AIR ASSISTANCE IN SLEEVE BOOM SPRAYERS

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ABSTRACT: The air assistance-sleeve boom sprayer contributes towards: reduction in spray drift and loss on the ground, an increase in the agrochemical deposits levels and coverage rate of the abaxial surface leaves, improvement in the penetration of the spray droplets into the canopy as well as enabling a reduction in both dosage and in application volume. However, the advantages of this spraying technique are not only dependent on the droplet size, but also on the vegetation coverage on the ground as well as monocotyledonous or dicotyledonous, speed and air volume generated by equipment. The use of the air assistance without vegetation on the ground or in the early growth stages can increase the spray drift. On the other hand cultivation at an advanced stage of development capture more droplets deflected by air currents close to the ground, thus reducing the spray drift. The penetration and leaf coverage of the spray application can be improved by positioning the air or placing the nozzles at an angle of 30° to the vertical forward the spraying equipment. This combination of air assistance plus the electrostatic “charging” of the droplets constitutes an important technique towards increasing the protection of plants.

KEYWORDS: pesticide application technique, sleeve boom, air assistance, spray drift.

AIR ASSISTANCE FOR FIELD CROP SPRAYERS

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The use of air assistance in the phyto-sanitary product application is very old. However, the enthusiasm by using this spraying technology has started in 1980, as reported by Robinson (1993). Four years later, Degania Sprayers Company, at Israel, developed a sprayer, revolutionary at that time, equipped with air assistance with the spraying sleeve boom. But, only in the end of the 1980s and start of the 1990s, the air assistance has been effectively adopted in sleeve boom sprayers. In Europe, this technology has been introduced by Hardi, and in Germany, in 1996, seven manufacturers exhibited equipment with air assistance in the "Agritechnica" agricultural trade show (KOCH, 1997). At that time, the Brazilian industry also incorporated this technology to the tractor-driven trailing sleeve boom sprayers.

The incorporation of this technology to sleeve boom sprayers was an attempt to improve the spraying penetration in the target culture, reduce the drift and the number of applications required, increase the time available for carrying out the spraying, and enable varying the spraying height over the culture (DEGANIA SPRAYERS Co., s.d.).

For applying phyto-sanitary products on low-stem cultivation, the spraying sleeve booms equipped with air assistance appeared as the ideal tools to improve the application quality (smaller droplets, in higher number), increase productivity (lower volumes and replenishments, higher displacement speed and extended spraying times), reduce the drift (the machine's wind speed is greater than the ambient wind) and exposure to these products (SARTORI, 1997).

After twenty years using the air assistance in sleeve boom sprayers, many information must still be clarified when interacting air volume and speed more adequate to the different cultures, angle of the nozzles on the boom in relation to the air, spraying height and displacement speed, among others, which enable wider spraying coverage and lower losses.

The tractor-driven sprayers with air assistance can be coupled to the tractor's hydraulic power take-off (3^{rd}. point) (those with lower capacity tanks or of trailing type). These sprayers are equipped with one or two fans, usually axial, positioned near the center section of the spraying sleeve boom, which distribute a very high air volume in an inflated duct, assembled over the boom and nozzles (MATTHEWS, 2000). The speed of the air generated may vary with the fan rotation (rpm), and generally it does not follow a linear relation. Also, air speed variations could occur along the bar, in the ends, when compared to the speed achieved in its center section (RAETANO, 2002).

There is an urgent need to establish standards for evaluating with accuracy the speed of the air generated by sleeve boom sprayers equipped with air assistance, because it is more and more important to standardize the measuring distance in relation to the air exit opening, as well as to specify anemometers that are able to record high air speeds (30 - 40 m/sec).

Raetano & Bauer (2003) evaluated the effects from air speed variation (50%, 75% and 100% of the maximum fan rotation capacity) on spraying sleeve boom, when depositing phyto-sanitary products in the bean cultivation. Forty-eight (48) days after the emergency, 200 g of copper oxide/100 L of water have been applied with the AXI-110015 tips at 206.7 kPa and JA-1 at 1,033.5 kPa, in the presence of air assistance or not, by using a sprayer Model Falcon Vortex. The broth volume has been 100 L/ha in both operational conditions. The air speed variation did not influence the deposit levels in the culture, but the use of air assistance, operated at full fan capacity, resulted in better deposit levels on the abaxial surface of the folioles positioned in the lower portion of the plants.

The cereal-cultivated soil contamination can be reduced in approximately 40% when using 50% of the maximum speed of the air generated by the fan in sprayer equipped with air assistance on the sleeve boom, when compared with the conventional application (without air), as reported by Taylor & Andersen (1997). The deposit and losses of spraying broth in the bean (*Phaseolus vulgaris*) cultivation, 26 days after the emergency, and using sprayers equipped with air assistance with the sleeve boom and conventional sprayers (without air) and volumes of 60 and 100 L/ha, have been evaluated by Raetano & Bauer (2004). The higher volume resulted in greater deposits, but high losses to the soil (above 60%) have been evidenced even when using the air assistance (air speed corresponding to 50% of the maximum fan rotation). In part, such results have been assigned to 40% of soil bare of vegetation in this growth stage of the culture.

The air volume generated may vary from 0 to 2000 m^3/hour/boom, depending on the number and power of the fans, distributed on variable-size booms that could reach 24-m length. The air distributed in the inflated duct is forced to pass through continuous or intercalated opening, in a perpendicular direction to that it has been generated, in the descending direction (Figure 1).

Figure 1 –Sprayers with air assistance near the spraying sleeve boom in the potato cultivation: Falcon Vortex (A) and Advance Vortex (B).

The positioning angle of the spraying nozzles in relation to the air curtain (Figure 2) generated by the equipment (vertical, descending), as well as the nozzles and air curtain simultaneously, in relation to the vertical position, may influence significantly the deposit levels and the spraying distribution. Today, in sleeve boom sprayers equipped with air assistance, the angle variations of the nozzles and air curtain, in relation to the vertical position, pro or against the tractor-sprayer assembly displacement, are made simultaneously with the single-cylinder command, clockwise or counterclockwise.

The results of researches carried out under controlled conditions and at field have evidenced that the nozzle positioning at 30° in favor of the displacement in conventional sprayers (without air) provides significant increase of the deposits on the leaf surface of different vegetal species: *Cyperus rotundus* (SILVA, 2000), *Brachiaria plantaginea* (TOMAZELA, 2001) and *Glycine max* (BAUER, 2002).

In England, experiences carried out in wind tunnels with plants cultivated on trays have confirmed that the spraying angle in favor of the displacement, in the presence of air assistance, has increased the deposit on cereals and reduced the soil contamination (HISLOP et al., 1995). Today, one may position the spraying nozzles and air curtain in angles of 15° and 30° in relation to the vertical position, in sleeve boom sprayers made in Brazil and equipped with air assistance.

The use of air angulation in favor of the displacement with fine droplets could increase substantially the spraying deposit levels on vertical targets. Results from experiences disclosed by Hardi Int. Tech. Report in the potato culture have indicated that the spraying penetration and retention have been greater with air assistance positioned in angle in favor of displacement, on the leaves in the lower portion of plants. In the upper portion, the retained broth volume has not been virtually influenced by the air exit angle, pro or against the equipment displacement (TAYLOR & ANDERSEN, 1997).

Figure 2 – Spraying sleeve boom angulation against the tractor-sprayer assembly displacement (A and B), and in favor of the displacement (C and D).

The spraying sleeve boom angulation interference, with or without the air assistance near the boom, on the deposit levels of a copper register in the potato culture (cv. Agate), has been recently studied by Scudeler & Raetano (2004). A copper fungicide (840 g of i.a./kg equivalent to 500 g/kg of metallic copper) in the dosing of 200 g of p. c. /100 L water was applied 58 days after cultivation, with or without the presence of air assistance, and combined with application angles of +30°(in favor the displacement), 0° (vertical) and –30° (against the displacement), with empty tapered jet spraying tip JA-4 (621 kPa) and broth volume equivalent to 400 L/ha. The largest deposits have been evidenced with nozzles positioned at 0° and +30°, with the presence of air assistance, both in the upper and lower portion of the plant. The air presence, in addition to provide larger deposits on the lower portion of plants, also provided higher evenness in the distribution of deposits on plant (Figure 3).

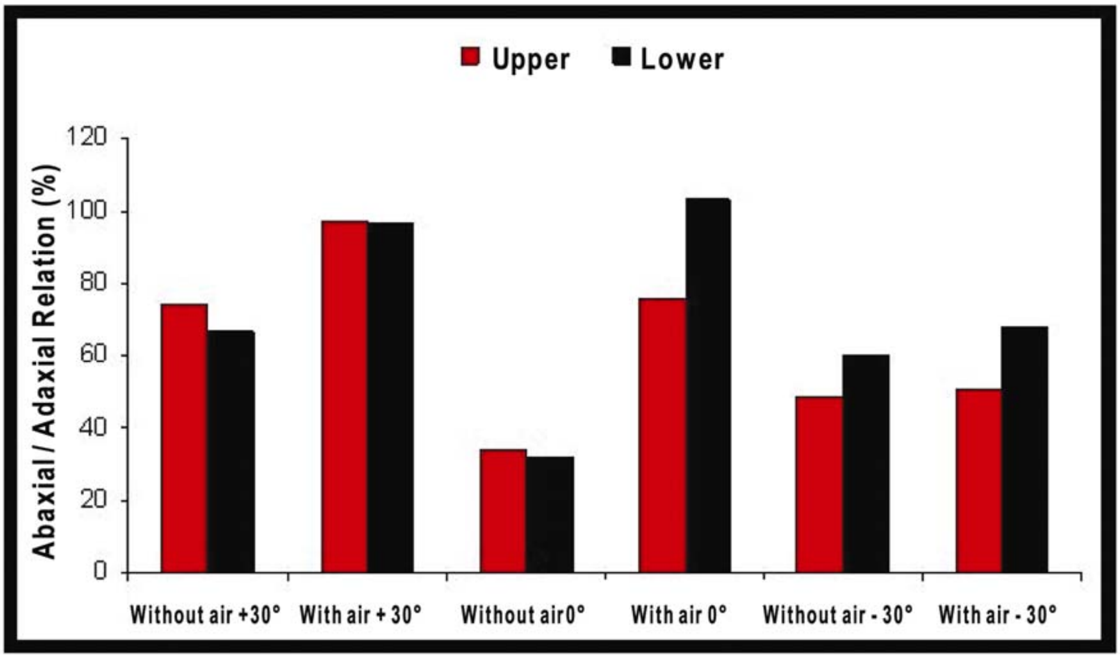

Figure 3 – Deposits on the abaxial / adaxial surfaces of the folioles in the upper and lower portions of potato plants (cv. Agate), after spraying the copper tracer (400 L / ha) with empty tapered jet tips JA-4, arranged at 0° (vertical), +30° (in favor of displacement) and –30° (against the displacement), with the presence of air assistance or not near the spraying sleeve boom.

Venegas et al. (2003), evaluating the effect of air assistance near the spraying sleeve bar on the broth deposit and control of black spot (*Alternaria solani)* in the 'Bintje' potato culture, have also evidenced that the air assistance reduced the variation of the spraying distribution along the boom, but did not influence the deposit levels in this species (Figure 4).

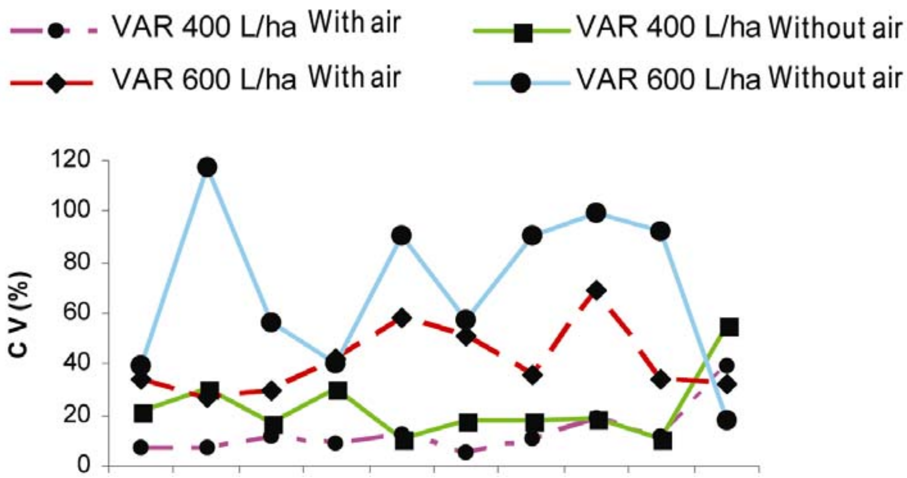

Figure 4 –Variation average total deposits in artificial target, arranged on 'Bintje' potato plants along the spraying sleeve boom and on the respective cultivation rows, after spraying copper ion at 400 and 600 L/ha, with and without air assistance near the boom.

In addition to the volume, generated air speed and nozzle angulation in these sprayers, other factors, such as displacement speed of the tractor-sprayer assembly, presence of vegetal coverage in the area or not, vegetal coverage type (monocotyledonous or dicotyledonous, plant density, architecture and plant cuticle characteristics), positions of insect-pests and plant pathogens, agrochemical product characteristics, droplet size and ambient conditions, especially the wind speed, may influence the phyto-sanitary control efficacy.

The air movement, caused by the tractor-sprayer assembly displacement speed, could influence significantly the dispersion of spraying from hydraulic nozzles. This is very evident when the displacement speed increases on plain areas (MATTHEWS, 2000). In some Brazilian states, the spraying at speeds over 16 km/hr has become a usual practice among farmers, favored by the local topographical conditions.

After the exit of liquid from the orifice in the spraying tips, 50 to 70% of the power originated from its pressurization is lost. The remaining power is in the form of movement, and then it is called of momentum. The reduction of momentum is caused mainly by the air resistance, with gradual falling of the droplets in the environment. Droplets with lower momentum are more prone to drift. Thus, when changing the trajectory, they are taken by ascending air stream behind the nozzle, with vortex formation. The induced descending air stream generates a pressure drop around the nozzle, which is restored by the air proceeding from the nozzle front, due to its movement in the displacement direction of the sprayer (JORGENSEN, 2000).

Since the smaller droplets extend their trajectories in air, they are exposed to aerial streams during time periods relatively long before reaching or penetrating in the vegetation, when they do not deviate from the target. Thus, the smaller droplet drift (air carried) is not only a function of its size and the wind speed, but certainly depends on the aerodynamic properties of the spraying nozzle selected. Equipment with descending air assistance has been used to increase the droplet penetration inside the culture and reduce the spraying drift (TAYLOR et al.., 1989; COOKE *et. al.*, 1990; TAYLOR & ANDERSEN, 1991; BAUER & RAETANO, 2000).

Bauer & Raetano (2000), evaluating the effect of air assistance on the deposit and losses of phyto-sanitary products in the spraying of soybean cultivation, when compared with the conventional equipment (without air) with artificial targets, have evidenced significantly lower levels of drift (air carried) for the equipment with air, in different distances from the spraying boom. The authors have also evidenced lower drift by sedimentation in the external area of the culture when using air assistance near the spraying sleeve boom.

The air assistance in the spraying sleeve boom improves significantly the penetration of spraying, especially in high cultures and high leaf density, such as potato, in addition to reduce the drift (KOCH, 1997). However, these effects are not observed when the air-assisted spraying is made on bare soil or plants in the first growth stages. Also, according to Matthews (2000), the air-assisted spraying penetration is better when compared to that on wide-leaf cultures, such as cotton.

In Holland, tests with the air-assisted sprayer TWIN (Hardi) have been carried out on potato cultivation. Generally, the air assistance has reduced the drift by sedimentation by 50% and the air-carried drift by 75%. In this country, the accepted drift percentage by sedimentation is 8 – 10% for a distance of 1.5 to 2.0 meters from the boom, and around 0.2% for 5.0 to 6.0 meters. The recommendation for making spraying in Holland is with a wind speed less than 5.0 m/sec. In Germany, the accepted drift values by sedimentation when applying phyto-sanitary products range from 0.6 to 0.1%, respectively, for distances of 5.0 to 30.0 meters from the spraying sleeve boom (JORGENSEN & WITT, 2000).

Considering the drift limits accepted in spraying at Germany, the safe distance for applying near the water channels (irrigation/draining) in that country is 10.0 meters for 80% of the herbicides approved for use, and 20.0 meters for other herbicides. France and Belgium comply with the drift limits accepted in Germany.

Artificial targets have been also used by the Morley Research Centre for simulating venomous plants in the sugar beet. The variations in the deposit values for air-assisted spraying were lower when compared to those achieved with the conventional sprayer (TAYLOR & ANDERSEN, 1997). These authors have also evidenced the influence of air assistance on the drift percentage reduction compared with conventional application (without air), by obtaining 90, 84, 83, 76, 68 and 61%, respectively, when spraying barley, bean, pea, Brussels sprouts, lettuce and leek, with fine droplets.

Today, studies involving computer models aim at clarifying the relationship among the air released, drift risk and deposit on target. Preliminary studies have evidenced that the increase of the displacement speed with air-assisted sprayers may reduce the drift, but provides lower evenness in the target culture treatment (MILLER, 1997). However, aiming at reducing the application volume, Nordbo (1992) has evidenced lower variation and improved deposit by using air assistance.

The density, architecture, cuticle type (pilose, glabrous, waxy) and growth stage of the vegetal species in the area are factors influencing the phyto-sanitary control efficiency when using air-assisted sleeve boom sprayers.

Fine droplets provide larger deposits on plants, especially monocotyledonous, but are very susceptible to drift. Their penetration capacity in cultures is small, and then the loss to the soil must be limited. Therefore, the air assistance enables using fine droplets more efficiently, by reducing the drift and increasing the deposits on the target, in addition to provide higher penetration of these droplets in cultures with higher leaf density, and reducing the losses to the soil (JORGENSEN & WITT, 1997).

On the other hand, coarse droplets generally provide a good drift control. In dicotyledonous, the deposits do not depend only on the droplet size (NORDBO, 1992). Unlike the results with lower diameter droplets, coarse droplets provide significantly lower deposits on vertical surfaces (monocotyledonous), and especially in the first growth stages, by increasing the loss to soil proportionally to their size (JORGENSEN & WITT, 1997).

In vegetables, where the droplet retention is limited by the presence of waxy layers on the cuticle, further studies are required, especially with air-assisted spraying, in order to evaluate the application quality (KOCH, 1997). In the absence of vegetation (bare soil), the air assistance may increase the drift and deflect the air from the sprayer by the soil, unlike the effect occurred in the presence of vegetation, with the impact of droplets on the leaf surface (MATTHEWS, 2000).

The increase of spraying deposits, especially on the abaxial surface, on leafs positioned in the lower portion of plants, has contributed for improving the efficiency of the insect-pest control, such as the aphid in potato and the white fly in bean.

The spraying deposit on the bean cultivation, 48 days after the emergency and in the presence of air assistance near the spraying sleeve boom, with different spraying tips and broth volumes, was not statistically different from that obtained by the conventional spraying (BAUER & RAETANO, 2003). However, deposits significantly larger have been obtained on the abaxial surface of folioles nearest to the soil, with the tapered jet tips JA-2 and AXI 11003 plain, at pressures of 1,033.5 and 206.7 kPa, respectively and volume of 200 L/ha.

The drift reduction, the higher penetration and evenness in the spraying distribution, lower dependency of the ambient wind and increased deposits, especially on the abaxial surface of plants positioned near the soil, constitute benefits of the air assistance in the spraying sleeve boom, in addition to the improved control efficacy and reduced environmental contamination. Besides these factors, the reduction in phyto-sanitary product dosing has been also evidenced in the control of insect-pests, pathogens and intruder plants by adopting this technology.

In the sugar beet culture, the phyto-sanitary products applied with air assistance near the boom, with 50% of the registered dosage, have provided a control as efficient as 100% of the dosage with conventional sprayer (MAY & HILTON, 1992). This effect was also observed in the control of intruder plants in the barley culture, where one-third of the sulfunylurea dosage applied with air assistance (100 L/ha) has provided the same efficiency as the application with 100% of the dosage with conventional sprayer (without air), in the volume of 200 L/ha (ANDERSEN et al.., 2000). However, when one-third of the dosage has been applied with conventional sprayer, the number of live plants increased.

A better efficiency in the control of *Botrytis* has been achieved on peas with 50% of the fungicide dosage, applied with air assistance, when compared with 100% of the dosage applied in the conventional mode (KNOTT, 1995).

Today, the air assistance is combined with the electrification (by induction) of the spraying droplets, aiming at reducing the drift and the appliers' exposure, as well as the environment, to the phyto-sanitary products.

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