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Drone Use in Agricultural Spraying: An Examination in Terms of Occupational Health and Safety

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ABSTRACT

One of the cornerstones of a developed economy is undoubtedly the agricultural sector. Agriculture is at the center of both human nutrition and economic activities. The use of drones, especially in the process of spraying fields, has the potential to increase the efficiency of agricultural production. Drones can be programmed to scan the field and spray pesticides on these areas. This allows farmers to manage the processes of protecting their crops and removing pests more effectively. Spraying with drones minimizes the negative effects encountered in spraying with tractor-drawn machines. Drones can easily reach places that tractor-drawn machine cannot reach and can spray more precisely. In addition, thanks to drones, the need for labor is also reduced, so that one person can spray a large area in a short time. In this study, the process of spraying with drones was observed in detail by a company with an unmanned aerial vehicle-2 (UAV) license for agricultural spraying. This modern spraying method using drones was meticulously evaluated step by step. In traditional methods, farmers or workers may be directly exposed to pesticides while spraying with tractor-drawn machines, but thanks to drones, this exposure is minimized, which provides a great advantage in terms of occupational health and safety (OHS). In addition, the speed of the work process, less use of water and pesticides, and the need for labor are among the advantages. However, the problem of not being able to connect to GPS, accidents that may occur under the command of the drone, and limitations such as adverse weather conditions can be considered disadvantages of drone spraying. The findings reveal how drone spraying has transformed agriculture.

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Introduction

The maintenance of food security and the increase in food production are increasingly becoming more problematic (Prosekov & Ivanova, 2018). The increase in the disruption of the fight against the spread of various harmful plants and plants also increases the environmental and worker parts (Shahrooz et al., 2020). Throughout history, management production methods have been developed and modernized, and agricultural technologies have been made more efficient and sustainable (Topal, 2010). With the widespread use of tractor-drawn machines, which are considered a revolution in annual agriculture, production capacities have increased, and large areas have become more cultivated in a shorter time and with less labor. However, today, the basis of this technological step has been passed. In recent years, the use of drone technologies in agriculture has become increasingly widespread. (Özgüven et al., 2022). Although the development of unmanned aerial vehicles (UAVs), which have an important place in the field of robotics, was initiated by military resources (Ergunşah & Koşunalp, 2022), it is present in many places today. UAVs are currently used in areas such as mapping (Avdan et al., 2014; Navia et al., 2016), agriculture (Mogili & Deepak, 2018; Ge et al., 2019), archaeology (Campbell, 2018), wind turbines (Wang & Zhang, 2017).

The use of drones in agriculture allows farmers to make the right decisions by providing real-time data (Emimi, et al., 2023), while the possibility of detailed imaging to monitor plant diseases and early detection of diseases allows intervention at certain times (Jain et al., 2023).

In their report, Ahirwar et al. (2019) argued that meeting the food needs of the growing world population can be achieved through the adoption of advanced technologies in agricultural production and stated that the use of advanced technologies such as drones offers the potential to face various challenges. Kalamkar et al., (2020) stated that today, farmers are turning to drone technology to obtain an effective solution to eliminate

problems such as weeds and insects that affect the success of farmers, and that unmanned aerial vehicles provide the opportunity to maximise yield in crop production.

Most of the economic loss in agriculture is caused by harmful insects and weeds (Mahajan et al., 2023), drone pesticide spraying provides faster, more efficient and targeted applications than manpower (Sahni et al., 2024).

Spraying drones used in agriculture can spray one hectare of land in about 10 minutes, depending on the model, and can speed up the normal spraying time (Shahrooz et al., 2020). There are many types of drones on the market according to their tank volume (10-50 liters) (Anonymous (a), 2024). Some of these have digital beam formation (DBF) radars that prevent diversity by sensing the environment (Puri et al., 2017) and normalized difference vegetation index (NDVI) sensors for creating maps (Meesaragandla et al., 2024).

The aim of this research is to determine the hazards and risks in this process by observing drone pesticide spraying on site. In addition, the precautions to be taken in terms of occupational health and safety in drone pesticide spraying were also mentioned.

Materials and Methods

This research was designed as a qualitative field study. In order to examine the effects of drone use in agricultural spraying on occupational health and safety, the activities of an agricultural spraying company were observed. Data collection was carried out with the unstructured observation technique (Yıldırım & Şimşek, 2005). The flow of actions was monitored without intervention and the findings were recorded. In addition, visual materials (video and photographs) obtained during the observation were used to support the data. In the research, the location of the area to be sprayed, the preparation of the pesticide diluted with water, the activities of drone operators on the job, potential occupational health and safety risks encountered during spraying, the equipment used and protective measures were observed. The observations were carried out as an external observer without any influence and were supported by field notes and photographs. The collected field notes and visual materials were categorized within the framework of risks and measures taken in terms of OHS.

Technical Informations, Observation

The drone in the study is the DJI brand T30 model and some of its technical specifications are as shown in Table 1.

The workflow is as follows:

- Mapping the area requested to be sprayed (at various points of the field depending on its geometry and whether it is hilly or flat) via GPS (Figure 1).
- Introducing obstacles that may collide in the mapping (such as electric poles, tall trees) one by one (Figure 2)
- First, mixing the pesticide and water to be used in the spraying process in buckets before filling the tank to obtain a homogeneous distribution (Figure 3)
- Filling the resulting mixture into the tank.
- Setting the distance and height at which the drone will spray by the drone operators (minimum 2.5 m for rice). (Uniform spraying is provided thanks to the altitude sensor) (Figure 4). The company is generally preferred for spraying rice fields, corn and canola fields.
- Ventilating and monitoring the drone from a safe distance (Figures 5)
- After the spraying process is completed, the device is closed and the tank is cleaned for next spraying (Figure 6).

Table 1. Some features of the drone used by the company (Anonymous (b),2024)

Hourly operating efficiency	40.000 m^2
Total weight (excluding batteries)	26,4kg
Maximum flight speed	7m/sn
Nozzle quantity	16
Maximum effective spray width	4-9 m (12 nozzles and 1.5 to 3 meters distance to the plant)
Battery	Two batteries that can be recharged 1000 times
Charger	Available
Obstacle avoidance radar	Available
Tank volume	30 L

Figure 1. Drone mapping

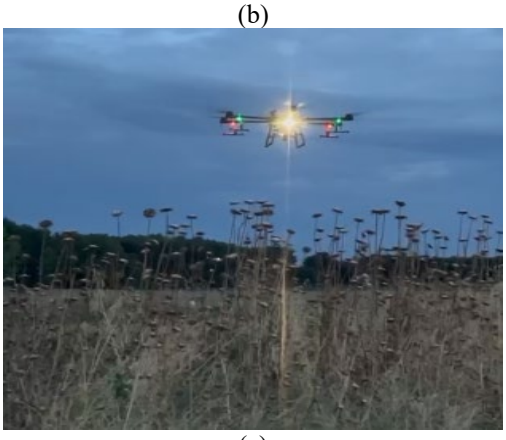
Figure 2. Drone flies through power lines

Figure 3. Preparation of the pesticides diluted with water

Figure 4. Drone spraying from a certain altitude (Still areas are sprayed areas)

(a)

(b)



(c)

Figure 5. (a)Taking off the drone from a safe distance, (b) Drone spraying monitoring, (c) Spraying of sunflower field in the evening hours

Figure 6. Cleaning the tank after spraying

Findings

The findings of the research based on the workflow and field observation are as follows:

- The company's spraying operations are carried out by two operators with UAV-1 and UAV-2 licenses serving the Thrace region. They have training and qualifications in this regard.
- The company uses the drone mostly for weed control, but also for insect control.
- In order for the crop area to be introduced to the drone, the drone operator must definitely establish a GPS connection and be at certain points in the crop area to determine which areas will be sprayed. Then, the drone autonomously adjusts its departure and arrival.
- During the windy, rainy and especially hot days in the summer months when the weather conditions are not suitable, spraying during the day is not preferred due to reasons such as battery heating and the spray drifting and blowing.
- Since there may be some dangerous situations (rough terrain, stones or pits) in the crop area, drone operators are at risk of falling and injury.
- The area visited may be a field where the spray has been applied before. In this case, the operators is likely to be exposed to the pesticide.
- There may be elements in crop fields that may pose a high safety risk for both the drone and the operators, such as power lines and high voltage.
- In the event of obstacles such as electric poles and large trees, these elements are introduced to the drone before the flight.
- The pesticide used in spraying the crop field is supplied by the field owner from the dealer selling agricultural pesticides.
- The dosage of the pesticide is mostly adjusted with the suggestion of the field owner, depending on the density of harmful weeds or insects. Sometimes, the dosage is adjusted based on the prescription given by the dealer selling the agricultural pesticide and in consultation with the company employees.
- After the amount of pesticide is determined, it is first mixed with water in buckets. At this stage, the company's drone operators may be exposed to high levels of pesticides. Drone operators use half-face masks with gas-vapor filters, nitrile gloves and daily long clothes to prevent contact with the body, especially against the risk of exposure to insecticides. When transferring the prepared pesticides diluted with water to the tank, the filling process is carried out again using personal protective equipment with the help of a dosing hopper, taking into account spillage and splashing situations.
- Failure to maintain a safe distance while the drone is taking off at the beginning of the spraying process may cause exposure to the sprayed pesticide. Drone operators start the drone at a certain distance from the drone and with protective clothing.
- Especially in the summer months when the air temperature is very hot, they also face possible risks such as exposure to sunlight due to being outdoors.
- The company sometimes sprays in the evening hours, taking into account conditions such as weather

conditions and explosions in the sun (as they negatively affect satellite and GPS systems). In spraying at night, both the battery heating is minimized and the pesticide sprayed from the nozzles is more effective due to excessive heat.

- One of the dangers during spraying of the drone is losing control of the drone. The software update of the device can lead to accidents. Drone operators have previously stated that the drone suddenly fell to the ground after an update.
- After the spraying process is over, the drone is turned off and loaded into the company's vehicle.
- White vinegar is generally preferred for tank cleaning. However, if oil-based pesticides are used in spraying, oil-dissolving chemicals on the market are also used to prevent accumulation or sedimentation at the bottom and thus reducing the effect of another pesticide.

Conclusion and Recommendations

Drones are highly preferred technology in terms of reducing the duration of agricultural spraying and reducing human exposure to pesticides used to eliminate harmful weeds or insects. In traditional spraying methods (using tractor-drawn machine or backpack-borne sprayers), the risk of workers being exposed to pesticides is quite high. Since pesticides can enter the human body through inhalation or skin, drone spraying makes a serious contribution in this sense.

In addition, traditional methods are physically demanding and can cause musculoskeletal disorders in workers. Drone spraying significantly reduces the physical load because workers control the process only by directing the drone. Drone spraying offers a safe and effective method, especially in hazardous areas such as flooded paddy fields.

When performing agricultural spraying with drones, careful planning of the workflow is critical for the safe and efficient completion of the process. This workflow can be divided into three main stages: pre-flight, during flight, and post-flight.

Before Flight

- Planning: The transportation route of the area to be sprayed must be determined and its geographical and topographic structure must be reviewed. In addition, the type of pesticide to be used, dosage, wind speed and air temperature must be taken into consideration to determine the time of spraying. It is important to check the mechanical and electronic parts of the drone, especially the nozzles, and to remove any blockages. Personal protective equipment (PPE) must also be ready at this stage.
- Pesticide Preparation: The pesticide must be prepared according to the instructions and mixed with water at the recommended dose. During this process, the drone operator must use appropriate PPE such as glasses, mask, gloves and protective clothing. In addition, precautions must be taken against leakage, spillage and splashing while filling the tank of the drone.

In the Flight Area

- Field Observation: It must be ensured that there are no people or animals around the area to be sprayed.
- Technical Checks: It must be ensured that the drone's GPS connection and mapping system are working, the route is loaded correctly and the signal connections are healthy. The operator must be at a safe distance while the drone is taking off.

Post-Flight

- Landing: After the drone completes its mission, it must land safely and wait for it to cool down.
- Equipment Cleaning: After the spraying process is completed, the drone's spray system, tank and propellers must be cleaned appropriately.

The following suggestions can be listed as improvements in agricultural spraying with drones:

Emergency action plans should be prepared for situations such as sudden health problems that employees may encounter, such as access to first aid and emergency health services, and for risks that may be encountered in transportation. Approaching power lines can be dangerous for both the drone and the operators. High voltage lines in particular pose a serious risk. On the other hand, insufficient knowledge and experience regarding the use of drones can endanger the safety of the device and the people and animals around it. In this context, operators need to have certain technical knowledge. Having an action plan in case of emergency ensures that the device is less affected by the possible negativities. If the periodic maintenance of the device is not done on time or is ignored due to its costs, the device may lose its reliability. This may have some negative consequences in terms of occupational health and safety and environmental safety.

Declarations

Limitations of the Research

The research only covers the flights and operations performed in the rice and sunflower fields within the scope of the specified drone brand. This situation expresses the limitation of the research. Since it cannot be generalized to other agricultural products, different regions and different device brands and models, it can be considered as an opportunity for future research.

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