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HUNGARIAN AGRICULTURAL RESEARCH

Spring 2023

Environmental management, land use, biodiversity

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DEVELOPING A NATIONAL REQUIREMENTS FRAMEWORK FOR SPRAYING DRONES

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ABSTRACT

The Hungarian University of Agriculture and Life Sciences (MATE) is designated by FVM Decree 43/2010 (IV. 23.) to determine the order and requirements of the type approval procedure for plant protection machines. International publications, experiences and methods have been studied to develop the criteria for spraying drones, attracting increasing interest. Field tests were conducted to determine the risks involved regarding the environment and the operator's workload. The measurements provided an opportunity to optimise the operational settings for better-quality treatments. Based on the literature and our tests, we developed a system of requirements for spray drones relevant to plant protection and identified further research purposes.

keywords: drone technology, legislation, plant protection machines, sprayer testing, sustainable agricultural

INTRODUCTION

Nearly 30 years ago, spraying systems mounted mainly on unmanned aerial vehicles (UAVs), commonly known as drones, appeared in Asian countries. Over the past decade, drone technology has exploded thanks to its wide range of potential applications. However, it is no longer only used for military, law enforcement and disaster management tasks but has significant commercial and private uses. In agricultural applications, remote sensing was primarily used for quick and cost-effective soil and cultivated crop assessment. With the rise of precision agriculture, in addition to drones equipped with various cameras providing input data and systems that process, analyse and support farming with large amounts of data, devices developed for the drone platform are increasingly appearing for use in the production process. Firstly, they offer an alternative to technologies based on traditional machines in plant protection. Spraying drones is currently the only solution for plant protection work that requires quick detection and intervention, often in extreme weather conditions, considering economic, work quality, and environmental protection aspects.

Unmanned aerial spraying systems (UASS) are licensed in approximately 20 countries. However, the growing demand for the introduction of the technology is prompting legislators to consider amending the legislative environment. The global agricultural drone market is estimated at $3,807 million in 2023. According to some research, this revenue will reach $14,237 million by 2033 (Future Farming, 2023). Within the European Union, aerial plant protection is considered environmentally risky, and its use is prohibited or only allowed under strict supervision and conditions. Directive 2009/128/EC proposes a prohibition on aerial spraying of pesticides, allowing derogations in cases where they have a clear advantage in terms of reducing impacts on human health and the environment compared to other spraying methods where no other alternative is justified, provided that the best available technology is used to reduce drift. In the European Union, two regulations control the use of drones. The first is Regulation 2019/945 on unmanned aircraft systems, and the second is Implementing Regulation 2019/947 on the regulation of operations with drones. Besides the directly applicable regulations, the Hungarian national regulatory environment provisions also apply to unmanned aerial vehicle operations. National regulations applicable to plant protection activities: the definition of the pilot's competence and the special regulations of the operation are included in the 44/2005. (V. 6.) FVM-GKM-KvVM joint decree. FVM Decree No 43/2010 (23.IV.) contains the specifications for plant protection machines. This decree assigned the MATE to inspect plant protection machines from drip formation and spraying technology aspects.

Additionally to these specifications, other obligations of the unmanned aircraft system operator include compulsory liability insurance, UASS and operator's official registration, meeting competence requirements, determining the operational category and fulfilling the relevant regulations, and obtaining the special permits required to use Hungarian airspace. The Hungarian Drone Coalition attempted to resolve the complexity of the legal environment when it prepared the barrier map, outlining the system anomalies and making proposals to simplify the regulation while keeping in mind the interests of all parties involved and the social risks.

MATE is legally obliged to publish the requirements for the type approval procedure for spraying drones on its website. Due to the rapid development of drone technology, no generally accepted standards or international specifications and test methods were available. Our goal is to present the development and description of the drone technology requirements from a spray technology viewpoint.

MATERIAL AND METHOD

To comply with our legal obligations and conduct a well-established official procedure, we had to consider the impact of drones on human health, the environment, and efficiency views. The following terminology was followed in setting up the requirements and the methodology: scientific publications on the relevance of the usability of spray drones were collected and analysed. We studied the certification system for spraying drones pioneered in Europe by Switzerland, where drones are widely allowed to apply chemicals.

Before developing the requirements, we carried out preliminary experiments with plant protection drones. Penetration, work quality features and working widths were investigated on the soil surface and the foliage of plants under different application parameters. Water-sensitive papers are laid out perpendicular to the direction of flight at 25 cm from the ground on special holders for fixing the pieces. The distance between each paper was equal

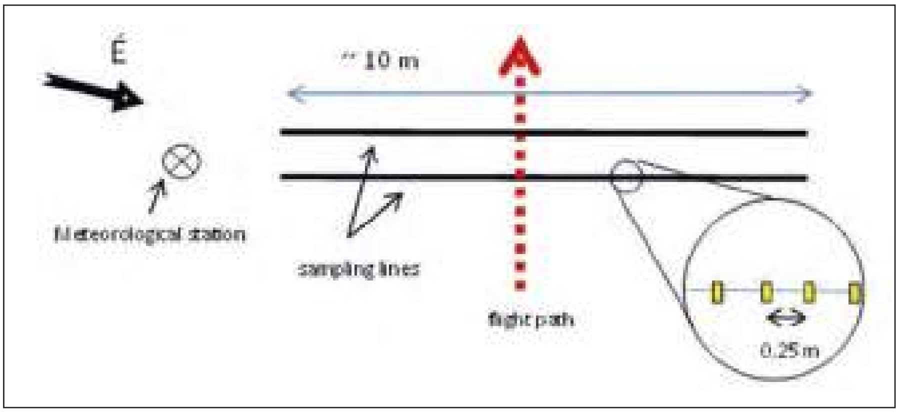

Figure 1: Test arrangement


Figure 2: Sampling site on the plant

Table 1: Flight parameters and environmental characteristics

dose (dm^3/ha)	flight altitude (m)	flight speed (m/s)	temperature (°C)	RH (%)	wind speed (m/s)	wind direction (°)	working width (m)
60,0	2,0	1,6	19,8	35,7	1,9	180	-
20,0	2,0	4,1	20,4	34,4	1,5	110	-
10,0	2,0	5,3	20,8	32,2	0,7	150	-
5,0	2,0	6,3	21,5	32,5	1,5	320	-

(25 cm) along the line for 10 m (Figure 1). In the experiments on the crops (sunflower, corn), water-sensitive papers were placed on the leaf surface at three different height levels, as shown in Figure 2. The parameters and environmental characteristics of the experiments are given in Table 1. The test was performed with a DJI AGRAS T20 UAV. Environmental features were recorded using a meteorological data collection station. After spraying, dried samples were collected, digitised, and relative coverage and specific droplet number were determined using National Instruments LabVIEW vision image processing software.

RESULTS

Our literature research found a small number of usable, relevant literature. Based on reliability, robustness, and comparability, only a few publications (approx. 20 pieces) can be considered and are reliable from a legislative point of view. Since the spread of spraying drones is the largest in Asia, most publications also come from there, but the operational and legal environment is different. The study prepared by the Working Party on Pesticides (WPP) working group of the Organization for Economic Co-operation and Development (OECD) assists researchers, legislators, and drone manufacturers in further development and suggests research directions. We also considered the cited study's guidelines and experiences during our work. The publications emphasise that the efficiency of spraying drones is affected by other factors, such as turbulence, speed, and nozzle location, compared to conventional technology, under the same application settings. Considering these conditions, overall lower coverage and poorer coefficient of variation (CV %) are achieved compared to conventional technology. Most studies conducted tests between 1.5-3 m flight height, while flight speed was typically between 3-4 m/s. In European publications, air volumes of 30-100 l/ha were mostly tested. Alternatively, a dose of 10 l/ha would be preferable for UAVs to achieve greater economic efficiency, but this may cause problems in achieving adequate coverage. Similar experiences were observed during our field tests. Without a defined quality standard, coverage quality is not defined because it depends on the number of droplets, the quantitative value of coverage, and the type of pesticide. Based on the measurement results, it can be concluded that at the dose settings of 60, 20, and 10 dm^3/ha (Figure 3), a specific droplet number of at least 20-30 pieces/cm^2 is provided, as accepted in literature sources.

For higher dose rate sprays, this is 5.5-7 m, for the lower

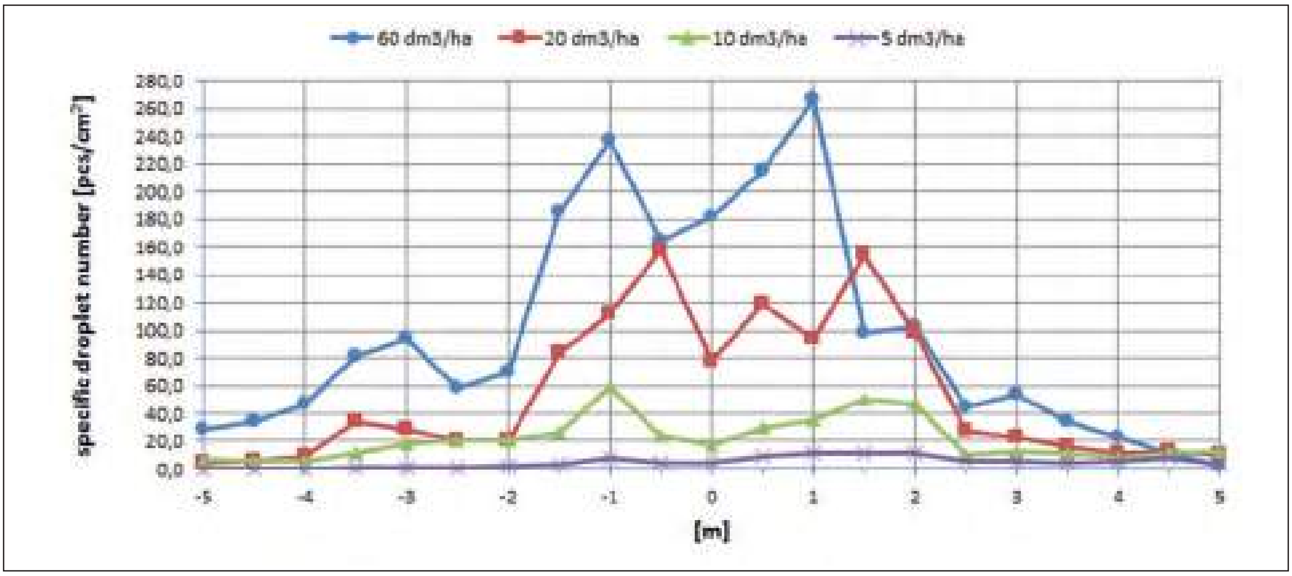

Figure 3: Specific droplet number at different application rates

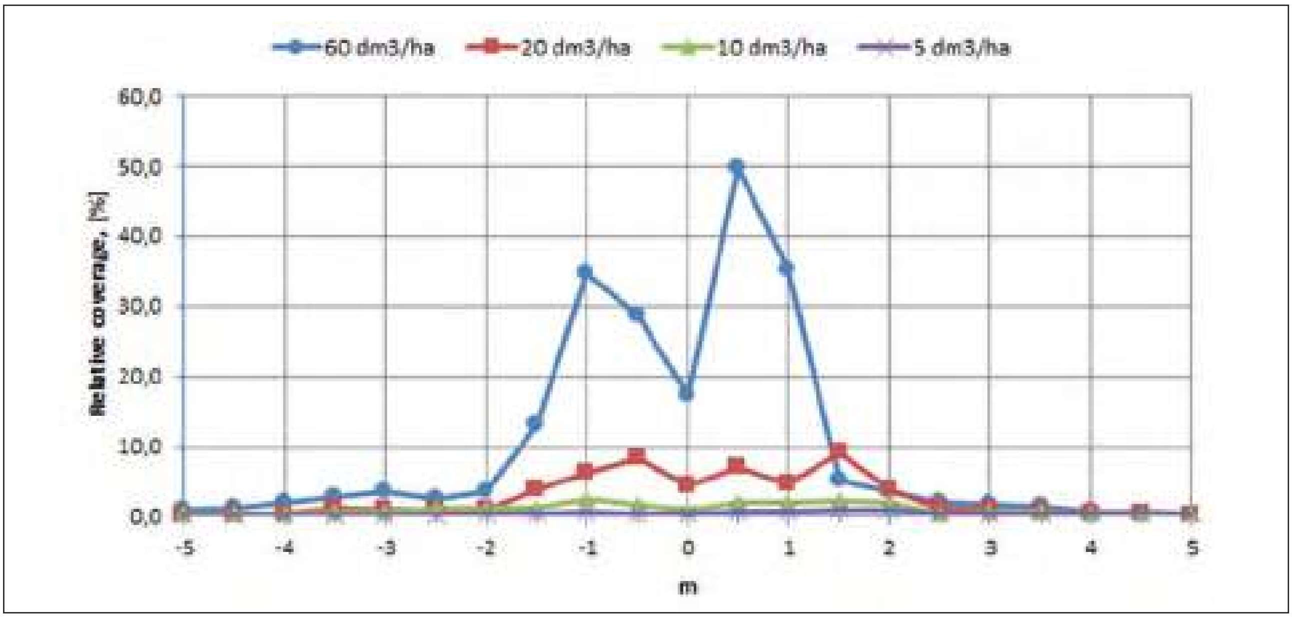

Figure 4: Relative coverage at 20 dm³/ha application rates

10 dm³/ha setting, this is only achievable at a working width of 3.5-4 m. When spraying with a dose of 5 dm³/ha, the desired spray coverage was not detectable on the target surface. The minimum specific droplet rate of 50 pieces/cm² accepted for fungicides can only be achieved at doses of 20, 60 dm³/ha up to working widths of 5.5 to 7.0 m. The relative coverage values for the above-mentioned working widths are 1.5-50% for the dose of 60 dm³/ha and 1.5-8% for the setting of 20 dm³/ha (Figure 4). In the treatment with a dose of 10 dm³/ha, the relative coverage value changes in the range of 0.7-3%, while in the case of a dose of 5 dm³/ha, it does not reach the value of 1%. The results show that the transverse distribution uniformity is less favourable than is usual for conventional spraying technologies but significantly better than aerial (rotary and fixed-wing application technology).

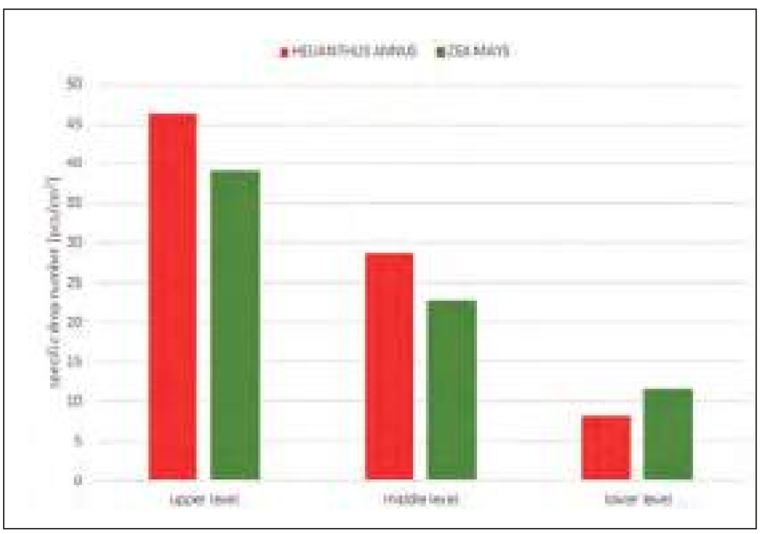

Figure 5: Specific droplet number at different height

Penetration was tested at three altitude levels in different crops (Figure 5), at a dose of 20 dm³/ha, 2 m flight height and 4 m/s flight speed. In summary, a satisfactory quality of treatment can be achieved (at least 20 specific droplet numbers per cm²) both in the upper and middle levels of the sunflower and corn stocks.

Two countries in Europe have authorised the use of drones for plant protection. In Germany, the use of UASS is allowed in terraced vineyards. According to the announcement of the Julius Kühn-Institut, the operation of 6 types is currently permitted. Applications of pesticides authorised by the Federal Office of Consumer Protection and Food Safety (BVL) can usually be applied with a water consumption of 75 or 150 dm³/ha (Bundesamt für Verbaucherschust und Lebensmittelsicherheit: Liste der Pflanzenschutzmittel, die für die Anwendung mit unbemannten Luftfahrzeugen (Drohnen) genehmigt sind, Stand: März 2023).

In Switzerland, all plant protection work carried out by UASS requires authorisation by the Federal Civil Aviation Office (OFAC). This authorisation can only be granted to equipment that has met the requirements specified in the type approval procedure carried out by the Swiss Agricultural Research Agroscope and the Federal Environmental Protection Office (OFEV). Moreover, for visual inspection and functional testing, the classification system developed by Anken, T. et al. also requires two essential parameters: measuring the horizontal uniformity of application on a test bench and determining the potential drift.

According to the results of literature reviews and the experience of the Swiss and German models, we have developed a set of requirements and a test method for the type approval procedure. In contrast to the Swiss model, the transverse distribution uniformity is not defined in a groove because it assumes floating, which does not consider the travel speed's effect on the distribution pattern. Instead, we measured the coverage on water-sensitive papers placed at a height of 80 cm. Our requirements included work safety, health and environmental aspects, droplet formation and spraying techniques, and plant protection flight safety requirements, detailed on the MATE website. In Hungary, 17 types are currently authorised for plant protection activities.

CONCLUSIONS

Based on the results of the tests and the literature data, it can be concluded that unmanned aerial spraying systems with well-chosen settings can be used for spot treatments in precision farming and in difficult-to-access inland water areas. Application with a low air volume significantly increases the risk of environmental pollution caused by higher concentrations of pesticides. Further drift studies are needed to assess and manage the risks, particularly regarding human health and environmental impact. In order to use the UASS technology, it is necessary to have plant protection products approved for aerial application. Similar to traditional technology, uniform, internationally accepted standardized methods and requirements would also be required for drones. The ISO 23117-1 standard on environmental protection requirements is expected to publish this year.

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