Вісник Тернопільського національного технічного університету
https://doi.org/10.33108/visnyk_tntu
Scientific Journal of the Ternopil National Technical University
2020, № 2 (98) https://doi.org/10.33108/visnyk_tntu2020.02
ISSN 2522-4433. Web: ***visnyk.tntu.edu.ua***

UDC 632.08

STUDY OF THE EFFICIENCY OF WORKING MIXTURE APPLICATION IN CHEMICAL CROP PROTECTION

Andrii Babii

Ternopil Ivan Puluj National Technical University, Ternopil, Ukraine

Summary. *The efficiency of chemical working mixture application on the surface of agricultural plants by rod sprayers has been studied in the paper under consideration. The analysis of specific fractures of main crops sprayed areas with pesticides in agro-industrial production in 2018 was made. The method of the sprayer efficiency assessment was described and some graphical and analytical dependences for selected slit sprayers on the formation of the working mixture spray dispersion and the pressure choice in the pressure mains on the sprayer speed at specified spraying rate were built.*
Key words*: chemical crop protection, pesticide, rod sprayer, slit sprayer, spray dispersion.*

https://doi.org/10.33108/visnyk_tntu2020.02.099 *Received 23.05.2020*

Problem statement. The considerable growth of population on the Earth is setting some essential tasks before the agricultural producers on agricultural products gross output increase. Not only the production capacity has to be increased but also cost per-unit must be minimal so that the products could be affordable by any segment of population with different shopping capacity.

Ukrainian agricultural market has one of the biggest rates of growth. The farming standards have been largely increased, new and progressive production technologies of crop and animal production have been mastered for the last 10–15 years. All these facts have contributed to the harvest increase but not necessarily to the production cost reduction. As, for example, in respect to crop agriculture there are many reasons: the use of purchased or hired-in expensive imported equipment, its servicing, high cost of quality seeds, fertilizers, protection products. Moreover, freight transport logistics of products delivery «from the field» to the centers of primary revision and further transportation is not still perfect etc.

All these problems should be solved step by step. Thus, when choosing the subject of the investigation the focus was made on the technological procedures of crops fertilization and protection. In this case, apart from financial load on the producer the ecological aspect is rather important. The first and the most important condition is to keep to the scientifically substantiated standards of the fertilizer application rate to minimize the harmful impact in crops fertilization and protection.

Analysis of the related research and published papers. Taking into consideration the focus on crop protection the analysis of a number of literary sources has been made. In particular, the authors have described the methods of crop protection in a slightly different manner. For instance, in [1] the methods were divided into the following categories: organizational-economic, agro-technical, mechanical, physical, biological, chemical and integrated. A group of authors in [2] has paid special attention to the following methods of crop protection: genetic, agro-technical, biological, chemical and integrated. Though, all the scientists have agreed that none of the methods provides the 100% protection. The most efficient is the integrated method which combined the above-mentioned methods taking into account the specific case effectively. In this integrated protection the chemical method is the most important one due to its efficiency and profitability. Nevertheless, under procedure violations conditions of a chemical working mixture application its long-term use may by extremely harmful for the flora and fauna causing drastic consequences.

Paper purpose. The aim of the study under discussion is to investigate the factors making impact on the efficiency of the working mixture application on the crop surface at chemical protection.

Results of the study. According to different data, the mankind has used a chemical method of crop protection for more than 4500 years [3]. The first pesticide – Sulphur dust was first mentioned as early as in ancient Sumeria. Moreover, there are numerous historical evidences which can prove that our ancestors used different poisonous plants in crop pest control. The history of chemical crop protection is rather long and quite interesting: there have been outstanding ups and downs. For instance, after a chemical had been discovered and its efficiency in crop protection had been proved it became very popular and a big seller but after a while the scientists found that it was very toxic and they inhibited to use the treatment by the agent.

Insecticide dichlorodiphenyltrichloroethane (chemical name: 1,1,1-trichloro-2,2-di (4-chlorophenyl) ethane), abbreviated DDT can be a perfect example of the history of chemical crop protection. This white crystalline substance, tasteless and almost odorless is an efficient pesticide. According to the data [4] the above-mentioned substance was synthetically produced by an Austrian chemist O. Zeidler in 1873 but was not used at that time. As an insecticide it was discovered by Swiss chemist P. Muller in 1939. The obtained insecticide was extremely popular all over the world. In 1948 a Nobel Prize in physiology and medicine was awarded to chemist Paul Herman Muller for the DDT high efficiency discovery as a contact poison.

Although, the considerable efficiency of the insecticide against different crop pests was deteriorated by its high resistance to decay in the environment and consequently it resulted in ability to be stored in human and animal bodies, destroy the immune system etc. Finally, DDT is banned to be used practically in all countries of the world. In 1972 it was forbidden in the USA and many other countries but the decisive ban from its use was made by the United Nations in 2001 after these chemicals were recognized as toxic ones [5]. Nevertheless, this group of chemicals is still used in separate cases in the world experience. This is especially true in regard to malaria treatment.

The modern list (2019) of chemicals allowed in Ukraine includes more than 9000 items [6]. All of them are considered to be safe for people and environment at the present stage of research and use under observance of application procedure requirements when rate of application is the main criterion.

According to the statistical data [7] approximately 16 mln ha of agriculturally used area was sprayed by pesticides in Ukraine to gather in the crops in 2018. However, they took into considerations only the cultivation area of the farming enterprises having more than 200 ha and the areas of temporarily occupied territories were not included.

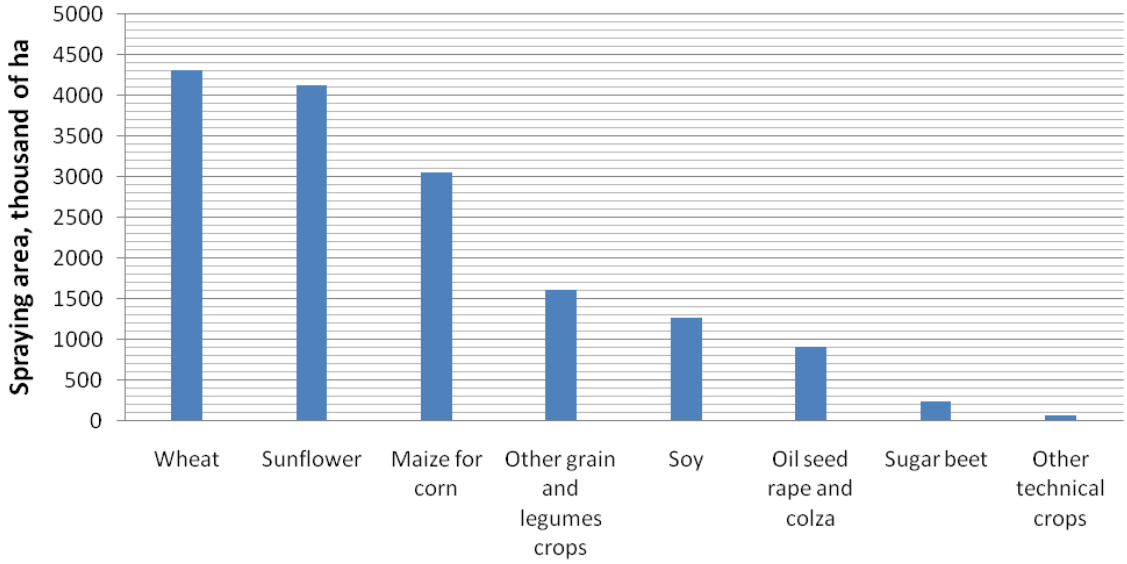


Figure1. Diagram of the areas division planted with major crops sprayed with pesticides in 2018

As you can see from the results of the analysis we have made, the infinite number of spraying machines must be involved in the spraying process to cover all these areas, and chemical crop protection was carried out many times. That is why the requirements to these machines are so high. Though, the most important requirement is the overall spread of working mixture on the crop surface according to the specified fertilizer rate.

According to the different literary sources analysis, agro-technical requirements to the spraying apparatuses are quite different. The requirements to the spraying quality are getting higher. For example, all authors [1, 8, 9] have agreed that weeping should make more than 80% of the upper part of the leaves and not less than 60% of the lower one. As for the deviation in fertilizer application rate, here the authors [1, 10] writes about +15% and -20%, though in the paper [9] these figures are a bit lower: the deviation should not exceed 5%, when the spraying control is automatic and 10% – at normal inspection. It can be explained by the higher requirements to the process of spraying at higher technology level of crop spraying apparatuses operation. Spraying unevenness by the spraying boom operating width should not exceed 30% [1] and 25% [9], and by the furrow length – 25% and 20% respectively. The speed of wind should not exceed 5 m/s, and the temperature of air should not be higher than 23^0C.

There is no the common standard on agricultural and technical requirements to the spraying machines nowadays and plants-producers are using the developed General specifications for such machines making.

From a technical point of view, the operational life of a sprayer must be not less than 1800 hours at annual duty 300 h [9]. The anticipated endurance is regulated by the General specifications and the above-mentioned figures can vary greatly. For example, the annual duty at the plant Lvivagromashproject is 320 h, operational life in not less than 5 years. Having analyzed the test protocol of the vessel Agro-200E (made by LLC «Chimbudplastmas») [11], conducted by a state institution «Ukrainian L.Pohorilyi scientific- research institute of equipment and technologies forecasting and testing for agricultural production» it was found that annual specified value equals to 550 h per spraying machine.

Amount and quality of the working mixture application on the crop surfaces is a direct function of the spray dispersion applied per unit of the area: 20–30 drops/sm^2 – for insecticides and systemic herbicides, 30–40 drops/sm^2 – for contact herbicides, 50–70 drops/sm^2 – for fungicides. Thus, using different types of spraying machines and setting the appropriate pressure in the pressure mains the necessary size of drops can be practically achieved. Due to the above mentioned characteristics there are different modes of spraying: ordinary or of full volume spraying – drops of 600…250 μm, low- volume – 250…100 μm, ultra low volume – 100…20 μm.

Spraying machine performance quality according to the method [8] can be estimated by the following criteria:

– average diameter of drop d_{cp}

$$d_{cp} = \frac{\sqrt{d_{сл}}}{(4\sin^3\alpha/(2+\cos^3\alpha-3\cos\alpha))^{\frac{1}{6}}}, \qquad (1)$$

where $d_{сл}$ – measured diameter of the drop trace, μm;
α – angle between tangent to the drop in its cross-section with the sprayed surface and the surface itself;

– degree of coverage by drops of the sprayed surface k (%) is calculated using the dependence

$$k = \frac{25\pi}{S_0}\sum d_i^2 n_i\,, \qquad (2)$$

where $d_1, d_2 \ldots d_n$ – drops trace diameters, μm;
$n_1, n_2 \ldots n_n$ – number of drops of each size;
S_0 – the area under study, μm ^{2};

– drop effective action coefficient $k_д$ is found as

$$k_д = \frac{S_{еф}}{S_{сл}} = \frac{(d_{сл}+2r)^2}{d_{сл}^2}, \qquad (3)$$

where $S_{сл}$ – drop trace area, $S_{сл} = 0{,}78 d_{сл}^2$;
$S_{еф}$ – area of drop effective action, $S_{еф} = 0{,}78(d_{сл}+2r)^2$;
r – effective action zone (r = 100... 200 μm).

Then the degree of the drops effective coverage of the sprayed surface $k_{еф}$ will be found as

$$k_{еф} = k_д k. \qquad (4)$$

The expression (4) proves that the smaller the drop size the bigger is the coefficient of its effective action but it should be mentioned only providing the condition when the formed fine particles settle on the object under spraying surface.

Practical experiments have proved [10, 12, 8], that the drops of the same mixture but of different size (at the rest equal conditions) have quite different toxic properties. Under the action of surface tension force of the liquid bigger particles may either roll down on the inclined surface on the soil or burn the crops in case they stay on the surface. While analyzing the action of smaller particles, for example at ultralow spraying, toxic properties and uniform spraying of the mixture are increasing providing the weather is windless as fine particles evaporate quickly, they can be easily blown away by the air flows and can deposit on other areas where the crops spraying wasn't intended. Moreover, if spraying speed is within 15–20 km/h, and modern spraying machines allow to implement this, one more problem is arising – swirl flows behind the working tool of the machine and its components. Besides, rising flows of warm air heated by the soil are to be added etc. These problems are especially important when the distance between the spraying tool and the sprayed object is more than 0,5 m.

Thus one must take into account and combine the technological characteristics of working mixture, phases of crops biological growth, nature conditions when the technological procedure takes place, parameters of the technical facilities to provide spraying etc.

Low-volume spraying with the flow within 200 l/ha is considered to be the most efficient for an average commercial farm unit, as ultra-low spraying should be performed by the sprayers having special systems of fine particles precipitation.

The type of sprayer is the decisive criterion for the spray dispersion, namely the shape of spraying swath, mixture uniform distribution and coverage are of primary importance. As a rule, as they leave the spraying nozzle the sprayers have polydisperse spraying spectrum, i.e. drops of various size are formed (Figure 2 [13]), and only rotational movements allow to obtain monodisperse spectrum – drops of the same size.

As for the working mixture disperse area, the Figure 2 shows their approximate distribution in a slit sprayer swath [13]. The author underlines the interrelation between the drop size and their capability to cover and stay on the surface of the object under application and also to be blown away by the air flow and to be evaporated.

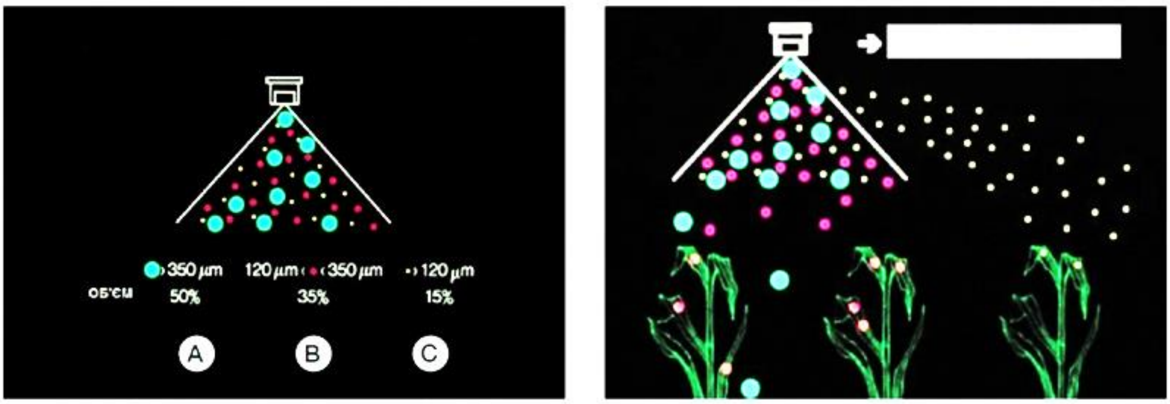
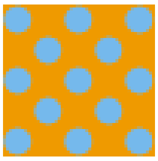
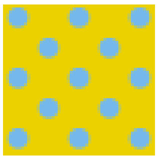
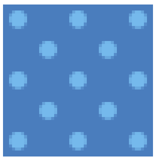
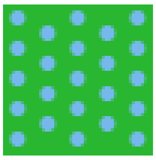
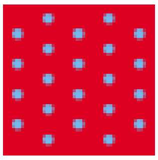


Figure 2. Example of the polydisperse spraying spectrum of the work mixture
A – coarse disperse spraying (500 μm); B – medium disperse spraying (120…350 μm);
C – small disperse spraying (120 μm)

Using the standard BCPC/ASAE, for the spray dispersion classification of working mixture by spraying machines the Table 1 can be made which will specify the interrelation of drop size, the type of spraying machine and range of usage of the specified chemical [14].

Table 1

Drops size according to the standard BCPC/ASAE [14]

Range of drop size	МОД, μm	Graphic symbol	Spraying machine model	Range of use
Extremely large	>575		ID, IDN – low pressure	Chemicals for systemic use, liquid fertilizers, soil herbicides
Very large	450–575		ID, IDN, IDK, IDKN – low pressure	Chemicals for systemic use
>large	350–450		ID, IDN, IDK, IDKN, IDKT, AD – low pressure	Chemicals for systemic use, contact chemicals
Average	250–350		IDK, IDKN, IDKT, AD, LU – low pressure	Systemic fungicides, systemic insecticides, herbicides
Small	125–250		LU, ST, SC, DF	Contact fungicides, contact insecticides, herbicides

Some graphical dependencies of working mixture spray dispersion formation and choice of pressure in the pressure mains on the sprayer speed for the most widely spread typical size of slit sprayer providing the specified rate of application 200 l/ha are presented on Figure 3.

The analytical dependencies of their approximation curves are the following:

– for slit sprayer ID-04

$$y_{ID} = 0{,}024x^4 - 1{,}273x^3 + 24{,}91x^2 - 214{,}4x + 691{,}0; \quad (5)$$

– for IDK-04

$$y_{IDK} = 0{,}062x^3 - 1{,}977x^2 + 20{,}15x - 61{,}72. \quad (6)$$

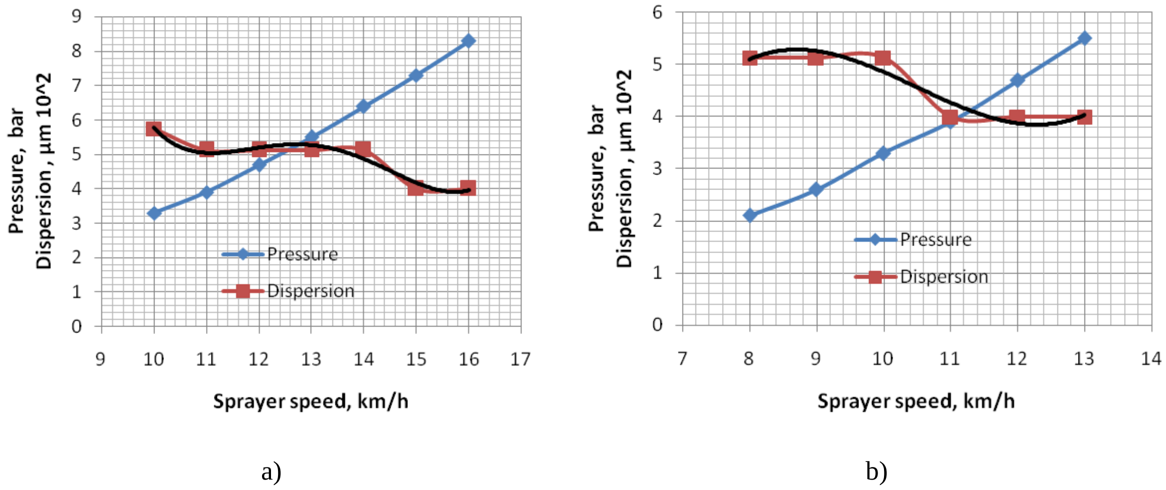


Figure 3. Graphical dependencies of the creation of the work mixture dispersion and the pressure choice in pressure line of sprayer speed
a – for slit sprayer ID-04; b – for IDK-04

Slit sprayers producers make them in color so that it will be easier to use. This tradition appeared in the USA though nowadays it is used by European producers as well [15].

It should be admitted that for the recent years liquid complex fertilizers application is getting more and more popular among the crop products producers. Carbamide-ammonia mixture (CAM) is the flagship among such group of chemicals. This is water solution of carbamide and ammonia nitrate at a ratio: 35,4% of carbamide, 44,3% nitrate fertilizer, 19,4% of water, 0,5% of ammonia water [16]. This mixture has considerable technological advantages over solid nitrogenous fertilizers as it doesn't contain free ammonia.

Chemical formula of CAM is [17]

$$NH_4NO_3–(NH_2)_2CO–H_2O. \quad (7)$$

The above-mentioned fertilizer is quite unique as it contains nitrogen in three forms: nitrate, ammonia and amidic. It allows to act immediately when the process of nitrification and the transition to nitrate form is taking place and after that due to the results of soil microorganisms it is followed by ammonia form and then by the nitrate one. [16].

The possibility of being in different forms allows either to start crop feeding immediately or to expand the time of feeding. As there is no free ammonia in the mixture, some surface treatment is possible.

In most cases CAM are being applied in autumn before the primary soil cultivation, in spring before the soil conditioning and also in the period of crops vegetation as root dressing or top dressing.

In case of leaf-feeding dressing here CAM can be combined in different tank mixtures, for example by adding microelements or protection aids.

Apart from technological and biological efficiency at CAM application one should keep to the strict rules[18]: fertilizers must be applied only by fitted spraying devices made of acid-resistant metals when contact with the mixture and the sprayers themselves must be ceramic and provide large-drop spraying at low pressure; when applied with pesticides or microelements which according to the technology have to cover the maximum crop surface with small drops, in case of tank mixture the drops must be larger so that they do not stay on the crop surface and leave it to avoid crop burning; CAM treatment must be done only when the leaves surface is dry, in another case the crop may receive a burn.

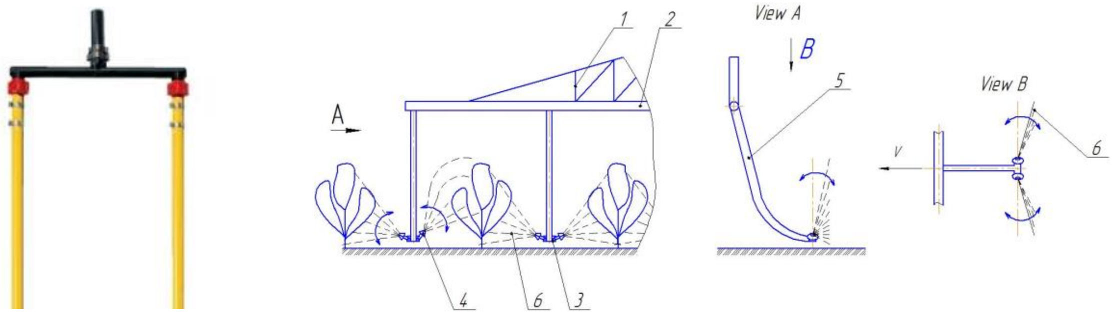
Thus, apart from the above-mentioned types of spraying devices for surface spraying the special attention is paid to the spraying machines for liquid complex fertilizers application whose samples are on Figure 4.

Figure 4. Spraying nozzles for liquid complex fertilizers application [18]

For example, five jet spraying unit FL made by Lechler (Germany) for liquid fertilizers CAM is designed to provide multiple-jet spraying in horizontal plane. There are grey and black standard sizes which can be combined with dosing gaskets in different ways. The process pressure varies from 0,8 to 1,8 bar. Dosing gaskets are made of high-quality steel V2A (corrosion-resistant).

Sprayers of FD series have a deflector sprayer з with horizontal torch of the work mixture dispersion. They are produced of the following standard sizes: 04, 05, 06, 08, 10, 15, 20; operating pressure – 1,5–4,0 bar. Their advantage over the multiple-jet sprayer is that they are less blocked by contaminants.

Nevertheless, the simplest and the most reliable device for CAM application is the system of suspension brackets from hoses, Figure 5 a [18], or invented rod according to patent [19], Figure 5 b.



a) b)

Figure 5. Device for liquid complex fertilizers applying using rod sprayer
a – system of suspension brackets from hoses; b – invented (improved) rod (patent [19]):
1 – section frame; 2 – pipeline; 3 – head; 4 – spraying devices; 5 – vertical curved pipelines; 6 – torch of the work mixture dispersion

In the rod device (Figure 5 a) the hoses are set in step of 0,25 m, the mixture is supplied under pressure of the range from 1,0 to 10 bar, providing the minimal possibility of the chemical entry on the crop leaves, besides the working mixture can be discrete etc.. The rod (Figure 5 b) is designed to operate in low spray mode of field crops or in the spray dressing mode. Its curved pipelines 5 опускають the heads 3 of spraying devices 4 close to the root system (under leaves space) and by fixing them in a certain position the necessary torch angle of working mixture dispersion 6, facilitating the most efficient availability of the working mixture by the crop.

Some similar decisions on possible variation of torch angle of working mixture dispersion were described in the patents [20, 21], where a special rotating-fixing mechanism allows to fix the rod in the certain position and in this way to direct the working jet as desired.

Thus, if we assume that some drops of specified size are the most effective in one or another way of spraying then one should guarantee the stability and the same concentration of the sprayed working mixture along the whole rod width to provide the specified application rate by spraying devices. Hence, a new task is arising- to provide the rod stabilization by height and horizontally as at its position varies the number of drops per crop surface area unit is greatly changed [22, 23].

Conclusions. Having analyzed the statistical data it was found that more than 16 mln ha of areas were pesticide-treated in Ukraine in 2018. In this case multiple chemical crop protection was observed. For that purpose the summary of agricultural and technical requirements has been done, the procedure of their performance quality assessment has been described and the analysis of factors influencing the quality of working mixture application on crop surface has been made for agricultural spraying units. Moreover, the summarized data on drops size formed by the slit spraying devices according to BCPC/ASAE standards have been given and graphic and analytical dependences of working mixture spray dispersion and pressure selection in the pressure mains on the sprayer speed have been built.

References

1. Vojtyuk D. G., Dubrovin V. O., Ishhenko T. D. ta in. *Sil`s`kogospodars*`ki ta melioraty`vni mashy`ny`: Pidruchny`k / za red. D. G. Vojtyuka. K.: Vy`shha osvita, 2004. 544 p.
2. *Strategiya* i takty`ka zaxy`stu rosly`n. t. 1 Strategiya / pid redakciyeyu akademika NAAN Ukrayiny`, doktora biologichny`x nauk, profesora V. P. Fedorenka. K.: Al`fa-steviya, 2012. 500 p. (Intensy`vne zemlerobstvo). Monografiya.
3. Tetyana Byelins`ka *Pesty`cy`dy`:* istory`chny`j ekskurs ta perspekty`vy`. AgroElita, 2017. URL: https://agroprod.biz/2017/12/21/pestytsydy-istorychnyj-ekskurs-ta-perspektyvy/.
4. *DDT.* Vikipediya. URL: https://uk.wikipedia.org/wiki/DDT.
5. Inna Kolesny`k OON pragne zaborony`ty` pesty`cy`d DDT. ORGANIC UA, 2010. URL: http://organic.ua/lib/198-oon-pragne-zaboronyty-pestycyd-ddt.
6. *Derzhavny`j* reyestr pesty`cy`div i agroximikativ, dozvoleny`x do vy`kory`stannya v Ukrayini 2019 roci.
7. *Vy`kory`stannya* dobry`v i pesty`cy`div pid urozhaj sil`s`kogospodars`ky`x kul`tur 2018 rok. Derzhavna sluzhba staty`sty`ky` Ukrayiny`. URL: http://ukrstat.gov.ua.
8. Ly`stopad G. E., Semenov A. N., Demy`dov T. K. y` dr. *Sel`skoxozyajstvennie* y` mely`oraty`vnые mashy`nы. M.: Kolos, 1976. 751 p.
9. A*grotexnichni* vy`mogy` do shtangovy`x obpry`skuvachiv / kas32. URL: http://kas32.com/ua/post/view?id=421.
10. *Karpenko A. N.*, Xalansky`j V. M. Sel`skoxozyajstvennыe mashy`nы. 6-e y`zd., pererab. y` dop. M.: Agrapromy`dat, 1989. 527 p.
11. *Protokol No.* 01-06-2017 vid 28 bereznya 2017 r. pry`skoreny`x vy`probuvan` Yemkist` Agro-2000E (Kolir – natural`ny`j, serijny`j nomer No. 30121216).
12. Komary`stov V. E., Dunaj N. F. *Sel`skoxozyajstvennie* mashy`ni. K.: Vy`shha shk. Golovnoe uzd-vo, 1987. 486 p.
13. Lyudvinovs`ky`j O. *Yakist*` zastosuvannya zasobiv zaxy`stu rosly`n. Speczvy`pusk zh. Propozy`ciya. Suchasna texnika dlya zaxy`stu s.-g. kul`tur. 2017. P. 12–16.
14. *Dovidny`k* agronoma. Ukrayina. Avgust u sviti. URL: http://ua.avgust.com/kalkulyator_forsunok.
15. *Viby`raem* raspily`tely` (forsunky`) dlya oprisky`vany`ya pod konkretnuyu normu vily`va / kas32. URL: http://kas32.com/post/view/399.
16. *Karbamido-amiachna* sumish KAS-32 / kas32. URL: http://kas32.com/ua/post/view?id=54.
17. *Sely`tra* karbamy`d-ammy`achnaya (KAS). Pesty`сзыды.ru. URL: http://www.pesticidy.ru/active_compound/Urea-ammonium_nitrate.
18. *Pereoborudovany`e* oprisky`vatelya pod KAS. VIPzapchasti. URL: http://www.vipzapchasti.com/sprayer/raspyliteli_kas.html#15.

19. Babij A. V., Bortny`k I. M., Stashkiv M. Ya., Oleksyuk V. P Shtanga obpry`skuvacha. Deklaracijny`j patent na kory`snu model` 137527 A01M11/00, A01M7/00; zayavleno 15.04.2019, opublikovano 25.10.2019, byul. No. 20.
20. Babij A. V., Ry`bak T. I. Shtanga malogabary`tnogo obpry`skuvacha. Deklaracijny`j patent na vy`naxid 55199 A 7 A01M7/00 A01M11/00; zayavleno 18.07.2002, opublikovano 17.03.2003, byul. No. 3.
21. Babij A. V., Ry`bak T. I., Popovy`ch P. V. Povorotno-fiksuyuchy`j mexanizm shtangy` obpry`skuvacha. Deklaracijny`j patent na kory`snu model` 59390 A01M 7/00 A01M 11/00; zayavleno 17.11.2010 U201013645, opublikovano 10.05.2011, byul. No. 9.
22. *Babii A. (2019)* Parameters investigation for independent pendular suspension of sprayer boom. Scientific Journal of TNTU (Tern.), vol. 96, no. 4, pp. 90–100. https://doi.org/10.33108/visnyk_tntu2019.04.090
23. *Babii A., Babii M. (2019)* Taking impact of oscillation amplitude of bearing frame sections of boom sprayers into account on its resource. Scientific Journal of TNTU (Tern.), vol. 95, no. 3, pp. 97–104. https://doi.org/10.33108/visnyk_tntu2019.03.097

Список використаної літератури

1. Войтюк Д. Г., Дубровін В. О., Іщенко Т. Д. та ін. Сільськогосподарські та меліоративні машини: підручник / за ред. Д. Г. Войтюка. К.: Вища освіта, 2004. 544 с.
2. Стратегія і тактика захисту рослин. Т. 1 Стратегія. Інтенсивне землеробство: монографія / під редакцією академіка НААН України, доктора біологічних наук, професора В.П. Федоренка. К.: Альфа-стевія, 2012. 500 с.
3. Бєлінська Т. Пестициди: історичний екскурс та перспективи. АгроЕліта. 2017. URL: //agroprod.biz/ 2017/12/21/pestytsydy-istorychnyj-ekskurs-ta-perspektyvy/.
4. ДДТ. URL: упу: https://uk.wikipedia.org/wiki/ДДТ.
5. Колесник І. ООН прагне заборонити пестицид ДДТ. ORGANIC UA. 2010. URL: http://organic.ua/ lib/198-oon-pragne-zaboronyty-pestycyd-ddt.
6. Державний реєстр пестицидів і агрохімікатів, дозволених до використання в Україні 2019 році.
7. Використання добрив і пестицидів під урожай сільськогосподарських культур 2018 року. Державна служба статистики України. URL: http://ukrstat.gov.ua.
8. Листопад Г. Е., Семенов А. Н., Демидов Т. К. и др. Сельскохозяйственные и мелиоративные машины. М.: Колос, 1976. 751 с.
9. Агротехнічні вимоги до штангових обприскувачів. URL: http://kas32.com/ua/post/view?id=421.
10. Карпенко А. Н., Халанский В. М. Сельскохозяйственные машины. 6-е изд., перераб. и доп. М.: Агрannромидат, 1989. 527 с.
11. Протокол № 01-06-2017 від 28 березня 2017 р. прискорених випробувань Ємкість Агро-2000Е. (Колір – натуральний, серійний номер № 30121216).
12. Комаристов В. Е., Дунай Н. Ф. Сельскохозяйственные машины. К.: Вища шк. Головное узд-во, 1987. 486 с.
13. Людвіновський О. Якість застосування засобів захисту рослин. Спецвипуск ж. Пропозиція. Сучасна техніка для захисту с.-г. культур. 2017. С. 12–16.
14. Довідник агронома. Україна. Август у світі. URL: http://ua.avgust.com/kalkulyator_forsunok.
15. Выбираем распылители (форсунки) для опрыскивания под конкретную норму вылива. URL: http://kas32.com/post/view/399.
16. Карбамідо-аміачна суміш КАС-32. URL: http://kas32.com/ua/post/view?id=54.
17. Селитра карбамид-аммиачная (КАС). Пестицыды.ru. URL: http://www.pesticidy.ru/active_compound/ Urea-ammonium_nitrate.
18. Переоборудование опрыскивателя под КАС. URL: http://www.vipzapchasti.com/sprayer/raspyliteli _kas.html#15.
19. Бабій А. В., Бортник І. М., Сташків М. Я., Олексюк В. П Штанга обприскувача. Деклараційний патент на корисну модель 137527 A01M11/00, A01M7/00; заявлено 15.04.2019; опубліковано 25.10.2019, Бюл. № 20.
20. Бабій А. В., Рибак Т. І. Штанга малогабаритного обприскувача. Деклараційний патент на винахід 55199 А 7 A01M7/00 A01M11/00; заявлено 18.07.2002; опубліковано 17.03.2003, Бюл. № 3.
21. Бабій А. В., Рибак Т. І., Попович П. В. Поворотно-фіксуючий механізм штанги обприскувача. Деклараційний патент на корисну модель 59390 A01M 7/00 A01M 11/00; заявлено 17.11.2010 U201013645; опубліковано 10.05.2011, Бюл. № 9.
22. Babii A. Parameters investigation for independent pendular suspension of sprayer boom. Scientific Journal of TNTU. 2019. Vol. 96. No. 4. P. 90–100. https://doi.org/10.33108/visnyk_tntu2019.04.090
23. Babii A., Babii M. Taking impact of oscillation amplitude of bearing frame sections of boom sprayers into account on its resource. Scientific Journal of TNTU. 2019. Vol. 95. No. 3. P. 97–104. https://doi.org/ 10.33108/visnyk_tntu2019.03.097

УДК 632.08

ДОСЛІДЖЕННЯ ЕФЕКТИВНОСТІ ПРОЦЕСУ НАНЕСЕННЯ РОБОЧОГО ПРЕПАРАТУ ПРИ ХІМІЧНОМУ ЗАХИСТІ РОСЛИН

Андрій Бабій

Тернопільський національний технічний університет імені Івана Пулюя, Тернопіль, Україна

Резюме. *Обробка рослин хімічними препаратами залишається одним із найефективніших способів їх захисту. Попри екологічні ризики хімічного захисту він є найбільш дієвим і доступним способом, який використовується практично всіма світовими виробниками сільськогосподарської продукції. Водночас часто буває не до кінця досліджено дію тих чи інших препаратів, які використовуються в технології обробки. Тоді ми спостерігаємо їх високу ефективність, а з плином часу – загрозу для людини та довкілля. На прикладі інсектициду ДДТ (дихлордифенілтрихлорметилметан) це продемонстровано.*

Тому в роботі розглянуто актуальність різних способів захисту рослин, узагальнено їх та вказано на значну питому частку хімічного способу в загальній технології захисту рослин. Небезпека використання хімічного захисту часто лежить у площині недотримання науково обґрунтованих підходів до внесення таких препаратів на поверхні рослин чи ґрунту. Сюди відноситься як норма внесення, так і терміни виконання цієї технологічної операції.

Основною машиною для хімічного захисту рослин є штанговий обприскувач. Площі, які обробляються, щорічно сягають понад 16 млн. га за статистичними даними 2018 року. Зроблено аналіз питомих значень обробки основних сільськогосподарських культур. Для оцінювання ефективності роботи обприскувача наведено методику, яка кількісно дозволяє оцінити роботу такої машини.

Вказано на важливе значення розпилюючих наконечників щодо дотримання норми внесення хімічного препарату, які формують дисперсність розпилювання. Зроблено аналіз спектра розпилювання та наведено залежності розміру крапель від тиску в напірній магістралі обприскувача та узгодження з його робочою швидкістю. Для найпоширеніших щілинних розпилювачів побудовано графічні залежності дисперсності розпилювання робочого препарату від тиску та швидкості руху обприскувача.

При використанні обприскувача в ролі поверхневого підживлювача сільськогосподарських культур наведено ефективні пристосування та розроблену конструкцію штанги з нижнім розміщенням розпилюючих пристроїв.

Ключові слова*: хімічний захист рослин, пестицид, штанговий обприскувач, щілинний розпилювач, дисперсність розпилювання.*

https://doi.org/10.33108/visnyk_tntu2020.02.099 *Отримано 23.05.2020*