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RESEARCH ARTICLE

ASSESSMENT OF TWO DIFFERENT TYPES OF SPRAYERS IN RESPECT OF RESIDUE DISTRIBUTION

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ABSTRACT

Lack of homogeneous distribution of pesticides in agricultural spraying is negatively affecting the success of pulverization, and causing unnecessary consumption. The use of suitable machines and spraying technologies are required to be used in order to abolish this problem. Especially in cultivation of tomato, this problem is causing large amount of product losses. For this purpose, two different sprayer (air-assisted, classic sprayer) –extensively being used at an enterprise where tomato cultivation is being realized- have been selected, and pulverization has been performed. The results of residue distribution obtained as the result of the applications have been assessed.

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INTRODUCTION

In order to protect plants against the effects of diseases, pests and weeds causing economic losses, minimizing the product losses and increasing the product quality is the purpose of plant protection applications in agriculture. Different techniques are being used in order to achieve this purpose. The ones that are preferred the most by the farmers among these are chemical applications whose high effectiveness had been revealed by various researches. But only 6% of the pesticide application is reaching the target living beings, and the remaining part is reaching the non-target organisms and soil in agricultural ecosystem, or they are mixing in water due to drift and flow to surrounding natural ecosystems (Unal and Gurkan, 2001; Yildiz *et al*., 2005). Since the end of 1950, pesticides have started to be applied by air-assisted sprayers both at high and low volumes (Derksen and Gray, 1995). The air-assistance has increased the movement of leaves, and thus the penetration on vegetation has increased. Spraying with gun in standard type hydraulic sprayers is being effective but expensive. The loss of pesticides especially arising by flow through is able to reach to high levels. Moreover, the grandness of land is also limiting the use of this equipment in respect of both labor and time.

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One of the most significant problems encountered in air-assisted applications is being unable to completely ensure the coating of the whole vegetation with pesticides. Selecting the pesticide amount that will be applied on the determined land or calculated plant volume, minimizing the losses due to drift and flow in soil, obtaining optimal coating and uniform distribution by the use of minimum pesticides matter in the effectiveness of the application, and thus in the solution of these problems (Walklate, 1996; Holownicki, 2000; Salyani, 2000). The pesticide production in Turkey–which consists of 47% insecticide, 24% herbicide, 16% fungicide and 13% others- is 33.000 tons, and its monetary value is 230-250 million USD (Turabi, 2007; Durmusoglu *et al*., 2010). While 80% of the world pesticide market belongs to other countries, the share of Turkey in this market is 0.6% (Kantarci, 2007; Ozmen, 2007; Durmusoglu *et al*, 2010; Yesil and Ogur, 2012). These values are revealing the importance of pesticide application technique in respect of both environmental pollution and human health, and economy. Nearly all the spraying techniques are quite inefficient when compared with the assumption of amount of applied dose that is received by the target or direct application on the ones constituting that population. In fact, generally 0.03 µl pesticide is being sufficient in order to kill a pest, and despite the use of 30 mg effective substance is sufficient for 1 million pests on a land, the sufficient effect is able to be obtained through the application of about 3.000 times of it on a land (Brown, 1951). This condition is a result of lack of

reaching the desired level in spraying techniques. A large part of the agricultural pesticides are being applied by classic type sprayers with spray lance having hydraulic nozzles. The nozzles spray the liquid pesticide on the target surfaces by a quite wide droplet spectrum. The pesticide drops generated by the nozzles are being carried on the target by the combined effect of inertial and gravitational forces. But these forces are generally not enough for abolishing the problems such as inability to obtain the accumulation of sufficient amount of pesticide at target surfaces, weak pesticide penetration in the plant canopy and use of high amount of pesticides. The top parts of the plant canopy and top surfaces of the leaves are mostly getting more pesticides compared to their lower parts and the bottom surfaces of the leaves. On the other hand, in order to ensure the required biological control in agricultural fight with minimum cost, enabling the accumulation of sufficient amount of pesticides at all parts of the plant and the sufficient penetration of pesticides along the vertical height of the plant are required (Dursun, 2002).

The purpose of this study is to reveal the penetration ability of two different types of sprayers –being extensively used on tomato plant that is being cultivated in Turkey- through examination of residue amount on top and bottom of the leaves.

MATERIALS AND METHODS

This study had been carried out at an enterprise cultivating tomato (Lycopersicon esculentum). The row spacing distances of the tomatoes were 100 cm, and their intrarow distances were 75 cm. The tests had been performed at 3 different sections as being the top, middle and bottom sections of the plant. During the practice, the average height of the tomatoes was 60 cm. The leaf area index of plants of this size is 1.9. The test parcels had been arranged one after another and against the wind. Specific 2 m distances had been left in between each parcel. 3 plants had been selected from each parcel with the purpose of iteration. In this study, a single application had been made by 2 different machines. The residue distribution had been determined. For this purpose, three different sprayers had been compared. One of these was a classic field sprayer with a 300 l/ha capacity having 10 units of XR 110004 spray nozzles (Taral 400 l), and the other one was a air-assisted (horizontal) sprayer with a 400 l/ha capacity having TXVK12 conic beam spray nozzle. The sprayers had been used by 6 km/h feed rate at settings specified by the manufacturers. Schlicher & Schuell 589 brand filter papers (30 cm^2) had been used as sampling surface. 3 plants, that are 1 m inside the parcels, had been selected from each parcel in order to position the filter papers. Filter paper had been placed on top and bottom parts of three leaves as being at top, middle and bottom parts on each plant. 54 filter papers in total had been used for all the tests (Onler *et al*., 2014). Tartrazine had been used as tracer due to ease of transition to water at a rate of 2 g/l (Celen, 2010).

After the application, each filter paper had been collected, and had been stored under dark environment. During analysis at the laboratory, colorimetric method had been used in order to measure the concentration of tracer. In the study, after the completion of each test, 80 ml pure water had been added in plastic boxes in order to ensure the washing of tracer from the filter papers. The filter papers, that were kept in wash water away from day light for about 15 hours, had then been removed from the boxes. In order to measure the concentration of tartrazine food dye within the obtained wash waters, spectrophotometer with a precision that will be able to measure dye concentration at a level of 1 ppm had been used. Standard series had been prepared, and the wash waters obtained from the filter papers and these values had been compared (Erman, 2003).

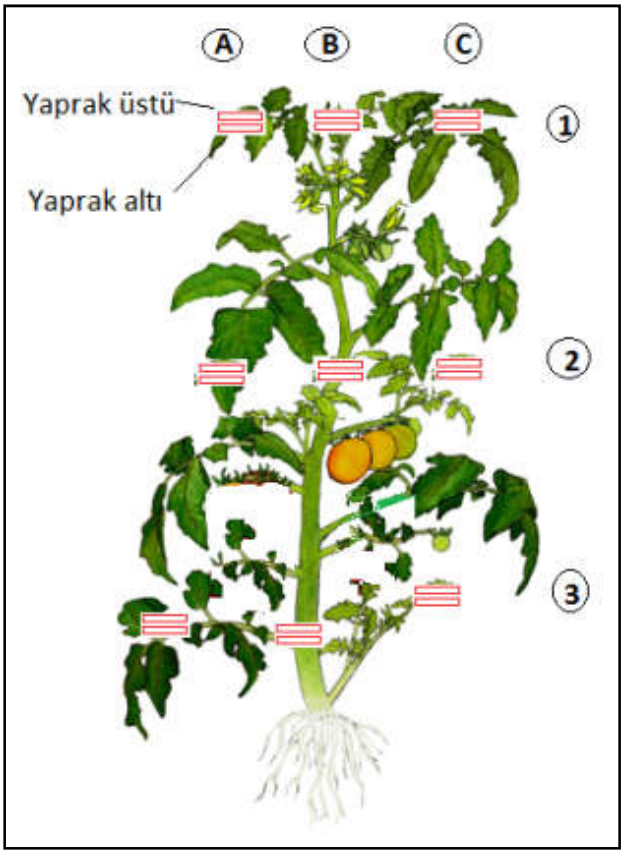

Figure 1. Placement of filter papers on the plant

The obtained values had been assessed by performing variance analysis (ANOVA), and LSD ($p<0.05$) test had been performed.

RESULTS AND DISCUSSION

The average temperature among the applications was 28^0C, and the average wind speed was 1 m/s. The leaf area index of the area where the tests were held had been calculated as 1.08 during the applications realized in July in which intensity of leaves is high. The coefficient had been used while calculating the tracer residue amount of this period. When the difference of residue values among the iterations of the spraying applications was statistically examined, the P value had been found as 0.73. This had shown that there was no difference while distinguishing the surfaces of leaves. Comparison analysis of residue amounts accumulating on the leaves at different parts as per the height of the plant had been performed (Table 1). The average of residue amounts on the

top surface of the leaves had been found as 90.71% by the classic sprayer, and as 81.99% by the air-assisted sprayer, and it had been found over 80% which is the industrial standard. The residue amount at middle and bottom parts had been higher by the air-assisted sprayer compared to the other (52.09% and 77.10%). This difference is arising due to the fact that spraying norm (400 l/ha) is higher compared to the other machine. But the differences had not been found statistically significant ($p<0.05$).

Table 1. The distribution of residue in percentages on the top surface of the leaf regarding the leaves of different heights in applications performed by different sprayers

(The Latin letters specify the relation among rows, and the Greek letters specify the relation among columns.)

Sprayer	Bottom	Middle	Top
Classic sprayer	20.33 b α	59.9 ab β	90.71 a γ
Air-assisted sprayer	52.09 b α	77.10 ab β	81.99 a γ
LSD	5.18	4.10	6.30

In Table 2, the residue amounts accumulating under the leaves had been statistically compared, and they had been specified as percentage. In applications performed by air-assisted sprayer, the reach to bottom of the leaf had been observed as high (15.24%). But the high level of spraying norm is a significant reason of this. In applications performed by classic sprayers, the residue amount reaching the bottom of the leaves had been very low.

Table 2. Statistical comparison of residue amount -as percentage- on the bottom surface of the leaf on leaves of different heights in applications performed by different sprayers. (The Latin letters specify the relation among rows, and the Greek letters specify the relation among columns)

Sprayer	Bottom	Middle	Top
Classic sprayer	0.21 a α	0.12 a α	0.71 a β
Air-assisted sprayer	8.25 b β	6.88 b α	15.24 b γ
LSD	9.01	7.56	12.33

While Walklate *et al*. (1996) are explaining through a theoretical study the decrease of air speed on the canopy and the kinetic energy generated by the turbulence in here, they had specified that the intensity of canopy is significant when air-assisted sprayers are used, and that the success increases by the effect of air. Gupta *et al*. (2012) had examined the relation in between the complexity caused by air speed and the intensity of canopy, and they had revealed the importance of the power of air flow by specifying that the speed decreases at the bottom parts of the canopy and that 15 m/s air speed is definitely required for a good penetration at top parts in plants such as aborigine and pepper. Pergher and Gubiani (1995) had specified in their study that high pesticide norm causes a decrease in residue and deterioration in the evenness of distribution in tests performed on vegetation whose leaf area index is high. This result shows parallelism with the distribution in residue amounts provided in the Table. And Derksen and Gray (1995) had specified in their study that air-assisted sprayer-whose fan and nozzle heights can be adjusted-provides higher pesticide amount at areas where the trees are hard and concentrated compared to the standard garden sprayer.

Conclusion

There are many factors affecting success in spraying. Primary criteria being used in specifying the success of spraying machine are the residue amount on the target plant, surface coating rate, evenness of distribution on the target plant, number of drops in unit area and diameters of drops. When the values obtained from all the surfaces of the plant are examined, the results have shown that a more intense and more homogeneous distribution is being observed in applications performed by air-assisted sprayers compared to applications performed by classic sprayers. When distribution along the plant is examined, the residue amount on top sections of the leaf was found higher in both applications. When top, middle and bottom parts are examined together, the differences among the three parts had been less in applications performed by air-assisted sprayers compared to applications performed by classic sprayers. When the bottom surfaces of the leaves are examined on the plant canopy, the success of penetration had been found to be low by classic sprayers while very few residue had been determined. And this had been found to be very high by air-assisted sprayers, and the amount of residue had increased.

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