrically in relation to the axis of rotation of the disk. The distribution of seeds in the ratio of mass deposited on the left side of the table to the axis of rotation to the mass deposited on the right side of the table was on average 1: 3.

Two-factor analysis of variance of the obtained results of seed weight measurement deposited in the patternator grooves, depending on the position of the groove on the table and the influence of air stream from the drone rotors, with a significance level less than 0.05, showed the significance of the influence of both factors, with the height H of the drone seeder of 0.5 and 1.0 m.



Source: own work / Źródło: opracowanie własne

Fig. 2. Transverse distribution of seeds deposited on the groove patternator at the spreader disk height above the table surface 0.5 m

Rys. 2. Rozkład poprzeczny nasion na stole pomiarowym przy wysokości tarczy rozsiewacza nad powierzchnią stołu 0.5 m

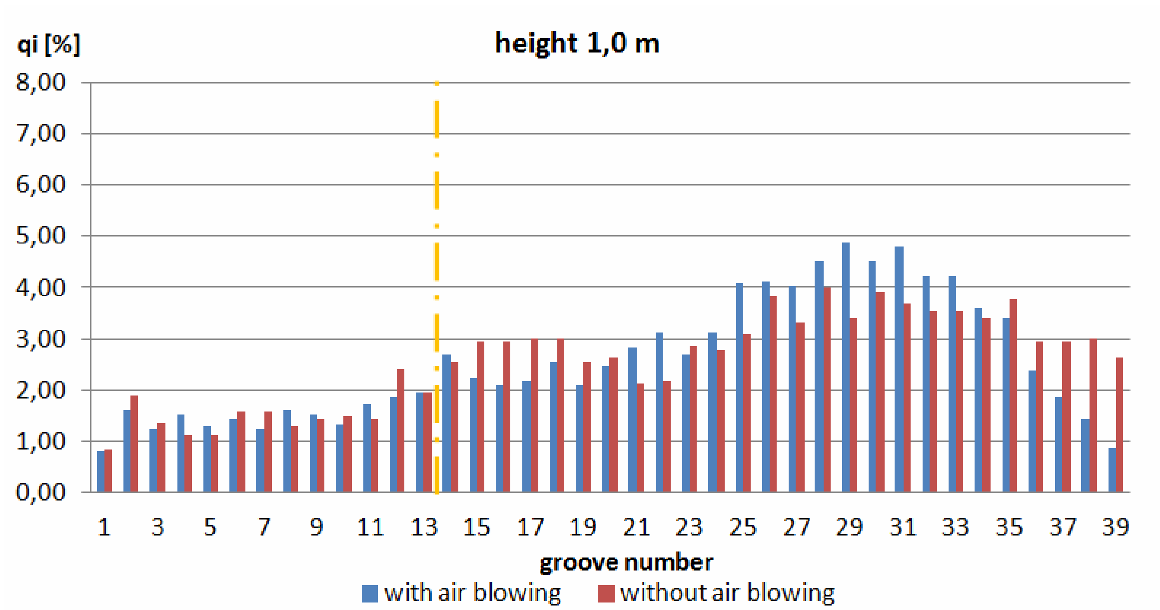


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Fig. 3. Transverse distribution of seeds deposited on the groove patternator at the spreader disk height above the table surface 1.0 m

Rys. 3. Rozkład poprzeczny nasion na stole pomiarowym przy wysokości tarczy rozsiewacza nad powierzchnią stołu 1.0 m

The effect of air stream from working drone rotors on the distribution of seeds on a grooved table is visible in Figs. 2 and 3, mainly on the right side of the diagram. It can be concluded that the air stream accelerated seed deposition, shortening their flight path. This is visible both at 0.5 and 1.0 m height H.

Table 2. Coefficient of variation (CV) of grain mass distribution

Tab. 2. Współczynniki zmienności (CV) rozkładu masy ziarna

Conditions	Height of the spreader disc above groove patternator [m]	
	0.5	1.0
Without air blowing	75.69	34.56
With air blowing	72.10	28.92

Source: own work / Źródło: opracowanie własne

Source: own work / Źródło: opracowanie własne

Fig. 4. Exemplary distribution of seeds on the groove patternator after spreading seeds with operating drone rotors and air stream

Rys. 4. Przykładowe rozłożenie nasion na stole pomiarowym po ich wysianiu z pracującymi wirnikami drona i nadmuchem powietrznym

The results of the calculation of coefficients of variation of seed mass distribution performed with formula 2 are presented in Table 2. The results indicate the improvement of the uneven distribution of seeds on the groove patternator caused mainly by the increase of the height of the spreading disc over the patternator. It was also found that there was an improvement in the distribution of seeds deposit caused by air stream from the drone rotors.

Moreover, during the tests it was found that in the course of spreading seeds with the rotors working, the air thrust caused sliding the deposited seeds in the grooves of the table until they were blown out from the surface of the grooves at the end of the table. To prevent this, at the end of the grooved table, a transverse strip was glued. Fig. 4 shows the effect of seeds blowing towards the end of the table.

5. Summary

The tests confirmed that when spreading seeds using an electric seeder coupled with the drone, the air stream from the drone rotors, necessary to create thrust to keep the drone at a height of 0.5 and 1.0 m above the grooved patternator, had a significant effect on the transverse distribution of deposited rye seeds. The air stream shortened the flight path of seeds sown with a rotating disk, shortening their flight path.

It was also found that the air stream from the rotors of drone seeder may have a positive effect on the improvement of the index of seeds transverse deposition irregularity.

It has been noticed that in the case of smooth surfaces on which seeds sown using a drone are deposited, the air stream from the drone rotors can blow them out and move over the surfaces.

6. References

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Acknowledgements

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