ISSN 2223-6775, Ukrainian Journal of Occupational Health, 2024, 20 (1), 54–58

УДК 613:632.982:331.436 https://doi.org/10.33573/ujoh2024.01.054

IMPROVEMENT OF WORKING CONDITIONS ASSESSMENT AND RISK CALCULATION METHODS TAKING INTO ACCOUNT THE SPECIFIC FEATURES OF PESTICIDE APPLICATION WITH UNMANNED AERIAL VEHICLES (UAV)

Borysenko A. A., Antonenko A. M.

Hygiene and Ecology Department of the Bogomolets National Medical University, Kyiv

Introduction. The implementation of modern technologies in the agriculture of Ukraine, such as the use of UAVs, has great potential for revolution and ensuring the country's food security. Considering the fact that the use of agricultural drones is a fairly new phenomenon in the agricultural market of Ukraine, the need for legislative foundations for their use is very high. The absence of appropriate rules and regulations, that would regulate this activity can cause a dangerous effect on the peoples' health, animals' and plants', and can cause a negative impact on environmental objects.

The aim of the research – improving the methodology for assessment of working conditions and risks calculation, taking into account the peculiarities of applying pesticides using unmanned aerial vehicles.

Materials and methods of the research. Analysis of literary sources, results of field and laboratory experiments, computer modeling of the process of spraying the pesticides solution during the processing of agricultural crops, statistical processing of the obtained results – were used during the adaptation of sustainable approaches to assessing the working conditions of workers involved in working with pesticides.

Results. It is suggested that the following features be taken into account when calculating the risks for workers carrying out processing from the air with the help of UAVs: 1) the absence of a ground support group: a signalman, and sometimes a refueler (therefore, it is necessary to provide an opportunity to calculate the risk for the refueling operator); 2) locating the agrodrone operator at a distance from the treated field (on the launch pad); 3) the volume of the working solution; 4) the height of the flight over the crop and the duration of treatment. Mandatory parameters that must be taken into account when calculating risks are the consumption rate of the working solution, the volume of the tank, the capacity of the agricultural drone, the drops size (type of nozzles), the movement speed, the height of the drone flight and the spraying width, meteorological conditions during treatment (humidity and air temperature, wind speed and direction, solar radiation intensity, etc.).

Conclusion. Additions to methodological recommendations on risk assessment and mitigation for workers applying pesticides from the air with the help of unmanned aerial vehicles are proposed. This will provide a more correct assessment of the professional risks associated with the use of this technology. This approach contributes to the creation of a more complete and balanced set of recommendations for UAV operators, which as a result ensures the safety, efficiency and sustainability of the use of this technology in agriculture.

Key words: occupational risk, agrodrone, chemical plant protection products, ultra-low-volume application, working conditions

Introduction

Improvement of chemical means of plant protection, applied technologies of their use and integration of chemical, physical and biological knowledge will allow to truly ensure the optimization of the pesticides use without harming the quality and efficiency of agriculture or consumers and the environment protection. In recent years, the practice of precision agriculture has developed significantly, and one of the innovative developments in such agriculture is the use of unmanned aerial vehicles (UAVs, drones). UAVs are expected to play an increasingly important role in this direction [1, 2]. Considering the advantages of using unmanned aerial vehicles, the government has somewhat relaxed restrictions on their use in Ukraine and supports startups in developing new ideas for their practical use.

The implementation of modern technologies in the agriculture of Ukraine, such as the use of UAVs, has great potential for revolution and ensuring the country's food security. Today, drones are becoming a component of precision agriculture, contributing to the sustainable development of the agro-industrial complex. The use of agricultural drones also has great prospects for ensuring the employment of the population in rural areas [3–5].

ISSN 2223-6775, Ukrainian Journal of Occupational Health, 2024, 20 (1), 54–58

Equipped with cameras and sensors, UAVs can provide valuable data on crop growth, soil moisture levels, plant health and other variables that affect yield. They can be used for aerial photography, monitoring fields, creating 3D maps, planting seeds, applying fertilizers and chemicals, monitoring crops, helping with irrigation, and controlling animals in agriculture. Compared to large "traditional" agricultural aircraft, drones have unique advantages, as they do not require a dedicated airport, the maneuverability of UAVs is very high, they have high adaptability to landforms and high power for low-altitude spraying. Compared to manned aircraft, UAVs can apply plant protection chemicals lower, at lower speeds, which can be useful for reducing the drift of chemical plant protection products, the risk of their negative impact on the health of professional and non-professional contingents and environmental objects. Numerous reports indicate that a significant portion of the chemicals during spraying drifts to non-target areas. The volume of such losses is estimated at 50–60%, which leads to significant economic losses [1, 4, 6–8].

Considering the fact that the use of agricultural drones is a fairly new phenomenon in the agricultural market of Ukraine, the need for legislative foundations for their use is very high. The absence of appropriate rules and regulations that would regulate this activity can pose a threat to the health of people, animals and plants, and can also cause a negative impact on environmental objects.

Therefore, the legislative basis for the use of agricultural drones in Ukraine is a necessity that will allow the achievement of the goals of state regulation and provide an opportunity to create a legal basis for the safe application of pesticides from the air using agricultural drones, which will contribute to increasing the level of environmental safety of the natural environment and public health, will have a positive impact on the development of technologies and their implementation, and in general on conducting business in Ukraine and creating new opportunities for it.

The aim of the research – is to improve the methodology for assessing working conditions and calculating risks, considering the peculiarities of applying pesticides using unmanned aerial vehicles (UAVs).

Materials and methods of the research

Analysis of literature sources, results of field and laboratory experiments, computer modeling of the working solution spraying process during the treatment of agricultural crops, statistical processing of the obtained results – were used during the adaptation of sustainable approaches to assessing the working conditions of workers involved in working with pesticides, taking into account the features of the latest technologies.

Results of the research and their discussion

To date, Ukraine has developed and officially approved methodological recommendations for risk assessment for agricultural workers, including during aerial processing [9]. We conducted a series of field studies, the results of which were used in the calculation of occupational risks when applying pesticides using unmanned aerial vehicles (UAVs) from the air during the treatment of agricultural crops [10, 11].

In a number of cases, occupational risks when using UAVs did not differ significantly, or were even higher, than during aerial treatments from an airplane, although in both cases residual amounts of the active ingredients of the studied formulations were not detected in patches on overalls and skin washes [12, 13]. This is one of the shortcomings of the above-mentioned methodological guidelines for risk assessment [9], because they do not take into account that the operator of the agrodrone, unlike the pilot, is not in the cockpit of the aircraft, but stands at a certain distance from the edge of the field, i.e. the risk should be less because of distance. The risk for an agrocopter refueler (it can be operator) should also be much lower than for an airplane refueler, since, in most cases, the application of plant protection chemicals by UAV is supposed to be an ultra-low-volume or low-volume method. That is, the total consumption of the working solution ranges from 5 to 50 l/ha (on average up to 15 l/ha). Filling the tank of the sprayer during aerial application of pesticides and the consumption rate of the working solution ranges from 50 to 100 l/ha (on average up to 75 l/ha). Therefore, by reducing the volume of the working solution, the refueling time should be reduced, and therefore the exposure of the refueler [14].

We propose to improve the methodology for assessing working conditions and calculating risks, considering the peculiarities of applying pesticides using agricultural drones.

It is suggested that the following features be taken into account when calculating the risks for workers carrying out processing from the air with the help of UAVs:

1) the absence of a ground support group: a signalman, and sometimes a refueler (therefore, it is necessary to provide an opportunity to calculate the risk for the refueling operator);

ISSN 2223-6775, Ukrainian Journal of Occupational Health, 2024, 20 (1), 54–58

2) locating the agrodrone operator at a distance from the treated field (on the launch pad);

3) the volume of the working solution;

4) the height of the flight over the crop and the duration of treatment.

Mandatory parameters that must be taken into account when calculating risks are the consumption rate of the working solution, the volume of the tank, the capacity of the agricultural drone, the drops size (type of nozzles), the movement speed, the height of the drone flight and the spraying width, meteorological conditions during treatment (humidity and air temperature, wind speed and direction, solar radiation intensity, etc.).

Considering the above-mentioned features, we offer the following additions (point by point) to the methodological recommendations for occupational risk assessment, which will take into account the specifics of applying pesticides from the air using UAVs.

P. 3.2 and 3.3 – it should be additionally noted that for the refueler-operator, air sampling of the breathing zone (aka his working zone) is carried out three times: before starting work, during refueling (and in most cases, simply attaching the finished tank with the working solution to the agrodrone) and when treatment is carried out on the launch pad outside the processed field.

P. 3.9.1, formula 3.2 – for UAV treatment, it is necessary to specify:

- options for the duration of the production operation (t, min) during refueling and spraying – refueling the agrodrone tank up to 5 minutes (when using a mixing station to prepare the working solution – up to 3 min), spraying up to 10 minutes;
- data for calculating the normalized number of cycles (repeated sets of operations) per work shift (n), namely: the productivity of different types of drones (R, ha/min) – approximately 0.4 ha/min, the duration of a work shift or the formulation application, intended for retail sale to the public when processing 0.1 ha (t, min) – 60 minutes, the volume of the tank for the working solution (or the actual volume of the spent working solution) (V, l) – 20 l, the consumption rate of working solution (v, l/ha) – 5–15 l/ha.

P. 4.7, formula 4.1 – if necessary, specify the typical number of production cycles for UAV processing per work shift or per contact period during the day (N) or weekends for their calculation, the average duration of one production cycle is 15 minutes and the duration of the work shift/period of contact – when using an active ingredient and its formulation of the first and second hazard classes, the duration of action is 240 minutes, for the third and fourth hazard classes – 360 minutes, or cases when the formulation intended for retail sale for treatment of an area of 0.1 hectare, used within 60 minutes.

P. 4.7.1., formula 4.2 – similar to formula 3.2, add data regarding options for the duration of the production operation during refueling and spraying (t, min) – refueling the agrodrone tank up to 5 minutes (when using a mixing station to prepare the working solution – up to 3 minutes), spraying up to 10 minutes; data for calculating the normalized number of cycles per work shift (n): productivity (P, ha/min) – 0.4 ha/min, duration of the work shift/contact period – when using the active ingredient and its formulation of the 1st and 2nd hazard classes, the duration is 240 minutes, for the 3rd and 4th hazard classes – 360 minutes, in the case when the formulation intended for retail sale for the treatment of an area of 0.1 hectare is used for 60 minutes, the volume of the tank for the working solution (or the actual volume of the spent working solution) (V, l) – 20 l, the consumption rate of the working solution (v, l/ha) – 5–15 l/ha.

P. 5.1 – it should be indicated that for professional contingents engaged in the treatment of agricultural crops using unmanned aerial vehicles, the preferred way of potential income of active ingredients of the used pesticide when filling the tank will be percutaneous, but only in cases of not using a mixing station to prepare the working solution or potential contingencies. During crop treatment, the main route of entry into the body of the drone operator will be inhalation, since the spread of a small amount of pesticide with wind gusts to the work site, where the operator is actually located, is more likely than drops falling on the skin at such a significant distance.

P. 5.6 – reduction of the risk of inhalation and percutaneous exposure of pesticides to professional contingents (drone refueler-operator) should be ensured:

- the priority is to use a closed type of refueling the agrodrone with a working solution (a mixing station for preparing the working solution), i.e. attaching a tank with a ready-made mixture of the required composition and concentration to the agrocopter;
- placement of the launch site at a sufficient distance from the cultivated field (it was experimentally established that at a distance of 30 m from the edge of the field, the active substances of the applied pesticide preparation were not detected).

ISSN 2223-6775, Ukrainian Journal of Occupational Health, 2024, 20 (1), 54–58

Therefore, the proposed additions to the methodological recommendations for assessing and reducing risks for workers who apply pesticides from the air with the unmanned aerial vehicles will ensure their detailed study of the features associated with the use of UAVs, will allow identifying potential risk factors and taking measures for them prevention.

Conclusions

1. Unmanned aerial vehicles open a new era in the application of pesticides and the implementation of agricultural treatments. Agrodrones allow precise and targeted application of pesticides, which significantly reduces losses and negative impact on the environment. Since this technology is quite new, the scientific and methodological base for its optimization and effective use has not yet been fully developed. The development of methodological recommendations regulating the work with agricultural drones is an important step in the improvement and safe use of the technology of applying pesticides from the air using UAVs. These recommendations contribute to the development of the agricultural sector, improve the quality of products and contribute to the preservation of human health and the environment.
2. Additions to methodological recommendations on risk assessment and mitigation for workers applying pesticides from the air with the help of unmanned aerial vehicles are proposed. This will provide a more correct assessment of the professional risks associated with the use of this technology. This approach contributes to the creation of a more complete and balanced set of recommendations for UAV operators, which as a result ensures the safety, efficiency and sustainability of the use of this technology in agriculture.

References

1. Tsouros DC, Bibi S, Sarigiannidis P G. A review on UAV-based applications for precision agriculture. Information. 2019;10(11):349. DOI: https://doi.org/10.3390/info10110349.

2. Mogili UMR, Deepak B. Review on application of drone systems in precision agriculture. Procedia computer science. 2018;133:502-9. DOI: https://doi.org/10.1016/j.procs.2018.07.063.

3. Nduku L, Munghemezulu C, Mashaba-Munghemezulu, et al. Global Research Trends for Unmanned Aerial Vehicle Remote Sensing Application in Wheat Crop Monitoring. Geomatics. 2023;3(1):115-36. DOI: https://doi.org/10.3390/geomatics3010006.

4. He X. Rapid development of unmanned aerial vehicles (UAV) for plant protection and application technology in China. Outlooks on Pest Management. 2018;29(4):162-7. DOI: https://doi.org/10.1564/v29_aug_04.

5. Velusamy P, Rajendran S, Mahendran RK, et al. Unmanned Aerial Vehicles (UAV) in precision agriculture: Applications and challenges. Energies. 2021;15(1):217. DOI: https://doi.org/10.3390/en15010217.

6. Wachenheim C, Fan L, Zheng S. Adoption of unmanned aerial vehicles for pesticide application: Role of social network, resource endowment, and perceptions. Technology in Society. 2021;64:101470. DOI: https://doi.org/10.1016/j.techsoc.2020.101470.

7. Wang G, Han Y, Li X, et al. Field evaluation of spray drift and environmental impact using an agricultural unmanned aerial vehicle (UAV) sprayer. Science of the Total Environment. 2020;737:139793. DOI: https://doi.org/10.1016/j.scitotenv.2020.139793.

8. Qin W, Chen P. Current Research on Deposition and Drift of Droplets Sprayed by Plant Protection UAV. Version: 1. Research Square [Preprint]. 2023 07 Mar [cited 2023 Mar 30]. Available from: https://www.researchsquare.com/article/rs-2607730/v1. DOI: https://doi.org/10.21203/rs.3.rs-2607730/v1.

9. [Study, assessment and reduction of the risk of inhalation and percutaneous exposure of pesticides to persons who work with them or may be exposed during and after chemical protection of plants and other objects: Methodological recommendations]. Approved by order of the Ministry of Health of Ukraine No. 324 (May 13, 2009). Kyiv: Ministry of Health of Ukraine; 2009. 29 p. Ukrainian.

10. Borysenko AA., Shpak BI., Omelchuk ST, et al. Hygienic evaluation of the most common methods of agricultural crops treatment with chemical protection products (literature review). Medicni perspektivi. 2021;26(3):19-25. DOI: https://doi.org/10.26641/2307-0404.2021.3.241913.

11. Borysenko AA, Omelchuk ST, Bardov VG, et al. Comparative hygienic assessment of working conditions and occupational risk in the application of pesticides (on the example of fungicide amistar extra 280, sc) using different types of sprayers. Wiadomości Lekarskie. 2021;74(3 Pt 2):726-30. DOI: https://doi.org/10.36740/WLek202103230.

12. Borysenko A, Antonenko A, Omelchuk S, et al. Ecological and hygienic assessment and regulation of innovative technology of pesticide application using unmanned aerial vehicles. Rawal Medical Journal. 2022;47(1):213-16. Available from: http://ir.librarynmu.com/handle/123456789/7307.

ISSN 2223-6775, Ukrainian Journal of Occupational Health, 2024, 20 (1), 54–58

13. Borysenko A, Tkachenko I, Antonenko A. Comparative hygienic assessment of working conditions and potential risks for workers' health when applying pesticides in different technics. In: Technology transfer: innovative solutions in medisine: Proceedings of the 5th Annual Conference; 2021 Oct 28; Tallinn, Estonia. 2021. p. 6-8. DOI: https://doi.org/10.21303/ 2585-6634.2021.002146.

14. Borysenko AA, Antonenko AM, Omelchuk ST, et al. Professional risks when applying pesticides using unmanned aircraft: features and comparative hygienic assessment. Medical Science of Ukraine (MSU). 2021;17(4):102-7. DOI: https://doi.org/10.32345/2664-4738.4.2021.15.

Потенційні та явні конфлікти інтересів, які пов'язані з рукописом, відсутні.

Борисенко А. А., Антоненко А. М.

УДОСКОНАЛЕННЯ МЕТОДИКИ ОЦІНКИ УМОВ ПРАЦІ ТА РОЗРАХУНКУ РИЗИКІВ З УРАХУВАННЯМ ОСОБЛИВОСТЕЙ ВНЕСЕННЯ ПЕСТИЦИДІВ ЗА ДОПОМОГОЮ БЕЗПІЛОТНИХ ЛІТАЛЬНИХ АПАРАТІВ (БПЛА)

Кафедра гігієни та екології Національного медичного університету імені О. О. Богомольця, м. Київ

Вступ. Впровадження сучасних технологій у сільське господарство України, таких як використання безпілотних літальних апаратів (БПЛА), має великий потенціал для революції та забезпечення продовольчої безпеки країни. Зважаючи на те, що застосування сільськогосподарських дронів є досить новим явищем на аграрному ринку України, необхідність законодавчих основ для їхнього використання дуже висока. Відсутність відповідних правил і норм, які б регулювали цю діяльність, може становити загрозу для здоров'я людини, тварин і рослин, а також може викликати негативний вплив на об'єкти довкілля.
Мета дослідження – удосконалення методики оцінки умов праці та розрахунку ризиків з урахуванням особливостей внесення пестицидів за допомогою безпілотних літальних апаратів.
Матеріали та методи дослідження. Аналіз джерел літератури, результати натурного та лабораторного експериментів, комп'ютерне моделювання процесу розпилення робочого розчину під час обробки агрокультур, статистична обробка отриманих результатів були використані під час проведення адаптації сталих підходів оцінки умов праці робітників, які задіяні в роботі з пестицидами.
Результати. Пропонується під час розрахунку ризиків для працівників, що проводять обробки з повітря за допомогою БПЛА, враховувати такі особливості: 1) відсутність групи наземної підтримки: сигнальника, а іноді й заправника (тому треба закласти можливість розрахунку ризику для оператора-заправника); 2) знаходження оператора агродрона на відстані від оброблюваного поля (на стартовому майданчику); 3) об'єм робочого розчину; 4) висоту прольоту над культурою та тривалість обробки. Обов'язковими параметрами, які необхідно враховувати при розрахунку ризиків, є норма витрати робочого розчину, об'єм бака, потужність агродрона, розмір крапель (тип форсунок), швидкість руху, висоту польоту дрона та ширину обприскування, метеорологічні умови під час обробки (вологість і температура повітря, швидкість і напрямок вітру, інтенсивність сонячної радіації тощо).
Висновки. Запропоновано доповнення до методичних рекомендацій щодо оцінки та зменшення ризиків для працівників, які виконують внесення пестицидів з повітря за допомогою БПЛА. Це забезпечить більш коректну оцінку професійних ризиків, які пов'язані з використанням цієї технології. Такий підхід сприяє створенню більш повного та збалансованого набору рекомендацій для операторів БПЛА, що в результаті забезпечує безпеку, ефективність і сталість використання цієї технології в сільському господарстві.

Ключові слова: професійний ризик, агродрон, хімічні засоби захисту рослин, ультрамалооб'ємне внесення, умови праці

ORCID ID співавторів та їхній внесок у підготовку та написання статті:
Борисенко А. А. (ORCID ID 0000-0002-0211-607X) – збір та наукова обробка даних, аналіз та інтерпретація даних, статистична експертиза, оцінка отриманих результатів, формування висновків, складання, оформлення та підготовка статті до друку;
Антоненко А. М. (ORCID ID 0000-0001-9665-0646) – визначення актуальності, розробка плану та мети дослідження, аналіз та узагальнення отриманих результатів, остаточне затвердження та гарант статті.

Надійшла: 1 березня 2024 р.
Прийнята до друку: 26 березня 2024 р.

Контактна особа: Борисенко Андрій Анатолійович, кандидат медичних наук, доцент, кафедра гігієни та екології № 1, Національний медичний університет імені О. О. Богомольця, буд. 34, просп. Берестейський, м. Київ. Електронна пошта: Andrey-b.07@ukr.net