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STUDY EFFECT OF FORWARD SPEED AND NOZZLES TYPES ON THE SPRAY CHARACTERISTICS OF AIR ASSISTANCE HYDRAULIC SPRAYER

*E.M.E. Sehsah

ABSTRACT

The performance of an air assistance hydraulic sprayer fitted with two vertical adjustable air outlets has been studied in apple field by investigating the selects of changing the forward speeds (6, 9 and 12 km/h) and the two different nozzles (Albus AVI 80015 and ATR 208). The ZA32 S1500 air assistance hydraulic sprayer, Wenner Co., Germany tested was a commercially available trailed, air-assisted machine with a 600 mm diameter axial fan, driven by the power take off (P.T.O.) via a gearbox allowing two transmission ratios between the P.T.O. and the fan, from 2.5 to 5.0. Laboratory measurements were carried out before the field trials in order to define the operating characteristics of the sprayer. The machine ZA32 axial sprayer was tested to state the drift and vertical distribution under the simulated vertical frame in laboratory of Landsanstahlt Geisenheim, Germany. The vertical drift and deposit were simulated and measured under Laboratory conditions. As well as the air velocity, air direction and air volume were determined by using the ultrasonic anemometer 2D (Clime Co., Germany).

The spray losses in sedimentation were measured for both nozzles and at different forward speeds in apple field conditions. Considering the spray deposit and the environmental losses, the best results were observed with the ATR208 nozzles they gave the low sediment values at all forward speeds compared to the Albus AVI80015 nozzles. The increasing of forward speeds tends to decrease the drift percentages at all treatment conditions. The forward speed 12 km/h reduced the drift to 95.1 % compared to forward speed of 6 km/h by using AVI80015 nozzles at the

* Lecturer Agriculturae Engineering Department, Faculty of Agriculture Kafr El-Sheikh, Tanta University, Egypt.

height 4 m. The AVI80015 nozzles gave the low values of deposit compared to the deposition values for ATR208 nozzles.

Keywords: *Sprayer, Forward speed and nozzles.*

INTRODUCTION

Air assisted spraying is a combined method. The air assistance combines the advantages of hydraulic spraying, like exact dosage and constant transversal distribution, with the advantages of pneumatic spraying, e.g. better penetration deep into the tree and improved coverage of the spraying mixture even onto difficult and dense trees with a reduced quantity of spraying mixture. Air blast sprayers have been used for many years to spray fruit trees. These units consist of a fan that is capable of producing a high volume of airflow into which the spray is deposited. As the sprayer moves through the orchard, it blows the spray-laden air into the tree canopy, displacing the original air and depositing the spray materials on the leaf surfaces. Appropriate use of air assistance is required to improve the distribution of deposits and collection efficiency of plant parts (Matthews, 2000). With a radial orchard sprayer, a higher airflow rate at a lower air speed penetrated trees better and produced better leaf coverage than lower volumes of higher air velocity. This held true provided that the air speed was high enough to form openings in the canopy for the air- stream to penetrate. The latest air carrier equipment uses diffusers of various shapes (turret, vertical slits, two fans-one in the standard position and a secound, less powerful one, placed above) to shift the point of spray emission and the auxiliary air-flow closer to the vegetation (Wilkinson et al., 1999). Siegfried and Holliger (1996) reported that about 40-50 % of applied products are deposited on leaves and fruit with axial-fan or cross-flow fan sprayers while deposits on dormant trees averaged about 24 %. Parallel to the efficacy trials, deposition measurements were done using a fluorescent tracer (sodium-fluorescent). Initial deposits on individual leaves tended to be even higher with the drift reducing configurations compared to conventional ATR-nozzles.

Spray drift:

One of the major problems in the application of pesticides is spray drift. Spray drift represents movement of a pesticide through air, during or after an application, to a site other than the intended site of application. Spray drift occurs when an agricultural spray nozzle produces droplets of 200 µm or less in diameter in the air (Solaneelles et al., 1996). Spray nozzle manufacturers have introduced new low-drift chemical spray nozzles in recent years. If these new low-drift nozzles actually reduce spray drift, the amount of pesticide lost in each application could be reduced, and thus save the farmers' money. Spray drift is a complex problem that affects all farmers. There are many factors that control drift. These include equipment design, application parameters, physical properties of the liquid spray, type of formulation and meteorological conditions (Salyani and Cromwell, 1992; Ganzelmeier 1993; Ganzelmeier et al., 1992). Some of the physical properties affect spray drift these are viscosity, surface tension and density of the liquid. Also,size of nozzle orifice, pressure, angle of the nozzle spray, nozzle design and air shear (airstreams hitting the liquid) affect spray drift (Smith, 1992).

MATERIALS AND METHODS

The tested sprayer was a commercially available trailed, air-assisted machine with a 600 mm diameter axial fan, driven by the power take off shaft (P.T.O.) via a gearbox allowing two transmission ratios between the P.T.O. and the fan, from 2.5 and 5.0 (ZA32 S1500 sprayer, Wenner Company, Germany). The air inlet of the fan was constructed in two vertical side air outlets as shown in **Fig 1**. These side deflectors directed the air-jet into the crop canopy and were adjustable to give an angle to the canopy of between 90 and 120^{day}. The other two deflectors were fixed to the upper part of the side deflectors and had the possibility of being opened up to an angle of 60^{day}, allowing the airflow to be adjusted to match the canopy height. The sprayer had 24 nozzles arranged on two vertical rows fixed in outside of the deflector and sprayed in the middle of the air outlets as well as two nozzles placed on the upper deflectors. The liquid pressure was produced by means of a volumetric pump, fitted with four diaphragms, and the liquid output was controlled by a constant pressure valve regulator. The operating pressure nozzles were 1000 and 750 kPa for AVI80015 and ATR208 nozzles, respectively.

Laboratory testes :

The machine ZA32 axial sprayer was tested to determine the drift and vertical distribution under the simulated vertical frame in laboratory of Landsanstahlt Geisenheim, Germany. The filter papers were used in these testes and fixed on the inside of the eight vertical bars and the underside of the three horizontal beams of the

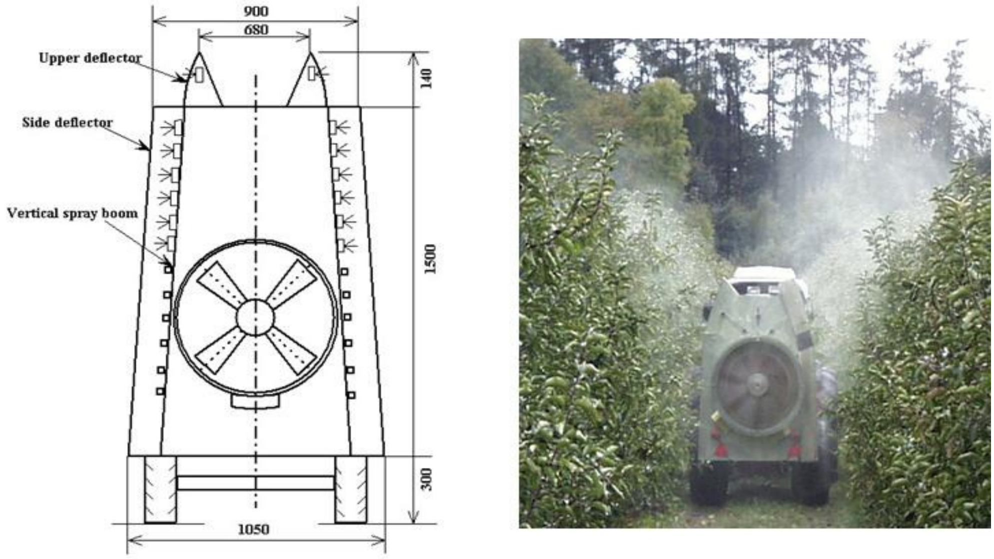

Fig.1: ZA32 S1500 air assistance hydraulic axial sprayer

test stand. After the first central pass, the vertical steel bars were removed and the sprayer followed the three tracks on both sides of the frame. BSF fluorescent dye was used at a concentration of 0.05 %. The samples were collected by cutting 5 cm of the filter papers from horizontal beams every 20 cm and every 5 cm from the vertical bars. The samples were directly transferred to Petri dishes for subsequent measurement of the concentration by a spectrophotometer PerkinElmer LS50.

Field Test :

Ten U steel profiles and Petri dishes were used as shown in **Fig. 2** to state the sedimentation in the apple orchard. Sixty Petri dishes were positioned in the U steel profiles on 25 cm distance (Sehsah, 2005). The targets had

14.2 cm diameter and 2.5 cm deep. Petri dishes were chosen in order to minimize splash and/or shatter problems discussed previously (Smith et al., 1984). On calm conditions the driving pattern was symmetrical. The experimental was designed as a completely randomized block design with three replications. The samples were collected after every treatment. BSF fluorescent dye was used at a concentration of 0.1 %. After each application the Petri dishes were coverd and stored in a dark cardboard box. The sample from the sprayer's tank was collected for calibration of the measurement. In the laboratory 100 ml of deminized water was added to each Petri dish to wash the tracer from both paper samples and Petri dishes. The dishes were placed on an oscillating conveyor belt to wash all dye deposits from the interior surface of each Petri dish. The tracer concentration in the washing solution was determined using a spectrophotometer. The tank sample was used to calibrate the measurement.

RESULTS AND DISCUSSIONS

The air velocity values between 0.25 m and 3 m height was indicated as shown in **Fig. 3**. The air velocity values at the range between 0.2 m and 2 m height of the target or apple trees were between 25.3 and 14.7 m/s, respectively. As well as the air direction between 1 m and 2 m height were(-20 degr) down and +20 top, respectively **Fig. 4**. It means the air is not cross at 1 and 2 m but it's a cross flow at the center of the trees. Both air velocity and air direction given an indicator for the spray liquid behavior which will be sprayed into the trees.

Effect of nozzles and forward speed on spray losses :

The two different nozzles Albus AVI80015 and ATR208 were investigated at different forward speeds in apple field on the spray sediment losses. The results showed that the ATR208 nozzles gave the low sediment values at all forward speeds compared to the Albus AVI80015 nozzles. As well as the increasing of forward speeds tend to decrease the spray sediment losses as shown in **Fig. 5**. Is clear that, the forward

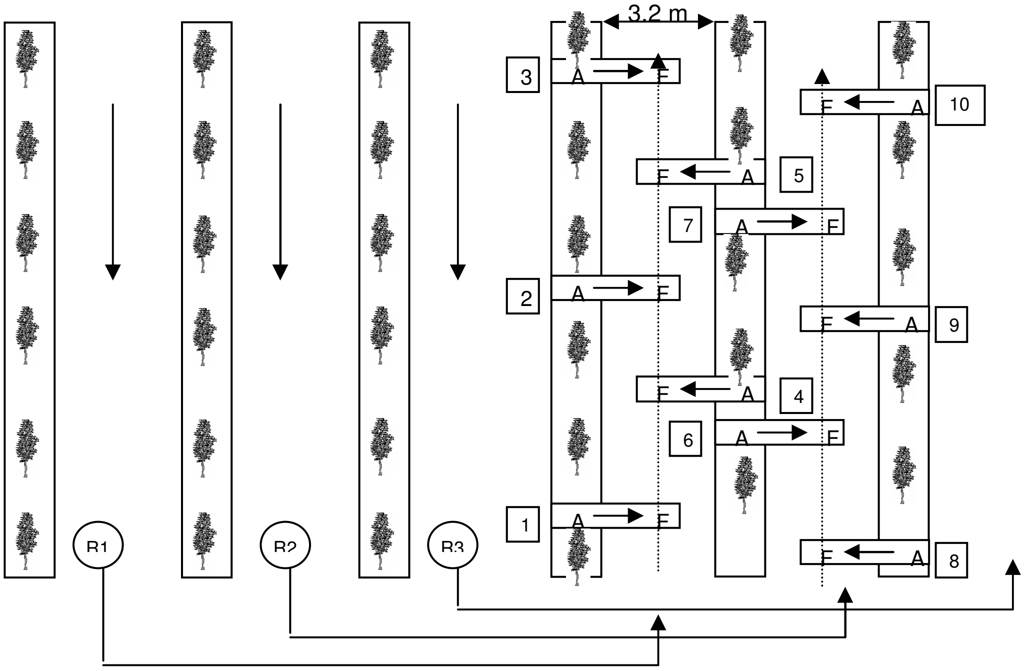

Fig. 2: The sediment collector positioning within the peach rows and the arrangement of trail within the peach plantation.

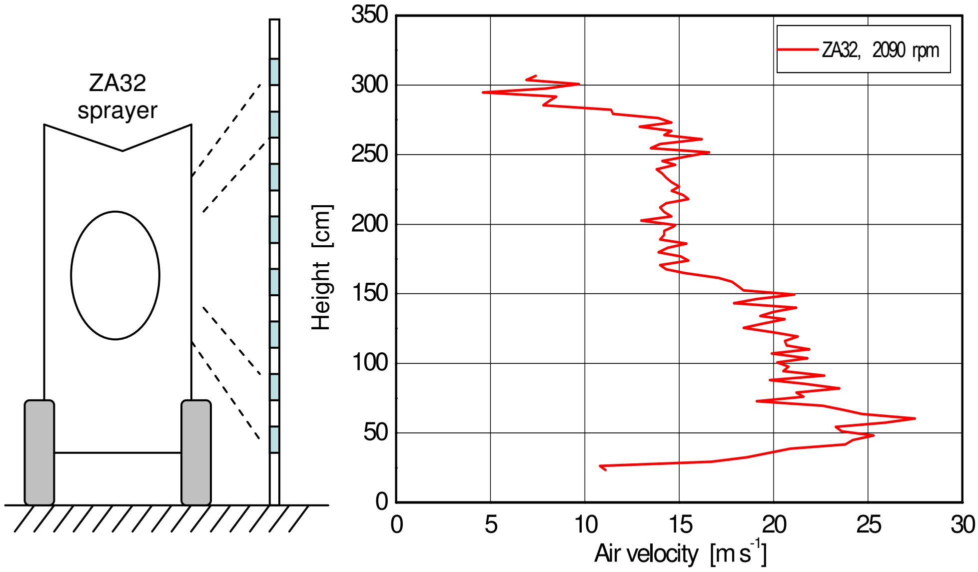

Fig.3: Air velocity measured at different heights for ZA32 air assistance sprayer.

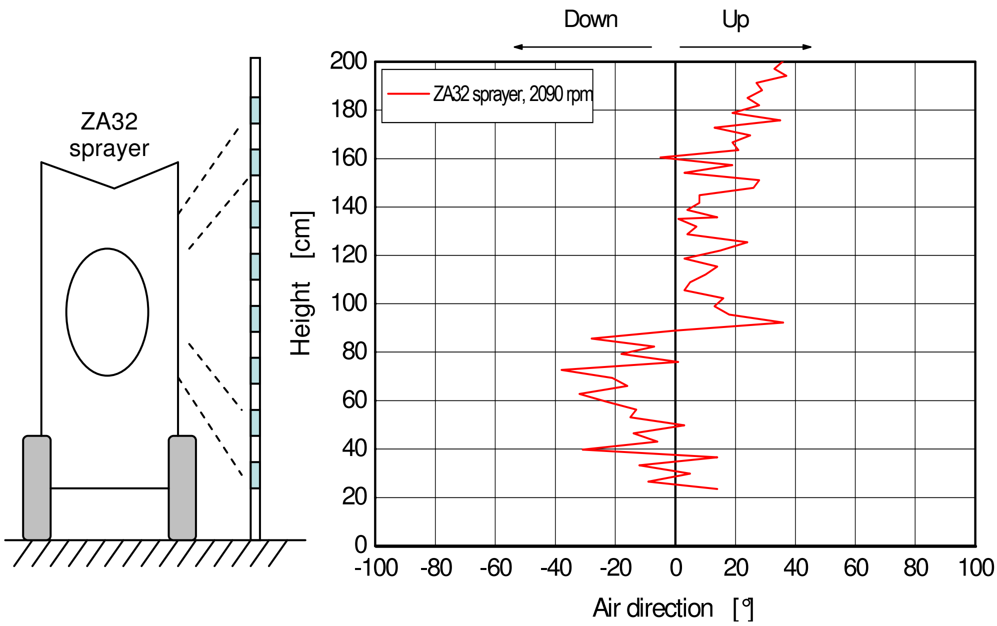

Fig. 4: Air direction measured at different heights for ZA32 air assistance sprayer

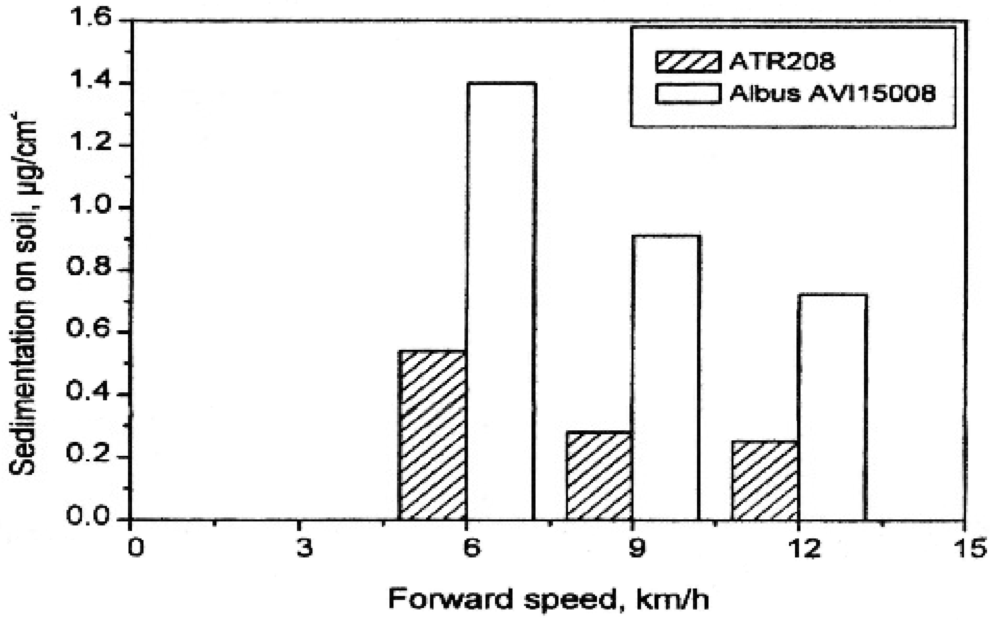

Fig. 5: Sediment spray losses for different nozzles and forward speeds in apple field.

speeds effected on the sediment losses because the increasing of the forward speeds tend to increase the turbulence behind the sprayer. Is noticed that the turbulence behind the sprayer go to into the center of the sprayer. The center of sprayer has an axial fan which increasing of air turbulence and than the droplets will be down on the soil. The AVI80015 nozzles produced the coarse droplets compared to the ATR2008 nozzles. The coarse droplets tend to go down by its drag force. Also, from the air velocity and air direction results, the air direction was -20 degree at height 0.3 m and air velocity was 10.5 m/s at same height. Its mean, there are a high probability to increase the sediment of the coarse droplets at low air velocity and increasing direction of air into down (Sehsah, 2005).

The sediment values at different position between the under trees and the centerline of the row was indicated in **Fig. 6**. It's found that the sediment under the tree is very low compared to the sediment in the centerline of the rows between the trees. Its mean also, the spray runoff from the apples' leaves was very low. The effects of forward speed and types of nozzles on the sediment at different position were given the same trend as in the above mentioned. The forward movement of the sprayer induces a relative cross wind, which together with any natural wind, affects the spray in two ways, first, bending over and distorting the vertical air jet induced by the spray and secondly, by deflecting the larger droplets.

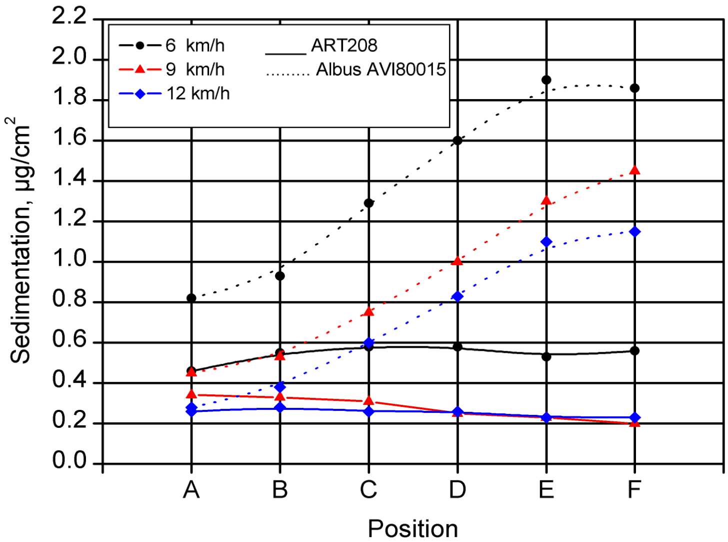

Fig. 6: Sediment spray for ZA32 sprayer on the soil at different position in apple field.

Effect of forward speed and type of nozzles on the drift :

The increasing of forward speeds tends to decrease the drift percentages at all treatment condition **Fig. 7**. Also, AVI80015 produced low drift compared to the ATR208 nozzles because the ATR208 nozzles produced a fine droplets compared to the AV15008. The low forward speed and ATR208 nozzles affect lead to the smallest droplets escaping from the sprayer and therefore, impinging directly on to the crops. Furthermore, by escaping into the atmosphere downwind of the sprayer although they dispersed by the atmospheric turbulence. Their concentration may be great enough to cause an environmental hazard, commonly trended \`spray drift\` was agreed with Ghosh and Hunt (1998). The forward speed 12 km/h reduced the drift to 95.1 % compared to forward speeds 6 km/h by AVI80015 nozzles at the height of 4 m. The reduction drift values are indicated in **Table 1**. The values were calculated by usingthe following equation:

$$RD = [(D1-D2)/D2)]100$$

Where:

RD = Reduction drift, %

D1 = Drift at high forward speed of 12 km/h and 5.5 m height, % and

D2 = Drift at low forward speed of 6 km/h and the same height, % .

Table 1: Reduction drifts values for different nozzles

Height, m	Reduction drift, %	
	ATR208	AVI80015
3	73.4	77.7
4	90.9	95.1
5.5	66.7	91.2

Spray deposition:

The deposit for AVI80015 nozzles had a low values compared to the deposition values for ATR208 nozzles. The total deposit was better using a lower airflow rate while, for a higher airflaw rate, the amount of spray blown through the canopy was increased (Holownicki et al., 2000). These results were reproduced when wind speed was low but, in higher wind speeds, mean deposits were lower at the lowest air flow rate (Cross et al. 2003). In the current investigation, the wind speed was a low value. As well as, is noticed that the increasing of forward speed tends to increase the deposit for both different nozzles of ATR208 and AVI80015 **(Fig. 8)**.

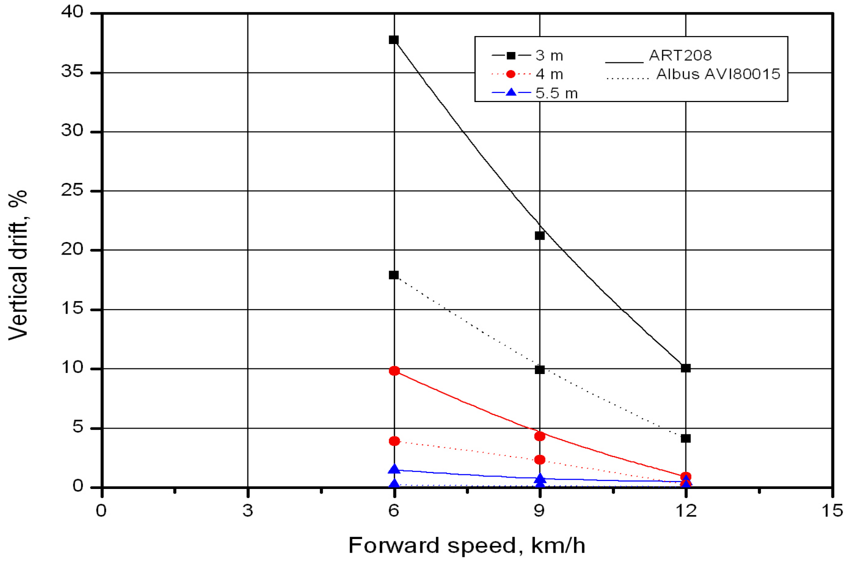

Fig. 7: Vertical drift spray for ZA32 sprayer at different nozzles and forward speeds.

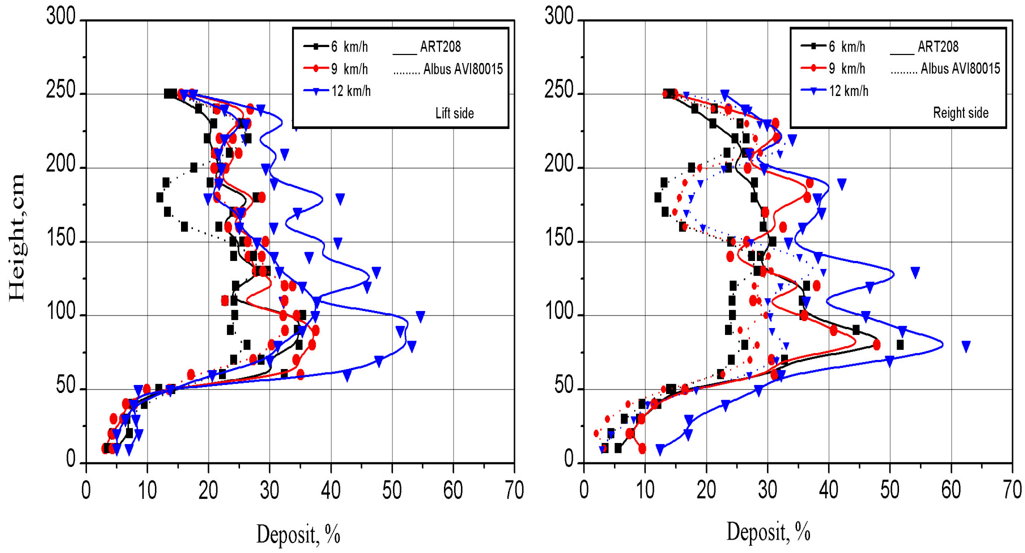

Fig. 8: Deposit perecent agefor ZA32 sprayer at different forwared speed and nozzles.

CONCLUSIONS

The spray losses in sediment and drift could be controlled if it was a good selection of the spray nozzles and operating forward speed under orchard trees conditions. The current study indicates that the high forward speed reduced the drift and sediment compared to low operating forward speed. As well as, the deposition will be better if there are possibilities to work at high forward speed in apple field. The venturi nozzle of AVI80015 reduced the drift but in the other hand, it increased the sediment. Also, the nozzles of ATR208 reduced the sediment but it increased the drift. It is better to make a combination between the two nozzles by setting the AVI80015 nozzles at the top and the ATR208nozzles in the bottom of the axial sprayer. The AVI80015 nozzles at top position will reduce the drift and the ATR208 nozzlesin the bottom setting will reduce the sediment.

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الملخص العربي

دراسة تأثير السرعة الأمامية و نوع الفوانى على خصائص الرش لآلة الرش الهيدرليكية

السيد محمود البيلى صحصاح*

تهدف هذه الدراسة إلى البحث في تأثير السرعة الأمامية ونوع الفوانى على أداء آلة الرش الهيدرليكية ZA32 S1500 حيث استخدم كل من الترسيب Sedimentation و التغطية Deposit والتطاير Spray drift لتقييم أداء الآلة ZA32 S1500 . و تعتبر ألآت الرش الأرضية واحدة من أهم الالآت التي تستعمل فى مكافحة الآفات المختلفة فى المحاصيل البستانية. حيث يستخدم بجانب الفوانى تيار من الهواء يتم إنتاجه بواسطة مروحة ذات قطر يصل فى البعض منها إلى 1.2 m .

* مدرس بقسم الهندسة الزراعية- كلية الزراعة بكفر الشيخ-جامعة طنطا - مصر

ويعمل الهواء على حمل سائل الرش و توجيهه إلى الأشجار و الشجيرات المطلوب رشها. ولقد أجريت هذه الدراسة فى حقل تفاح فى مزرعة بوبرلنجن بألمانيا أبعادة ١٢٠ m x ٣٠٠ و المسافة بين الأشجار داخل الصف الواحد وبين الصفوف هي ٢×٣ م على الترتيب. واستعملت آلة الرش الهيدرليكيةZA32 ألمانية الصنع سعة الخزان ١٥٠٠ لتر وبها مروحة خلفية ذات قطر ٦٠ سم حيث تم إدارتها بواسطة عمود الإدارة الخلفى للجرار عند أقصى سرعة للمروحة م/ث (٢٠٩٠ ك/ت) وذلك لقياس حجم وسرعة الهواء الناتج من الآلة. كما استعمل نوعين مختلفين من الفوانى الذى تم تركيبهم على جانبى للآلة وهما ATR208 ، AVI80015 حيث تم تشغيل الآلة عند ثلاث سرعات أمامية هما ٦،٩،١٢ كم/س عند كل الفوانى . كما استعمل جهاز anemometer ultrasonic لقياس سرعة الهواء وحجمه و كذلك جهاز spectrophotometer لتقدير الترسيب و التطاير و التغطية و من النتائج الملاحظة فى تقييم أداء آلة الرش ذات المروحة المحورية ، أن هناك تأثير واضح للسرعة الأمامية على كل من فواقد الرش و التغطية حيث يمثل الترسيب و التطاير فواقد الرش و الذى كان من الملاحظ أنه بزيادة السرعة الأمامية يقل الترسيب لكل من الفوانى ATR208، AVI80015 . بينما أعطى nozzles ATR208 أقل نسبة ترسيب مقارنة بالفونيه AVI80015. كما وجد أن زيادة السرعة أيضا يؤدى إلى خفض التطاير اى فواقد الرش بنسبة بلغت ٩٥,١% للفونيه AVI80015 إلا انه عند مقارنة النتائج فى تأثير نوع الفوانى على التطاير وجد أن الفونيه AVI8005 قد أعطت أقل نسب فى التطاير اى فواقد الرش مقارنة بالفونيه الأخرى. كما وجد أن هناك تأثير عال المعنوية للسرعة الأمامية على التغطية إذ أنه بزيادة السرعة يزداد نسب التغطية كما أعطت الفونيه ATR208 أفضل قيم لنسب التغطية مقارنة بالفونيه AVI80015 الأخرى و يمكن الخلاصة بأنه بزيادة السرعة الأمامية و اختيار النوع المناسب من الفوانى Nozzles يمكن زيادة أداء الآلة إلا أن هناك حدود للسرعة و التى يجب مراعاتها حيث أن المشغلين لا يميلون إلى العمل عند السرعات العالية نظرا لعدم توفر حد الأمان. ويمكن القول بأنه كلما زادت السرعة الأمامية للرش إلى حد الأمان فى التشغيل فأنه يؤدى إلى زيادة كفاءة تشغيل الآلة و من جانب آخر تقليل كميات المياه و محلول الرش . كما أن اختيار نوع الفوانى المناسبة يعمل على تقليل فواقد الرش أيضا و الحد من التلوث الناجم عن استعمال تلك الآلات و زيادة نسب تغطية المحلول على النباتات . و من الممكن زيادة كفاءة عمله الرش للآلة الهيدرليكية ZA32 S1500 بتركيب الفوانىAVI80015 التى تقلل التطاير drift فى الجزء العلوى منها والفوانى ATR208 التى تقلل الترسيب فى الجزء السفلى منها وحتى منتصف الآلة.