

Drift Retardant Chemical Effects on Spray Droplet Size, Pattern and Drift

H. Erdal Ozkan*, **Donald L. Reichard****, **Hepping Zhu****, and **Ahmed S. Babeir*****

Professor, Agricultural Engineering Dept., The Ohio State University, Columbus, Ohio, 43210, USA, **Agricultural Engineer, and Post-doctoral Agricultural Engineer, respectively, SDA-Agricultural Research Service, Application Technology Research Unit, Wooster, Ohio, 44691, USA. *Associate Professor, Agricultural Engineering Dept., King Saud University, Saudi Arabia (formerly Visiting Professor at the Ohio State University).*

(Received 23/4/1414; accepted for publication 18/1/1415)

Key words: Drift, Retardant, Droplet Size, Spray Pattern, Nozzle.

Abstract. Objectives of this study were to determine the effects of various drift retardant chemicals on droplet size, spray pattern, and spray drift reduction of sprays from an XR 8004VH fan-pattern nozzle. Results indicated that, at recommended rates, Nalco-trol provided the largest increase in volume median diameters of the sprays followed by Direct, Target, Driftgard, and Formula 358. All drift retardants created patterns with greater volume toward the center than sprays of water only. Cumulative deposits beyond 0.5m downwind increased for all drift retardants when the wind velocity was increased from 2.0 to 4.0 m/s. The least amount of downwind deposit beyond 0.5m at 4.0 m/s was with Nalco-trol followed by Target, Driftgard, Direct and formula 358.

Introduction

Due to increasing concerns about crop production costs and environmental pollution, it is essential to apply pesticides with precision and care. A very large portion of pesticides are applied in the form of sprays using hydraulic pressure nozzles. Spray drift can occur from these applications. Drift is undesirable because it may result in inefficient use of pesticides, ineffective pest control, pollution of air and water resources, and losses and/or costly litigation if sensitive crops in adjacent fields are damaged.

Although complete elimination of spray drift is very difficult, its magnitude can be reduced significantly if factors which enhance creation of drift can be altered or eliminated. Spray droplet size is a major factor affecting drift. Small droplets, if depo-

sited on the target, provide better coverage and this usually results in increased control of some pests. However, small droplets are susceptible to drift. Large drops are less susceptible to drift, but may result in inadequate spray coverage at low spray application rates. Reichard *et al.* [1] determined drift distances for droplets discharged downward with 20 m/s velocity toward a target 0.5m below point of discharge. They found that for wind velocity of 4 m/s and 60% relative humidity, 100 and 200 μm diameter droplets drifted 5.1 and 0.28m, respectively, downwind.

Spray droplet size distribution from a given atomizer can be altered by changing the physical properties of the spray mixture such as viscosity by adding drift retardant chemicals to the spray mixture. There are many drift retardant chemicals commercially available to pesticide applicators. However, the information related to the performance of these products is limited.

The objectives of this study were to determine the changes that occur in droplet size and volume distributions of a fan nozzle, and the amount of spray drift when some commercially available drift retardant chemicals are added to the spray mixture.

Materials and Methods

The XR 8004VH nozzle (Spraying System Co.⁽¹⁾) delivered 1.5 l/min at 276 kPa in a flat pattern with 80° spray angle. The nozzle has a hardened stainless steel tip. Tests were conducted to determine droplet size and spray volume distributions, and spray drift both with drift retardants and water, and water only. The drift retardants used were: Direct, Driftgard, Formula 358, Nalco-trol, and Target. The first four drift retardant are liquid formulations, and Target is a powder formulation. Active ingredients, and concentrations used in tests are given in Table 1. The spray mixtures consisted of distilled water and a fluorescent tracer with each of the five drift retardants. Tinopal CBS-X fluorescent tracer, at a concentration of 0.1 g/l of distilled water, was used to trace the spray deposits. Concentrations of the drift retardant formulations were 0.634, 0.156, 6.26 and 0.547 ml/l of water for mixtures with Direct, Driftgard, Formula 358, and Nalco-trol, respectively. The mixture of Target and water contained 0.37g of Target per liter of water. These were either recommended by the company sales representatives or mid range of the label recommendations.

⁽¹⁾ Reference to a proprietary product or company is for specific information only and not to imply approval or recommendation of the product by The Ohio State University or the USDA to the exclusion of others that may be suitable.

Table 1. Drift retardants, active ingredients (AI), and concentrations of AI used in tests

Drift retardant	Active ingredient (AI)*	%AI*	%AI in mixture
Direct	Polyacrylamide polymer (Pap)	30	0.019
Driftgard	Anionic Pap	25	0.004
Formula 358	Pap	1	0.006
Nalco-trol	Acrylamide polymer	30	0.016
Target	Polymers of acrylamide, acrylate and saccharides	30	0.011

* Source: Harvey, L.T. [2]

Droplet size tests

Droplet size spectrums of the spray mixtures with drift retardants, and water only, were measured, and Volume Median Diameters ($D_{v,5}$) of droplets were determined using a 2600C Malvern particle size analyzer. To better understand the overall droplet size distributions across the spray pattern, a weighted volume median diameter, designated as $D_{v,5}$, was calculated. This was accomplished by measuring volumes of amount of the liquid sprayed at 10 cm intervals across the swath (9 points), and using this data in conjunction with the droplet size measurements taken at each of these 9 positions. Detailed information about the system and the procedures used to measure droplet sizes is given by Ozkan *et al.* [3].

Spray pattern tests

After the droplet size tests were completed, we determined the spray distribution patterns of the nozzle using an automated, computerized spray pattern analysis system, described by Ozkan and Ackerman [4]. It consists of a pumping system, a spray table, and an automated weighing and data acquisition system. The spray nozzle was mounted 0.5 m above the patternator table and sprayed onto it while an electronic balance with container traversed the bottom of the patternator table. A roller pump delivered spray solution from a tank to the nozzle. A spray pressure of 276 kPa was maintained during all tests.

Spray drift tests

The spray drift tests were conducted in a wind tunnel with 3.7 m long test section (0.61 m wide and 0.91 m high). Details of the structure of the wind tunnel and measurements of wind velocity, turbulence intensity, temperature and relative humidity were described by Reichard *et al.* [5]. Simulated winds with about 2.0, 3.0 and 4.0 m/s velocities and 4.0% turbulence intensity were used in all tests in the wind tunnel. Experimental conditions for the spray drift tests are given by Ozkan *et al.* [6]. Two replicate tests were conducted for each combination of wind velocity and drift retardant used in this study.

The nozzle was mounted in the test section of the wind tunnel at 0.67 m above the wind tunnel floor, midway across the width of the tunnel and 2.5 m upwind from the downstream end of the test section. The long axis of the spray pattern from the nozzle was across the width of the tunnel. Flow to the nozzle was controlled with a solenoid valve. A timer was used to keep the valve open five seconds during each test. Liquid was delivered to the nozzle at 276 kPa from a container pressurized with air from an air supply line.

A strip of cotton fabric (10×170 cm) was used as the target to collect spray drift downwind from the atomizer. The nozzle was 0.5 m above the target. The target surface was placed 0.17 m above the wind tunnel floor to avoid collecting any rebounding droplets from the wind tunnel floor. The target was placed in the center of the wind tunnel and with its long axis parallel to the wind direction. There were some unusually large drops created because of low liquid pressure at the orifice of the nozzle during the brief period of starting or stopping spray. The large drops fell vertically onto the floor of the wind tunnel. To avoid collecting these large drops, the upwind side of the target was placed 0.3 m downstream from the nozzle.

Three cotton string targets hung vertically from the top of the wind tunnel and attached to the center and two sides of the downstream end of the plywood strip for each test. Each string was about 0.1 cm diameter and 70 cm long, and its projected area against the wind was about 7 cm^2 . The strings were used to collect samples of the airborne droplets above the downstream end of the cloth strip.

Immediately following each spray, the strip of cloth was cut into 17 square samples (10×10 cm). Each sample was placed into a glass bottle, and the bottles were stored in refrigerator. At time of analysis, 30 ml of distilled water was added to each bottle, and the bottle was shaken for 3 min to remove the tracer from the sample. The wash solution was analyzed with a fluorometer (Turner Model 112).

Results and Discussion

Effect of drift retardants on droplet size

The results of droplet size measurements obtained from spray mixtures with and without the drift retardant chemicals are shown in Fig. 1. The graph indicates the $D_{v,5}$ values of droplets measured at 10 cm increments along the X axis. The data near the edges of the spray patterns for several tests are greatly different from the rest of the curve. However, the flow rate and number of drops at the edges of the patterns were much less than in the centers of the spray patterns.

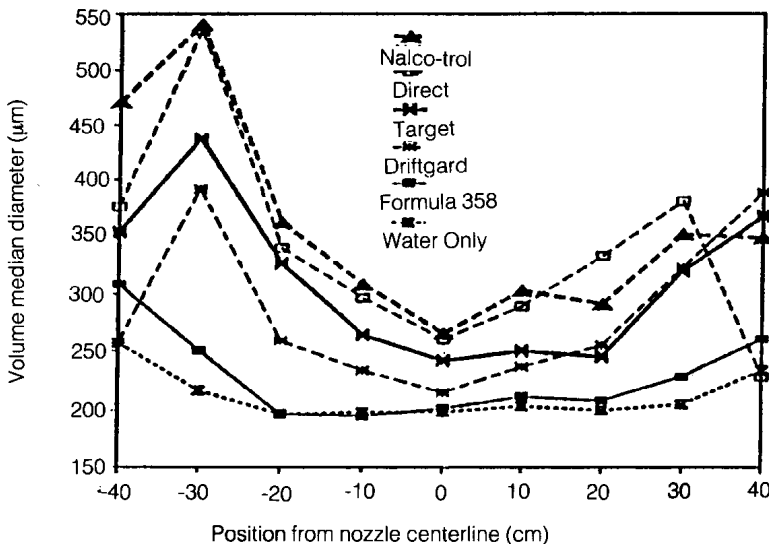


Fig. 1. $D_{v,5}$ (VMD) distributions from an XR 8004VH nozzle spraying mixtures containing drift retardants, and water only.

Figure 1 shows that Nalco-trol provided the largest $D_{v,5}$ values across most of the spray pattern. Direct, Target, and Driftgard resulted in smaller $D_{v,5}$ values. Formula 358 resulted in the smallest increase in $D_{v,5}$ values when compared with water only. The drift retardants that were more effective in increasing $D_{v,5}$ values also caused greater droplet size near the edges of the spray pattern compared to those at the center. Larger droplets at the edges of the pattern are characteristic of these types of flat fan nozzles even when spraying only water. However, this difference in droplet size was greater for the drift retardants that were more effective in increasing overall $D_{v,5}$ values.

The mixture that contained Nalco-trol had the greatest Weighted Volume Median Diameter ($\bar{D}_{v,5}$) value followed by Direct, Target, Driftgard, and Formula 358 with values of 332, 325, 283, 262, and 211 μm , respectively. These values represented 63.0, 59.8, 38.9, 28.6, and 3.5 percent increases respectively, in $\bar{D}_{v,5}$ over the 204 μm $\bar{D}_{v,5}$ value for water.

For mixtures with different drift retardants, we also determined the percent reduction (relative to a water spray) in spray volume contained in droplet sizes less than 100, 150 and 200 μm diameter. In comparison to spraying water only, all drift retardants reduced portion of small droplets in the spray but at varying magnitudes. For instance, Nalco-trol caused the highest reduction (62.6%) in the portion of spray volume in droplets less than 200 microns, followed by Target, Direct, Driftgard and Formula 358 with reductions of 61.4, 55.8, 34.5 and 23.1%, respectively.

Effect of drift retardants on spray pattern

Figure 2 shows spray patterns associated with spray mixtures containing drift retardants, and water only. There was little difference in the shapes of the spray patterns of water and spray mixtures containing drift retardants, except those containing Nalco-trol and Direct. Spray patterns associated with Driftgrad, Formula 358, and Target were triangular shaped with a sharp peak at the center. The pattern from the Nalco-trol mixture was rounded at the center with the sides of the pattern bulged out more than the patterns from the spray mixtures with the other four drift retardants. Similarly the pattern from the direct mixture bulged out on the sides but it had sharp peak at the center unlike the Nalco-trol pattern. In general all drift retardants caused patterns with lesser volume of spray at the edges and greater volume toward the center than that of water only.

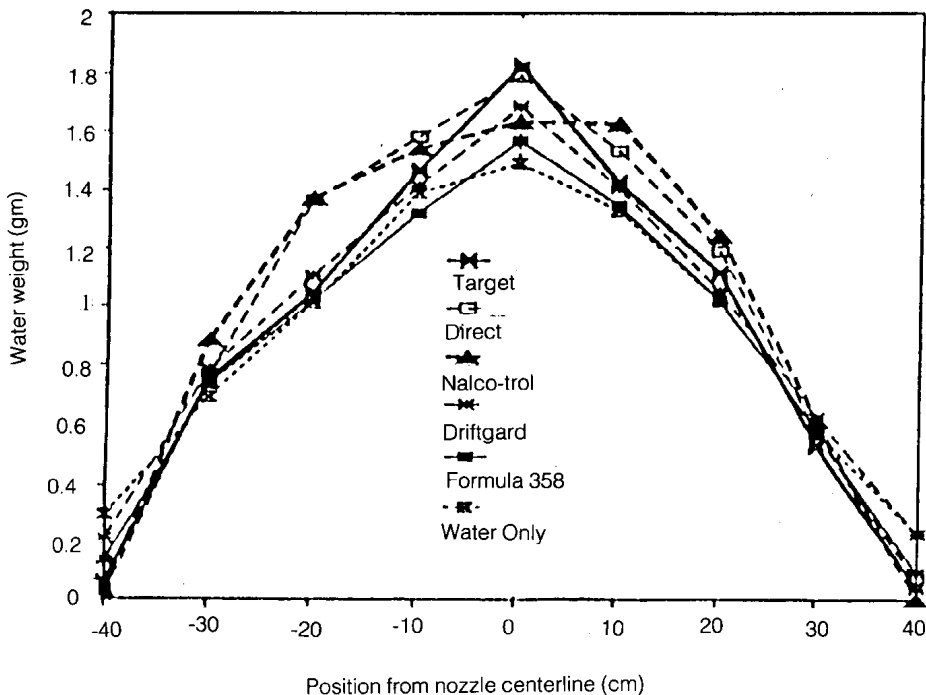


Fig. 2. Spray distributions from an XR 8004VH nozzle spraying mixtures containing drift retardants, and water only.

Effect of drift retardants on reducing drift

Figure 3 shows the amounts of cumulative deposits on the horizontal Targets beyond various distances downwind from the 8004VH nozzle for various drift retar-

dants when wind velocity was 2.0 m/s. Each spray deposit value shown in Fig. 3 represents the sum of deposits from a downwind distance to 2.0m downwind from the nozzle. The mean tracer deposits on the 10×10 cm samples from two replicate tests were used in the calculations of the cumulative deposits. Nalco-trol, Target, Direct, and Driftgard reduced spray drift as evident from the total deposit beyond 0.5m in Fig. 3. The curve of cumulative deposit for distilled water without drift retardant is higher than the curves for spray mixtures with Nalco-trol, Target, Direct, and Driftgard (Fig. 3). Total drift deposits beyond 0.5m increased for all drift retardants when the wind velocity was increased from 2 m/s to 4 m/s. For example, total deposits beyond 0.5m were reduced 34.1, 42.1 and 17.6% respectively for wind velocities of 2.0, 3.0 and 4.0 m/s when the spray mixture contained Target instead of only water and tracer.

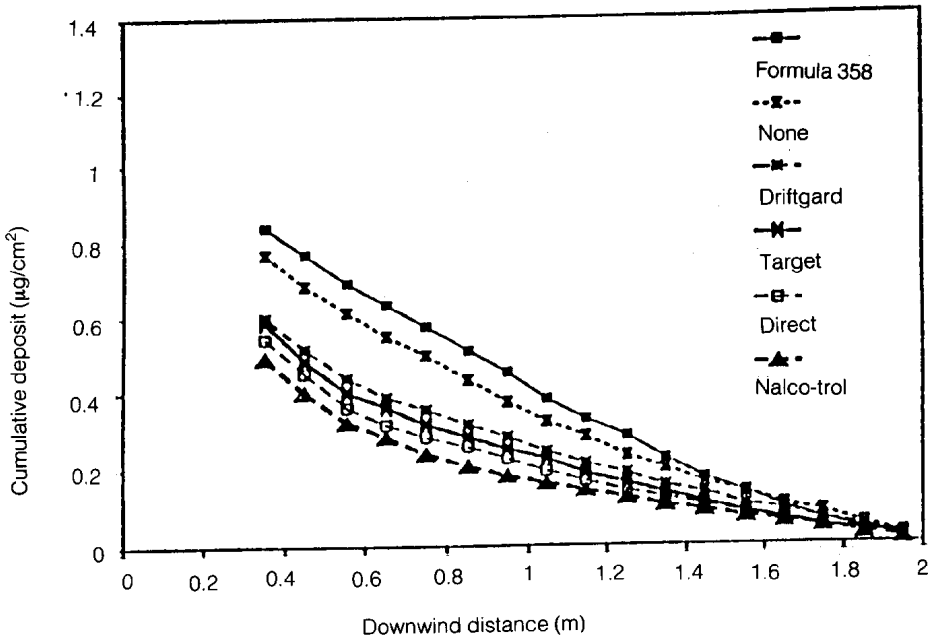


Fig. 3. Cumulative downwind spray deposits for drift retardants, and water only, sprayed from an XR 8004VH nozzle when wind velocity was 2.0 m/s.

Spray deposit data in Fig. 3 appears to indicate that the concentration used, the mixture containing Formula 358 dose not reduce spray drift deposits. This drift retardant resulted in greater total deposits beyond 0.5m for wind velocities of 2.0, 3.0 and 4.0 m/s than from sprays containing only water and tracer. One reason for this is that drift retardants make the spray pattern narrower and produce greater flow rates in the centers of the patterns, and the drift targets were located on a line through the centers of the patterns.

Figure 4 shows deposits collected on the vertical cotton strings at 2.0m downwind from the 8004VH nozzle when wind velocities were 2.0, 3.0 and 4.0 m/s. Each data point in Fig. 4 is the mean tracer deposit on the projected area of the three strings (21 cm²). Most of the deposits on the strings were close to the bottoms of the strings that were attached to the support for the horizontal targets. For nearly all drift retardants and wind velocities, deposits of airborne droplets on the strings were less than for sprays containing only water and tracer. The deposits of airborne droplets with the mixture containing Formula 358 on the strings is greater than deposits from the mixture of distilled water and tracer in 3.0 and 4.0 m/s wind velocities. Spray mixtures containing Nalco-trol or Target resulted in the least amount of deposit on the strings. When the wind velocity was 3.0 m/s, spray containing only water with tracer resulted in deposits 4.8 and 3.6 times greater than the sprays with Nalco-trol and Target, respectively. Deposits on the strings increased with increased wind velocity especially for the spray mixture without drift retardants. Drift deposits on the strings were 5.2 and 3.3 times greater for spray without drift retardant than for spray containing Target at wind speed of 2.0 and 4.0 m/s, respectively.

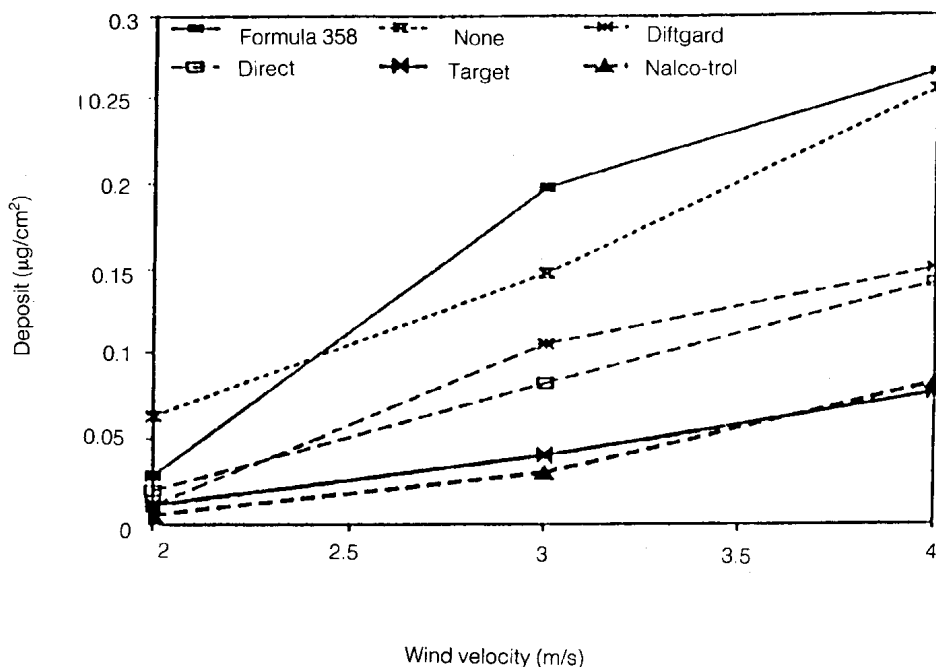


Fig. 4. Effects of wind velocities on deposities collected on vertical strings for sprays containing drift retardants, and water only with tracer, from an XR 8004 VH nozzle.

Conclusions

1. Of all the drift retardants used in the experiments, Nalco-trol provided the largest increase (63%) in weighted volume median diameter ($\bar{D}_{v,5}$) relative to water sprays. Increases in $\bar{D}_{v,5}$ with Direct, Target, Driftgard, and Formula 358 were 59.8, 38.9, 28.6, and 3.5% respectively. All drift retardants reduced portion of small droplets in the spray.

2. All drift retardants caused spray patterns with greater volume in the center than for sprays with water only.

3. Total deposits on the horizontal target at 0.5 to 2.0m downwind from the 8004VH nozzle increased for all drift retardants when the wind velocity was increased from 2 m/s to 4 m/s. The least amount of deposit at 2.0 m/s was with Nalco-trol followed by Direct, Target, Driftgard, and Forumula 358. At 4.0 m/s wind speed, Nalco-trol had the lowest amount of deposits beyond 0.5m followed by Target, Driftgard, Direct, and Formula 358.

4. In general, a comparison of the spray deposits from mixtures containing drift retardants on horizontal targets and vertical strings indicated that Nalco-trol and Target were the most effective in reducing spray drift followed by Direct, Driftgard, and Formula 358.

References

- [1] Reichard, D.L.; Zhu, H.; Fox, R.D., and Brazee, R.D. "Computer Simulation of Variables that Influence Spray Drift." *Transactions of The ASAE*, 35, No.5 (1992), 1401-1407.
- [2] Harvey, L.T. *A Guide to Agricultural Spray Adjuvants Used in the United States*. Fresno, California: Thompson Publications, 1992.
- [3] Ozkan, H.E.; Reichard, D.L., and Sweeney, J.S. "Droplet Size Distributions Across The Fan Patterns of New and Worn Nozzles." *Transactions of the ASAE*, 35, No.4 (1992a), 1097-1102.
- [4] Ozkan, H.E. and Ackerman, K.D. "An Automated Computerized Spray Pattern Analysis System." *Applied Engineering in Agriculture*, 8, No.3 (1992), 325-331.
- [5] Reichard, D.L.; Zhu, H., and Brazee, R.D. "Wind Tunnel Evaluation of a Computer Program to Model Spray Drift." *Transactions of the ASAE*, 35, No.3 (1992b), 755-758.
- [6] Ozkan, H.E.; Reichard, D.L.; Zhu, H., and Ackerman, K.D. "Effect of Drift Retardant Chemicals on Spray Drift, Droplet Size and Spray Pattern." *ASAE Paper No. 921613*, (1992b) ASAE, St. Joseph, MI, 49085-9659, USA.

تأثير معوقات الانحراف الكيميائية على حجم حبيبات الرش ونمطها وانحرافها

ح . إرداك أوزكان*، دونالد ك . ريكارد**، هيينتق زهو** وأحمد ص . بابعير***
 * قسم الهندسة الزراعية، جامعة ولاية أوهايو، كولومبس، أوهايو، الولايات المتحدة الأمريكية
 ** قسم البحوث الزراعية بوزارة الزراعة الأمريكية، وحدة بحوث تطبيقات التقنية، ووتر، أوهايو،
 الولايات المتحدة الأمريكية، *** قسم الهندسة الزراعية، جامعة الملك سعود، الرياض،
 المملكة العربية السعودية

(قدم للنشر في ٢٣/٤/١٤١٤هـ؛ وقبل للنشر في ١٨/١/١٤١٥هـ)

ملخص البحث . الهدف من هذه الدراسة هو تحديد تأثير معوقات الانحراف الكيميائية المختلفة على حجم حبيبات الرش، وتقليل انحراف محاليل الرش عند استخدام البشوري المروحي XR 8004 VH . أوضحت النتائج، عند معدلات التطبيق الموصى بها، أن المركب الكيميائي نالكوتترول أعطى أكبر زيادة في حجم أقطار العدد المتوسط لحبيبات محاليل الرش تلاه في ذلك كل من المركبات الكيميائية دايركت، تارقت، دريفتقارد، وفورميولا ٣٥٨ . وجد أن جميع معوقات الانحراف كونت أنماط رش ذات حجم كبير اتجاه مركز الرش أكبر عن تلك التي كونت باستخدام الماء فقط . زادت الرواسب المتراكمة على مسافة أكبر من ٥ , ٥ م في اتجاه الهواء لكل معوقات الانحراف عندما زادت سرعة الهواء من ٢ إلى ٤ م / ث . أعطى المركب نالكوتترول أقل رواسب في اتجاه الهواء عند مسافة أكبر من ٥ , ٥ م عند سرعة هواء ٤ م / ث، تلاه في ذلك المركبات تارقت، دريفتقارد، دايركت، وفورميولا ٣٥٨ .