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Aerial method of plant protection with the use of an autogyro for sustainable agriculture

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Abstract

Despite the limitations in the use of aerial applications resulting from Directive 2009/128/EC of the European Parliament and of the Council and the Plant Protection Agents Act (OJ L item 455. 2013), scientific progress in engineering enables the development of new, environmentally safe technologies to expand the use of agroaviation. This paper proposes an innovative method of biological protection of corn against *Ostrinia nubilalis* with the use of an autogyro and presents the results of these operations. An autogyro adaptation for forest applications is proposed, and the preliminary results of a spray uniformity assessment are presented. Based on a two-year study (542.5 ha), the introduction of the Tricholet preparation against *Ostrinia nubilalis* was found to be highly effective (73.55%), which is a positive indication for the innovative autogyro method for introducing *Trichogramma evanescens*. Similarly, positive results were obtained for a liquid agent application using an autogyro-mounted installation: an even coverage of the area was achieved across the entire spray path width while maintaining the required dosing of the plant protection agent.

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Keywords: autogyro; biological; chemical protection; forests; maize.

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1. Introduction

The EU strategy for a sustainable economy in terms of agriculture, forestry and food production requires the use, among other things, of plant protection techniques and technologies that enable both safety and high efficiency levels to be maintained (EU Directive 2009/128/EC). This requires accurate application of the smallest possible amounts of chemical agents in a short period of time, due to their toxic nature. It is also necessary to diversify the dosage depending on the locally variable severity of agrophage occurrence while at the same time minimizing any possible crop losses. The problem of pest protection includes forests as well as agriculturally productive areas, both in Poland and elsewhere in Europe.

The following requirements are crucial for protection to be effective: appropriate time of application, accuracy of dosing, doses meeting the requirements, and short application time, all of which must be met simultaneously. The current technologies and ground-based equipment that are commonly used include tractors with sprayer attachments and self-propelled sprayers, although they do not provide the optimum combination of quality, efficiency and safety. The more accurate and safer the sprayer is, the lower its efficiency is. One advantage of aerial applications over ground-based spraying is the elimination of mechanical damage to crops, rapid execution of the operation and a significant reduction in the required amount of working liquid with its added adjuvants (Mierzejewski et al., 2007). However, aerial applications performed by airplane or helicopter are also very expensive (Głowacka 2009, Majewski 2012).

Despite the limitations in the use of aerial applications resulting from Directive 2009/128/EC of the European Parliament and of the Council and the Plant Protection Agents Act (OJ L item 455. 2013), scientific progress in engineering enables the development of new, environmentally safe technologies to expand the use of agroaviation. A solution meeting the requirements of safe and effective (cost, efficiency, and manoeuvrability) protection of crops and forests is the use of an ultra-light aircraft: the autogyro (World Directory of Light Aviation 2014/2015; Rotorcraft Flying Handbook. 2015). The autogyro is an aircraft of the rotorcraft family, equipped with a rotor and a pusher propeller. The autogyro has fewer requirements in terms of landing site or flight technique than airplanes or helicopters, while operations can be accurately performed even on small areas, and at a significantly lower cost.

2. Objectives, data and methodology

The goal of this study was the assessment of autogyro operations for the biological protection of corn and for forest protection. Tests were performed using the Aviation Artur Trendak & Son ZEN-1 autogyro. This autogyro was modified for the individual tests by installing only the equipment required for each task.

Biological protection of corn against the corn borer (*Ostrinia nubilalis*) was executed using a loose Tricholet formulation (*Trichogramma evanescens*). The preparation was placed in dispensers installed on pylons mounted on the autogyro fuselage (Fig. 1) (Bzowska-Bakalarz et al. 2013). The GPS system installed in the autogyro enabled the aircraft to be guided onto successive flight paths and operational reports to be prepared (Fig. 1), including preparation consumption. Two dispensers provided a Trichogramma dose sufficient for 80 ha.

The territorial range of *Ostrinia nubilalis* occurrence continues to grow, not only around the world but also in Poland, particularly in the south-west of the country. This can lead to damage to all the plants, and therefore biological treatments that reduce the population of *Ostrinia nubilalis* are of a considerable economic significance (Bereś, 2012; Bereś & Konefał, 2010, Sudha Nagarkatti, H. Nagaraja, 1977).

Operations related to Tricholet introduction were performed in 2013 and 2014 on plantations located in the Lower Silesian voivodeship, twice, at a seven-day interval, in accordance with the assessment of corn borer infestation severity. The total area protected was 247.4 ha in 2013 and 295 ha in 2014. The operations were performed at an airspeed of 100 km/h (80 ha/h efficiency) (Bzowska-Bakalarz et al., 2013). Operational effectiveness was determined by comparing the number of plant damage on the protected field and on the control field (without protection agents) as per Abott's formula (1925). The tests were performed on 100 plants in 4 repetitions on each control field and protected field.

The positive results of the biological treatments encouraged the authors to analyse protection options that involve the use of liquid preparations. For this purpose, an autogyro was prepared for oak forest protection concerning the winter moth *Operophtera sp*. This involved setting the spray width and performing preliminary verification of liquid distribution uniformity during liquid spraying. Four AU 7000 atomisers were installed on the autogyro beam, enabling fine-droplet ULV (ultra-low volume) spraying (Fig. 2). At a liquid use rate of 2.2 l/ha (as per the recommendation on