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The Spraying Technology on Iraqi Agricultural Researches

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Abstract: Many of the Iraqi agricultural researches are used spraying technique to add chemical products including pesticides and growth regulators. Various studies were performed to study the effect of these substances at different concentrations to improve plant production. In order to adopt specific criteria of spraying researches and to replicate them easily, it is a necessary to mention all information related to the spraying processes and regulations for improving sprayer's performance by increasing the amount of pesticide deposited on the target. The current study aims to survey Iraqi researches in details and analyse them randomly. Also, to highlight on the importance of information applied in spraying techniques and its relationship with improving of agricultural production. The survey showed most of these researches does not mention sufficiently the basic information, especially in the spraying or calibrating processes. These processes are important to ensure the best distribution of spraying in the field depending on type of sprayer, nozzle type, and operating pressure. Also, some of these researches do not show the application rate of pesticide and the factors affected on it, which may lead to imbalance in homogenization of the pesticide distribution. This study recommended using a power sprayer to avoid the misapplication in droplets distribution in comparison with pack back sprayers, which have a complication in the operating pressure and nozzle height regulation. Another recommendation was a necessity to select the perfect nozzle type that agrees with the global publications.

Keywords: spraying processes, droplet size, nozzle, application rate

1. Introduction

Generally, pesticides are applied using agricultural sprayers which are considered one of the most important for pests control and to improve crop production [1]. The using of these products come after a series of stages as the type and intensity of disease, type of pesticide, type of spraying process that is an appropriate for crop intended and the type of infection, technological parameters related to sprayer used [2]. Sprayers efficiency according to the purpose

of use depends on multiple factors such as nozzle selection (jet or atomize) that produces relatively coarse droplet sizes compared with another nozzle with fine droplet sizes [3]. Droplet size that emerges from the nozzle will affect the droplets trajectory to reach a specific goal (leaf or insect) and their impact, then its deposition or bounding from the target to the soil out of the target. Whereas, small droplets are susceptible to move away as spray drift or evaporated as soon as or after spraying application [4]. Small droplets are moving to the surrounding environment (population, water plants, etc.), which increases the percentage of environmental pollution, especially when the chemical products with high dangerous materials on the living organisms [5]. In most cases, agricultural pesticides are usually sprayed in the form of solution, by providing a suitable operating pressure by a pump depending on nozzle characteristics and the goal of spraying. Previous studies showed increasing in operating pressure at the time of application led to increase the number of small droplets emerging from the nozzle thereby increasing the amount of pesticide prone away the target [6,7]. Following the correct instructions recommended by the companies producing the nozzles will improve nozzles performance in the field. Nozzles performance is achieved by increasing the percentage of droplets deposited on the target, increasing of droplets coverage, and reducing the percentage of the pesticide losing. This loss occurs as spray drift through transporting of pesticide sprayed with the air action (especially when inappropriate meteorological conditions). There are many types of agricultural sprayers that are classified according to the power source, method of work, and the purpose of use. Each of these sprayers has advantages and disadvantages related to the efficiency of the spraying process [8]. The results of [9] on spraying methods in a tomato plastic house showed using of the handheld trolley sprayer with higher efficiency in spray deposition and spray droplet size distribution compared to the self-propelled sprayer and the self-controlled. One of the most important parts of the agricultural sprayer is the nozzle. The main function of nozzles is to transfer the solution in the tanks to droplets through the sprayer pump. Nozzles also play an important role and consider a key element in modern agriculture. Moreover, droplet sizes and the type of spray pattern depend on nozzle type. There are many types of nozzles available as flat fan nozzles and hollow cone nozzles, which are classified depending on their sizes, material made, their design, and spray angle. The spraying angle has also an effect on the lateral spray distribution, especially for the flat fan nozzles, which requires the overlap between adjacent spray nozzles for uniformity of spray. The results of [10] showed that using of nozzles at a spray angle less than 110 degrees led to reduce spray drift when spraying at a nozzle height of 50 cm. The study of [11] mentioned the spraying with small size nozzle XR 110 01 VS, which produces a large quantity of small droplets, has resulted in a high proportion of adhesion on the target compared to traditional nozzles XR 110 04 and XR 110 08 with coarse droplet sizes. The study of [12] found that the use of rotating nozzle resulted in best spray distribution and more spray penetration into cotton plants even when the plants were in an advanced growth stage (high density of leaves) compared to standard nozzles and mirror nozzles with air carrier. Recently, flat fan nozzles have been developed in order to increase the droplet sizes and to reduce the amount of pesticide that moves away from the target site as spray drift by air action. Among the developed nozzles are the flat

fan air induction nozzles, which are either single jet or double jet. The study of [13] illustrated the nozzle type has a significant effect on droplet size by studying three types of flat fan nozzles as AXI, Flat Fan air induction (single jet) and Flat Fan air induction (Twin Jet) under the effect of different wind speed. Also, there is a laboratory study conducted by [14], showed that using of the Venturi nozzle has significant differences to reduce spray drift compared to hollow cone and full cone nozzles. This study recommended using this type of nozzle in orchards to reduce the risks associated with human and the environment. In the same context, the use of the air induction nozzle according to the results of [15] led to reduce in amount of spray drift by 56% to 91% compared to the standard nozzle. As noted above, the nozzle size affects the droplets size, as well as the material made from the nozzle also affects the consumption thereby affects the amount of pesticide sprayed and distributed. Other important factors related to technological parameters are application rate. Application rate determines the rate of pesticide discharge from the sprayer to be used by knowing the desired rate of use ($l.ha^{-1}$), and the sprayed area in the time unit per minute ($ha.min^{-1}$). There are different parameters that affect application rate using agriculture sprayers, including nozzle type, number of nozzles mounted, operating pressure and forward speed at the spraying time. Various studies were performed about application rate [16, 17, 18]. The results of these studies showed a clear relationship between the application rate and nozzle type, nozzle size, operating pressure, and forward speed. The interaction between these factors affects the amount of pesticide sprayed per unit area, which reach the target and the amount of pesticide that is lost on the soil surface according to the characteristics of the cultivated plant or its transport with air action during spraying depending on the droplet sizes, and the physico-chemical properties of spray liquid, and the prevailing weather conditions during spraying. There is a study carried out by [11] showed that the high application rate with AI 110 08 VS air induction nozzle caused a significant decrease in the retention ratio on the target site compared to XR 110 01 VS flat fan nozzle. One of the main reasons that led to decrease the retention ratio is the run-off of the spray droplet as well as the variable behavior of the droplets on the wet surfaces (due to the high spray rate). Increasing the forward speed is usually used to reduce the spray rate and sometimes to increase the efficiency of sprayer, but at the same time contributes to increase of spray deposited away target [19], especially when spraying using small droplets size. The study of [12] found that the change in the regulations in order to increase the forward speed of sprayer led to a negative effect on the droplet size spectrum and homogeneity of cotton plant treated. Spray pressure has a direct effect on both of the flow rate nozzle and spray angle with a side effect on droplet size [20]. Sprayers mounted on the hydraulic tractor system which contain a large number of nozzles mounted on the boom, which need to adjust many factors that affect the regularity or homogeneity of the pesticide amount. Improving agricultural sprayer can be achieved by decreasing of boom height as possible closed to the target. This study mentioned decreasing of nozzle height from 70 to 50 cm led to reduce in the potential of spray drift by 55% using standard nozzle and by 36% using induction air nozzle [15]. The amount of spray deposited on the target site can be evaluated through the number of indicators, such as: 1- Spray coverage: This means the ratio between the surface area of the spray and the

area of the target to be sprayed (ex. leaf). 2- Droplet size density: This means the droplet numbers impacted per an area cm^2; 3- Penetration of spray droplets: This means the amount of spray droplet that penetrates from the upper surfaces of the plant into the surfaces located in the center and bottom of it. [21] Showed that the ratio of spray coverage increased with increasing spray rate. This study showed selecting a suitable nozzle and sprayer regulations for pest control reduced spray drift ratio and improved spray droplet penetration. While the spray droplets density decreased with decreasing of droplet size [6]. All the previous studies showed a good relationship between pesticide spraying and the technological parameters using one of chemical products to be sprayed. In Iraqi agricultural researches, a lot of researchers carried out their studies to investigate the impact of spraying processes on pests control and plant growth regulators with insufficient information on spray technologies. So, the objective of this present study is to highlight on the adequacy of information related to spraying technology used in Iraqi agricultural researches. As well as to mention the factors that affect the spraying processes in the research that have great influence on the efficiency and effectiveness of the spraying for pests controlling and improving plant productions.

2. Materials and methods

2.1 Researches About the Liquids Spraying

A random sample of agricultural researches were selected and considered in this study. These researches were published recently in the Iraqi scientific journals. The main objective of these studies was to pest control, adding plants growth regulators and chemicals or organic fertilizers. Most of these studies refer to the word "spraying" in the title or in the research aims. Table (1) introduce these studies, which they indicated the type of sprayed material (its name), and the levels of concentrations used in each research (considers the main factor in these studies). Some of these studies required spraying more than once to perform the biological efficacy, which is recommended by the product manufacturer or the experts of the pest control and the fertilizing. Moreover, the results of experiments in the table (1) showed importance to mention all the information in the both of abstract and the materials and methods sections. Also, this information must be taken into a consideration in each research related to the spraying applications. Therefore, any information concerning the method of research conducting must be mentioned on these two sections.

Table 1: Randomly selected researches for spraying different types of agricultural solutions

References	The sprayed material	No. of concentrations used in the research	No. of spraying processes	Experiment site
Sadiq et al., 2017 [22]	[illegible] and Florin	3+1	2	Plastic pots inside a wooden canopy
Abd-[illegible] et al., 2017 [23]	organic fertilizer, growth regulator	3+1	3 sprayings for each treatment	Orchard inside University of Baghdad
Saadi, 2017 [24]	Seaweed extract	2	3 in each stage of plant growth	Agricultural field + Lab experiments
[illegible] et al., 2017 [25]	Alkaline Acid	2	2	Agricultural field
[illegible] et al., 2018 [26]	extract of [illegible] L.	3	3	Nursery
Al-[illegible] et al., 2018 [27]	Bio health	3+control	1	Wooden canopy and plastic pots
Al-Abbas et al., 2018 [28]	Gibberellic acid, [illegible] Liquid	3+1	3	Agricultural research station
Al-[illegible] et al., 2018 [29]	Seaweed extract, amino acids	3+1	2	Greenhouse
Al-[illegible] et al., 2018 [30]	Bioregulator (Prohexadione)	3	2	Agricultural field
[illegible] et al., 2018 [31]	[illegible] Acetic Acid, nutrient solution "[illegible]"	3+1	2	Nursery
Al-[illegible] et al., 2017 [32]	Methionine, salicylic acid	3+1	2	Agricultural field
AL-[illegible], 2017 [33]	Three types of plant extractions	2	4	Research station at Pomegranate seedlings
AL-[illegible] and AL-[illegible], 2017 [34]	licorice root extract, seaweed extract	4+1	2	Agricultural field
Al-[illegible] and El-[illegible], 2017 [35]	compost extract ([illegible]), Boron	4+1	-	Agricultural field
AL-[illegible] and Ibrahim, 2016 [36]	Amino acid	2+1	7	Greenhouse
Mohammed et al., 2016 [37]	Potassium Sulphate, Ascorbic acid	2+1	3	A canopy covered with Saran from plastic
Al-[illegible] et al., 2016 [38]	[illegible] acid spray	2	6	green nursery shade
Al-[illegible] and Al-[illegible], 2016 [39]	Nutrient solution ([illegible])	2	8	Wooden canopy
Al-[illegible], 2015 [40]	[illegible], organic fertilizer for poultry dropping	3+1	3+1	Greenhouse
AL-Waggaa, 2015 [41]	Glyphosate	3	-	A pomegranate orchard
[illegible], 2015 [42]	Nutrient solution, boron+ together	3+1	3+1	Experimental field
Adil et al., 2015 [43]	Salicylic acid and a synthetic cytokinin KT-30	4+1	3	Wooden canopy
AL-[illegible] and AL-[illegible], 2016 [44]	Glutathione	4	-	Botanical garden
[illegible] and Al-[illegible], 2016 [45]	ascorbic acid, salicylic acid	3+1	-	Agricultural field
AL-Mohammedi and AL-[illegible], 2016 [46]	Bio plant extract, micro elements	3+1	3	Agricultural field
[illegible] and [illegible], 2017 [47]	Vitamin C, (Ascorbic acid)	4	-	[illegible] research farm
[illegible] and [illegible], 2017 [48]	[illegible] acid	3	-	Vegetables field
Abo AL-[illegible], 2017 [49]	Potassium Nitrate, [illegible]	4+1	3	Wooden canopy

Sprayer calibration

Improper sprayer calibration is one of the more points faced farmers or researchers especially when a spray application doesn't work quite and stable at the time of spraying processes. So, there will awful results with high variability when spraying in the field intended without a proper calibration. Several variables must be considered during sprayer calibration, each of them is important to obtain satisfying results. There are several ways to calibrate a sprayer depending on sprayer type. For example calibration of a self-propelled or pull-behind sprayer involves determining sprayer discharge, sprayer forward speed, and application rate. Whereas,

the calibration of backpack sprayers are calibrated somewhat differently, but with the same goal intended. To ensure the delivering of the recommended spray application rate ($l.ha^{-1}$), the sprayer must be calibrated according to the sprayer type. The calibration process of the backpack sprayers with one nozzle mounted in orchards sprays which used an air flow to assist the penetration of the spray inside the trees canopy achieved by the following as calibration of the boom sprayers. The sprayer needs to be inspected to check if there are any damaged parts, then the sprayer speed must be determined. After that, measuring the flow rate for each nozzle tested. The application rate can be calculated as follow:

$$R = \frac{F \times N \times 600}{S \times V} \dots\dots\dots\dots\dots (1)$$

R= Application rate ($l.ha^{-1}$)

F= Averaged nozzle flowrate ($l.min^{-1}$)

N= Number of nozzles on boom

S= Boom swath (m)

V= Sprayer speed ($km.h^{-1}$)

For changing the application rate to appropriate of the spraying process, it is a necessitate for replacing one or all of the following factors as nozzle type, nozzle size, the spraying forward speed, and operating pressure. In the contrary, changing one or all of the previous factors will lead to modify in the application rate amount to be applied. The concentration of the pesticide to be sprayed is based on the instructions for use on the product label, which is usually indicated with $l.ha^{-1}$ units. The control product must be added after sprayer calibrating, and this process (the calibration) must be done it using water tap only. For example, adding 0.04 $l.ha^{-1}$ plants growth regulator (depending on the manufacturer recommendations) with 300 $l.ha^{-1}$ application rate will require adding 12 l of the product. It is importance to mention that it is a necessary to fill the sprayer tank with the solution (water+ pesticide) to the level that is enough amounts to spray in the intended area to be sprayed. Adding more solution than it is needed will cause a problem to throw away of this excess quantity after finishing the spraying process. The concentration of the active ingredient with the $gm.l^{-1}$, and sometimes is used as a percentage of the recommended quantity as 5%, 10%, or 15% when using the concentration as a factor in the experiment.

Results and discussion

Surveying results of the random researches mentioned in Table 2 which is related to the parameters and settings of the spraying. Data revealed that 57% of these researches do not

mention the type of spray used. Also, 68% of these researches do not indicate the type of the sprayer either it is a manual or an automatic. Moreover, all these researches do not point to the nozzle type, and only 4% of them reported the spraying pressure. The information about the spraying speed does not comprise in Table 2. Most of the researches were carried out their work using a worker speed which depends on different conditions as the physical force, worker age, and length of worker step during the pesticide application process. The spraying speed has a direct influence on the application rate as mentioned in the previous section.

It is important to refer to the sprayer type because it determines the accuracy of the application rate used in the application process. For example, when using a handheld sprayer, the application rate accuracy will decrease because it will be affected by the operator skill. This skill is difficult for measuring in the field experiments and it is different from one person to another. Moreover, this skill is varying from field to other depending on conditions of field preparation. On the contrary, using of an automatic sprayer will contribute for adjustable application rate more accurate, especially when a stable operating pressure and forward speed. It is important to indicate that the nozzle type and spraying pressure have more effect on the determination of the application rate (solution volume ($l.ha^{-1}$), which must be mentioned (in the materials and methods section) of each study. Using of different application rate in spraying application as results in inconstant in the technological parameters as nozzle type, nozzle size, operating pressure, and forward speed, thereby, lead to an undesirable variation among the experimental units finally, affect the validity and reliability of the experiment results. For example, pesticides applying with a low concentration applied can be used with a high application rate would have a similar effect of adding with a high concentration of the pesticide using a low application rate. This situation may lead to the same approximate effect of the different factors at the time of investigation (the concentration factor). The nozzle type and the spraying pressure have an effect on the spray droplets quality. During spraying application, the pesticide spray is broken into droplets at various sizes depending on technological parameters. Small droplet sizes less than 150 μm are often resulting from one or all these factors as high operating pressure, small nozzle size, and wind speed shear across the nozzle as well as nozzle design. Also, these factors have direct effect on a droplet size. However, the spraying with small droplet size has a larger amount quickly moved with air action as spray drift particle and allow to evaporate as vapor drift than large droplets. Whereas, large droplet sizes more than 300 μm are less affected by air action at the time of spraying application. Also, it means to fall more quickly on the ground or shutters from the leaves. Therefore, the relationship between the spray droplet size and spraying efficiency of the target intended needs to be determined best setup of sprayer parameters. Furthermore, the impact of pesticide amount and other spray characteristics as spray droplet distribution, liquid concentration, and droplet density need to be determined to achieve the uniformity of pesticide distribution on the target. The two situations will affect decreasing in the spraying efficiency. There are many kinds of sprayer used on farms in agriculture spraying applications, which they used to spray pesticides and plant growth regulars as a means of crop

production quality. The sprayer types in the market are widely in terms of tank capacity, pump type, etc.

Table 2: General Information on the spraying technique in Iraqi agricultural researches

Reference	Spraying type	Degree of spraying	Sprayer type	Nozzle type	Spraying pressure	Application rate	Additional info.
[22]	-	Spraying until the complete wetting	-	-	-	-	
[23]	-	Spraying until the complete wetting	-	-	-	-	Adding adjuvant
[24]	Foliar application	Spraying until the complete wetting	Backpack sprayer	-	2.8 kg/cm^2	-	
[25]	Foliar application	-	-	-	-	-	
[26]	-	-	-	-	-	-	
[27]	-	-	-	-	-	-	
[28]	On the canopy	Spraying until the complete wetting	Manual sprayer	-	-	-	Adding adjuvant
[29]	Foliar application	Spraying until the complete wetting	-	-	-	-	Adding adjuvant
[30]	-	Spraying until the complete wetting	-	-	-	-	
[31]	-	Spraying until the complete wetting	2 L sprayer	-	-	-	
[32]	-	-	-	-	-	-	
[33]	On the canopy	Spraying until the complete wetting	Manual sprayer (1 L tank)	-	-	-	Adding adjuvant (washing detergent)
[34]	-	-	-	-	-	-	-
[35]	-	-	-	-	-	-	-
[36]	-	-	-	-	-	-	-
[37]	Foliar application	-	-	-	-	-	Adding soap as aquvant
[38]	-	Spraying until the complete wetting	-	-	-	-	-
[39]	Foliar aevlication	-	Manual sprayer (20 L tank)	-	-	-	Adding adjuvant (washing detergent)
[40]	-	-	-	-	-	-	Adding adjuvant (washing detergent)
[41]	Surface application	-	Backpack sprayer	-	-	1.8 kg/ha + 400 L water	-
[42]	On the canopy	Spraying until the complete wetting	Backpack sprayer (16 L tank)	-	-	-	Adding adjuvant (washing detergent)
[43]	-	Spraying until the complete wetting	-	-	-	-	-
[44]	Foliar application	-	Compressio n sprayer	-	-	-	-
[45]	Foliar application	Complete wetting of the leaves	-	-	-	-	-
[46]	Foliar application	Spraying until the complete wetting	-	-	-	-	Adding adjuvant (washing detergent)
[47]	-	-	-	-	-	-	-
[48]	-	-	-	-	-	-	-
[49]	-	Spraying until the complete wetting of the seedlings	Manual sprayer (2 L tank)	-	-	-	-

The sprayer types are backpack sprayer, ATV, UTV, two behind, truck bed, three point hitch, boom, boomless, spot, and mist. So it is necessary besides mentioning the type of sprayer when writing the "materials and methods" in the researches related with spraying (pesticide application), the nozzle type (Flat fan nozzle, Hollow cone or other), the nozzle size, nozzle angle, the spray pattern (or design), and nozzle material. The decrease in spraying operating pressure resulting from the gradual decrease in the amount of solution in the backpack sprayer tank (which

may not be noticed by the operator or is sometimes ignored) has a clear effect on the size of the droplets produced from the nozzle, as well as the effect on the application rate as explained previously. Then, the spray pressure should be fixed depending on mechanical pumps and providing the sprayer with pressure regular and pre-calibrated pressure gauge.

Some studies that appeared in Table 2 which introduced additional information about the spraying application as the degree of spraying or addition of the adjuvants to enhancing the spread factor of the droplets solution to reduce of the surface tension of spray droplets then to cover a large area of the leaf with a small amount of spray droplet deposited. This procedure is applied when spraying with not enough amount of application rate. The addition of some substances to the spray liquid in order to change in the physical properties of spray liquid as surface tension, and viscosity, which needs to mention the concentrations of these additives specifically and unify them of all the research parameters because of their effect droplet sizes and the degree of adhesion on the target. The best selection of this concentrate will affect directly on the quantity absorbed by the target intended. It is important noting that the current global researches are examining the possibility of spraying at different application rates depending on plant canopy, plant stage, and the need for each part of the field instead of spraying at a constant spray rate for the entire field, the latter method increases the pesticide waste,the application cost,and the percentage of the enveromental pollution. The risk of these warnings increases in the case of spraying at an uncontrolled rate. The spraying technique at different rates requires controlling these factors that determine of the application rate as the spraying speed, operating pressure, etc. rather than neglecting them.

Conclusions

The main conclusions of the survey and analysis of the researches showed that the information related to the spraying processes were very insufficient. Some of this information was inaccurate and others were incomplete. The survey also showed absenct or limited of the information that will affect the probability to retry these researches at the same conditions applied. In some cases, there is a defect in the factors studied as concentration of pesticides that is a consequence of the underestimation to select proper procedure. This study recommended to use powered sprayers equipped with pumps and indicators of operating pressure. As well as, it recommended using a standard a Flat fan nozzle 110 03 at 3 bar in spraying processes.

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