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Effects of Spray Release Height and Nozzle/Atomizer Configuration on Penetration of Spray in a Soybean Canopy – Preliminary Results

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Abstract. *Preliminary experiments were conducted using three nozzle/atomizer configurations to determine spray characteristics and to evaluate relative penetration of spray into a soybean canopy. Water was applied at three different spray release heights in a random sequence using an Air Tractor 402-B agricultural aircraft. Sampler stands were placed at twenty four locations in the field with water sensitive paper (WSP) cards clipped onto stands just above the canopy and one foot off the ground within the canopy. Weather data were recorded using two different stations on-site and wind was predominantly from the west and parallel to the direction of spray runs. Spray nozzles and atomizers compared were the Micronair® AU5000 (14 mesh screen), Accuflo® (64 needle 0.020 opening), and CP®-07 with 5 degree deflection. The three nozzles/atomizer types were configured for a spray rate of 18.7 L/ha (2 GPA or gallons/acre). A total of 54 runs were made over three days, and*

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18 of those runs (two complete replications; east to west runs) were analyzed for this preliminary study. Spray cards were scanned and analyzed using an image analysis system and programmed analysis macros written for SigmaScan software. Results indicated Volume Mean Diameter (VMD) within the expected ranges from published data for the CP® nozzles. Statistical analysis was then performed. Altitude and Nozzle X Altitude interaction were significant effects on coverage at the 0.01 and 0.07 significance levels, respectively for the top cards. Nozzle type was not a significant effect for the top cards, but was significant at the 0.01 level for the bottom cards. Altitude alone had no obvious effect on coverage for the bottom cards, although it had an effect for the top cards. The highest percentage area of coverage was observed from the Accuflo® nozzles, especially for the bottom cards. Average spray coverage from the Accuflo® nozzles was 1.6 times higher than coverage from the CP® nozzles or Micronair® atomizers for the bottom cards within the canopy. The Micronair® atomizer showed a smaller average VMD (181 microns), and some of the finer droplets could have drifted or evaporated before reaching the cards. Propeller blade angle for the Micronair® atomizers will be increased by 10 to 15 degrees to promote larger droplets (near the 250 um range). Alternatively, the AU5000LD (Low Drift) retrofit with deflectors might be considered as this setup permits larger droplets. Different spray formulations commonly used for control of soybean rust and different spray rates will be evaluated in subsequent studies. Analysis of spray card data is continuing.

Keywords. Spray deposition, soybean rust, rotary atomizer, spray nozzle, aerial application, canopy penetration

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Introduction

The deleterious effects of fungal spores on soybean health and yield have been well documented. Soybean rust is a serious problem that is beginning to show its effects in the United States. In order to combat this problem with aerial application, the best nozzle and atomizer setups need to be evaluated for their effectiveness in penetrating sprayed fungicide into soybean canopies. This ultimately should also include evaluation of spray mixes and varied spray application heights. Many studies have attempted to define optimal application volume/adjuvant combinations for improving within-canopy spray deposition (Wolf, 2004), have presented summary information and guidelines for soybean rust control (McCracken, 2005; Gardisser, 2007), and have tested atomizer/adjuvant combinations for their effectiveness in rust control (Antuniassi, 2006).

Materials and methods

Preliminary experiments were conducted using three nozzle or atomizer configurations to determine spray characteristics and relative penetration into a soybean canopy. Soybeans (Glycine max) were planted in twin rows on 40 inch centers. Water with a Rubidium Chloride (RbCl) tracer was applied at three different spray release heights of 3.7, 4.9, and 6.1m (12, 16, and 20 ft) in random sequence using an Air Tractor 402-B agricultural aircraft. The RbCl tracer was collected on mylar collection sheets and will be analyzed for swath patterns and off-target drift (data not presented here).

Twenty-four rigid sampling stands were placed in two rows north and two rows south of the east-west centerline. Water sensitive paper (WSP) cards were clipped onto horizontal trays just above the canopy and one foot off the ground on trays within the canopy, for a total of 48 cards per run.

Weather data were recorded using both a Campbell CR21-X data logger with weather sensors and Kestrel 4500 weather tracker. During the experiment, air temperature ranged from 30º to 35ºC (86º-95º F); relative humidity ranged from 50 to 71%; windspeed ranged from 0.68 to 2.79 m/s (1.53 to 6.23 mph). Wind direction was from W to NW, essentially parallel to the flight-line.

Spray nozzles and atomizers compared were the Micronair® AU5000 atomizer (using a 14 mesh screen), Accuflo® nozzle (64 needles per nozzle with 0.020 opening), and CP®-07 nozzle (0.062 orifice, 5 degree deflection). The two nozzle types and Micronair® atomizer were configured for a spray rate of 18.7 L/ha (2 gallons/acre) and a 65 foot swath. Nominal system pressures were 48 psi when using the Micronair® atomizer, 24 psi when using the Accuflo® nozzle, and 36 psi when using the CP® nozzle. Height of spray release was determined using a Laser Technology ULS laser connected via USB 2.0 interface to a notebook computer mounted in the belly of the aircraft. The laser data acquisition computer, Campbell data logger, and Kestrel 4500 weather tracker were all synchronized in time using an atomic watch. A total of 54 runs were made over three days, randomized on altitude. Time of field entry for each run was noted to the second with the aid of the atomic watch.

For this study, the twenty four cards from the two rows closest to the centerline were sampled (12 top, 12 bottom). Eighteen of those runs (morning runs; two complete replications; east to west direction) were analyzed for this preliminary study. A total of 432 cards were scanned and analyzed (216 top, 216 bottom) using an image analysis system and programmed spray card analysis macros for the SigmaScan 5.0 software. Volume mean diameter (VMD), Relative Span, and percentage spray card coverage are reported herein.

Results

Results indicated Volume Mean Diameter (VMD) within the expected ranges from published data for the CP® nozzles (Table 1). Statistical analysis was then performed. Weather effects were not significant on spray coverage for either top or bottom cards. Altitude and (Nozzle X Altitude) interaction were significant effects on coverage at the 0.01 and 0.07 significance levels, respectively for the top cards (Table 2). Nozzle type was not a significant effect for the top cards, but was significant at the 0.01 level for the bottom cards (Table 3). Altitude alone had no obvious effect on coverage for the bottom cards, although it had an effect for the top cards. The highest percentage area of coverage was observed from the Accuflo® nozzles, especially for the bottom cards. Average spray coverage from the Accuflo® nozzles was 1.6 times higher than coverage from the CP® nozzles or Micronair® atomizers for the bottom cards within the canopy (Fig. 1). The average number of drops on cards were 92 for the Accuflo®, 60 for the CP®, and 138 for the Micronair®.

Table 1. Summary data for top cards. VMD = Volume Mean Diameter (microns); Ave Span = Average Relative Span; SD= Standard Deviation

	Ave % coverage	SD coverage	Ave VMD	SD VMD	Ave Span	SD Span
Accuflo	1.18	0.22	367.17	51.70	1.31	0.50
CP	1.03	0.11	369.83	67.56	1.39	0.46
Micronair	0.85	0.19	181.67	20.44	0.81	0.31

Table 2. Statistical analysis results– top cards

Effect	Num DF	Den DF	F Value	Pr > F
DAY	2	1	0.62	0.6680
ALT	2	6	11.41	0.0090
NOZZLE	2	1	2.37	0.4174
NOZZLE*ALT	4	6	3.96	0.0657

Table 3. Statistical analysis results– bottom cards

Effect	Num DF	Den DF	F Value	Pr > F
DAY	2	7	5.68	0.0343
ALT	2	7	0.75	0.5048
NOZZLE	2	7	10.37	0.0081
NOZZLE*ALT	4	7	0.59	0.6781

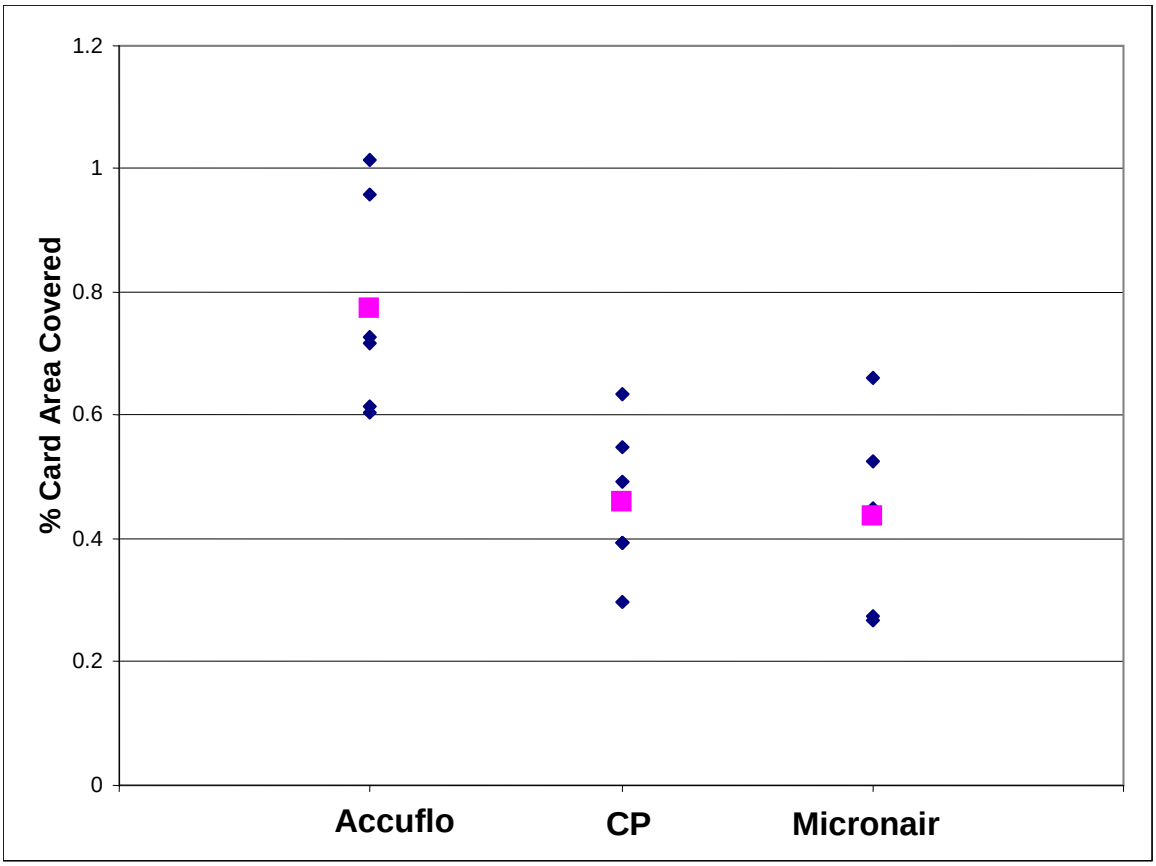

Figure 1. Percentage coverage for bottom cards - two nozzles and Micronair® atomizer. Each point represents an average of twelve cards. Square boxes represent the average of all data points shown per nozzle/atomizer.

Discussion

Data analysis is continuing for the spray cards. Data from the height sensing laser was limited because the computer running the laser halted acquisition ½ hour into initial runs. Although careful analysis of data showed that the pilot did a decent job changing altitudes in a relative sense, altitude effects on deposition are inconclusive for this study.

The Micronair® atomizer showed a smaller average VMD (181 microns), and some of the finer droplets could have drifted or evaporated before reaching the cards. There was still room for adjustment of the AU5000 to reduce propeller (and spray cage) speed so for subsequent tests, propeller blade angle for the Micronair® atomizers will be increased by 10 to 15 degrees to promote larger droplets (near the 250 um range). We believe this can be achieved with the standard AU5000 and the 14 mesh cage. Alternatively, the AU5000LD (Low Drift) retrofit with deflectors might be considered as this allows production of larger droplets. Since the droplets showed the expected good size uniformity (or small Relative Span (Table 1)), % fines will probably be small and spray coverage area should improve with careful selection of target droplet size.

The smallest restrictors (3/32) had to be used with the Accuflo® nozzles in order to obtain adequate pressure for smooth operation. However, observation of log files from the Satloc guidance system showed occasionally irregularities in flow, even at a seemingly acceptable operating pressure (24 psi). The Accuflo® nozzles used their own check valves for improved

aerodynamics, and these valves open above 18 psi. It is possible that some “chatter” around the operating point still took place when pressure became intermittently low, although the pilot (co-author D. Poythress) and ground observers did not observe significant problems. Even so, spray coverage performance of the Accuflo® nozzles seemed to be quite acceptable, and they showed the highest % spray coverage within the canopy for this preliminary study.

Higher flowrates might provide smoother operation for the Accuflo® nozzle (if using their check valves) and might also improve droplet spectrum. The CP® nozzle and settings can be easily selected for desired droplet size. A slightly smaller droplet (than 360 um) may ultimately be advantageous for fungicide effectiveness, although no attempt has been made herein to determine this with bioassay.

Because the Accuflo® nozzles operate on a different principle than nozzles that shatter the spray by pressure into small droplets, the droplet spectrum is also more highly dependent on forward travel speed. The Accuflo® nozzles are advertised to give a narrow droplet spectrum, and the use of drop tubes are recommended for their operation with fixed-wing aircraft to really demonstrate their potential (Bergey, 2006). We did not use drop tubes that assist in assuring the “cleanest” air possible for spraying, but their use should improve droplet size uniformity. It is critical that the Accuflo nozzles be set exactly parallel to air flow in flight. No problems were observed for setup and use of the CP® nozzles, and these same drop tube arrangements should benefit the CP®, also.

Mylar samplers were also placed in a cut area of the spray swath, and spray patterns will be determined by analysis of Rubidium Chloride (RbCl) tracer concentration. Five stations with mylar samplers were also placed in the northerly direction to quantify near-field spray drift. Wind direction was not favorable for quantifying spray drift during for morning runs, but a south to north wind was observed during many afternoon runs. Concentration of RbCl tracer will be analyzed for runs where afternoon wind conditions were favorable.

Altitude data were limited due to problems with laser data acquisition, and this limited observation of altitude-dependent trends. However, interesting comparisons could still be observed with three nozzle/atomizer setups in their conventional modes.

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