Table 1. Efficacy of fungicide treatments applied pre- and postinoculation with *Phytophthora parasitica* for control of lesion development on citrus seedlings.

Treatment	Method of application	Rate (ppm)	Lesion area (mm^2)		Disease rating[z]		% isolation[y]	
			Pre	Post	Pre	Post	Pre	Post
Fosetyl-Al	Foliar spray	1500	185 bc[x]	215 cd	1.90 bc	2.10 bc	50	65
Fosetyl-Al	Foliar spray	3000	134 c	239 bc	1.45 c	2.35 bc	55	50
Phosphorus acid	Foliar spray	2000	183 bc	282 b	1.65 bc	2.50 b	50	55
Metalaxyl	Soil drench	50	239 b	229 bcd	1.95 b	2.05 c	15	20
Noninoculated control	—	—	169 c[w]	169 d[w]	0.25 d[w]	0.25 d[w]	0	0
Inoculated control	—	—	437 a	437 a	3.25 a	3.25 a	75	75

[z]On a scale of 0 = no effect to 4 = severe girdling.
[y]Percentage of stem pieces from which *P. parasitica* was reisolated.
[x]Mean separation in columns by Duncan's multiple range test, p = 0.05.
[w]Values indicate the amount of mechanical injury caused by the inoculation procedure.

Proc. Fla. State Hort. Soc. 99:59-65. 1986.

PERFORMANCE CHARACTERISTICS OF PTO AIRBLAST SPRAYERS FOR CITRUS

J. D. Whitney
University of Florida, IFAS
Citrus Research and Education Center
700 Experiment Station Road
Lake Alfred, FL 33850

S. L. Hedden and D. B. Churchill
USDA-ARS
700 Experiment Station Road
Lake Alfred, FL 33850

R. P. Cromwell
University of Florida, IFAS
Agricultural Engineering Department
Gainesville, FL 32611

Additional index words. horsepower, deposition.

Abstract. **Power requirements and spray depositions were determined for a number of power-take-off (PTO) airblast sprayers. They ranged in horsepower requirements from 8 to 81 at PTO speeds of 540 and 600 rpm, respectively. Copper was used as a tracer on artificial targets for the spray deposition studies. These tests were conducted on 16 ft high 'Valencia' trees with all sprayers applying the same amount of copper per acre at a ground speed of 1.5 mph, with application rates per acre up to 125 gal per acre. The maximum deposit, averaged over all sprayers, was 5 times the minimum deposit within the tree. Deposition results are presented with respect to target height in the tree and horizontal radial distance from the tree trunk.**

Florida Agricultural Experiment Station Journal Series No. 7692. Cooperative research by University of Florida and U. S. Department of Agriculture, Citrus Research and Education Center, Lake Alfred. Trade names and company names are used in the publication solely for the purpose of providing specific information. Their mention does not constitute a guarantee or warranty or an endorsement of the product by the University of Florida or the U. S. Department of Agriculture. The authors gratefully acknowledge Luther Hart for loaning of a dynamometer, Alcoma Packing Company for use of their facilities and grove to conduct the field tests, and the sprayer representatives for furnishing the sprayers.

Airblast sprayers driven by tractor power-take-off (PTO) have been available for applying pesticides to Florida citrus for several decades. However, the grower demand for PTO driven airblast sprayers has recently increased relative to conventional, engine-driven, airblast sprayers due mainly to the size and cost of the machine. Higher powered tractors are more readily available to accommodate PTO sprayers. In many cases, this combination can be bought and operated at a cost equivalent to that of a large engine-driven sprayer. Recent freeze losses in the northern citrus production areas have eliminated many large citrus trees and reduced the need for the large engine-driven airblast sprayers.

Since operating costs of a spraying system are directly related to its power consumption, this factor as well as pest control (uniformity and quantity of deposition) are important considerations in the purchase of a sprayer. The two objectives of the research reported herein were to measure the power requirements and deposition characteristics of a number of PTO driven airblast sprayers.

Materials and Methods

Sprayer Power Requirements

A Ford, Model TW-10, diesel tractor was used to determine the power requirements of the PTO airblast sprayers. A dynamometer (AW Dynamometer, Inc.) test was conducted on the tractor to determine the relationship between fuel consumption rate and power developed at the PTO using PTO speeds of 540 and 600 rpm. From that information horsepower requirements for each sprayer were determined. Tractor power output (hp) was calculated from best fit "least squares" regression equations at 540 and 600 rpm as given below.

$$HP_{540} = -38.4 + 70.6\ (\ln X)$$
$$HP_{600} = -59.3 + 81\ \ (\ln X)$$

Where X = fuel consumption rate in gallons per hour

These equations provided reasonably good fits to the data with coefficients of determination greater than 0.99.

The sprayer power consumption tests were designed to measure the horsepower requirements of the sprayers under the following operating conditions:

1. High and low speed gearbox or fan speed positions on those sprayers having this feature.
2. High and low pump liquid output.
3. PTO speeds of 540 and 600 rpm.

Conditions 1 and 2 determined the range of power requirements within the adjustments on the sprayer. Condition 3 showed how power consumption changes with tractor PTO speed. Some of the sprayers were not operated under all the conditions stated above.

Sprayer pressure gauges were calibrated prior to the tests. Rotational speeds of the fans, etc. were measured with a mechanical tachometer. Gearbox ratios were determined by counting shaft input and output revolutions. The horsepower requirement was determined by measuring the time required for the tractor to use 500 or 1000 ml of fuel. The gallons per minute output of the sprayer pump was determined by filling the tank, operating the sprayer for 1 to 3 min, and measuring the gallons of water required to refill the tank through a water meter.

Spray Deposition Trials

Spray deposition trials were conducted at Alcoma Packing Co., Inc., east of Lake Wales, FL in a 'Valencia' orange grove which had a tree spacing of 25 ft between rows and 15 ft spacing in the row (Fig. 1). The field experiment was arranged in a 5 tree factorial design with each tree being a replication. The test trees were in a north-south row of trees approximately 16 ft high. Factors were designated as sprayer (A), height of spray targets in the tree (B), and location of the targets at each height (C).

Spray deposition was collected on 2 x 3 inch rectangular mylar targets which were attached to 7 vertical poles placed at 3 radii in one quadrant of each of the 5 trees as shown in Figure 1. Targets were held in place by spring clips and located at 3 heights on each pole. Each target was mounted with the 2 inch dimension vertical and the flat surface of the target facing the outside of the row. Clean targets were placed in the spring clips just prior to running each sprayer test. Spraying was done in a southerly direction in both middles either side of the experiment row so that both sides of the sprayer were used to spray the trees.

After the trees were sprayed, the mylar targets were allowed to dry before placing each target individually in a polyethylene container. Each target was washed in 50 ml of 0.05 N nitric acid solution to remove the copper. Contents of a copper reagent powder "pillow" were added to a 10 ml solution sample and the concentration in mg/l or ppm of free copper was read on a Hach Model DR-100 colorimeter. The methodology for measuring copper was patterned after Potter and Ryan (1). The copper concentration of the sprayer tank-mix sample was measured in the same way. The sample concentration from each target was converted to oz of copper per acre of target surface area.

A laboratory test was conducted to determine the amount of copper that would remain on the mylar targets if they were dipped in copper-water mixtures from 500 to 2500 ppm and allowed to dry. Copper depositions in oz per acre were determined in the same manner as described

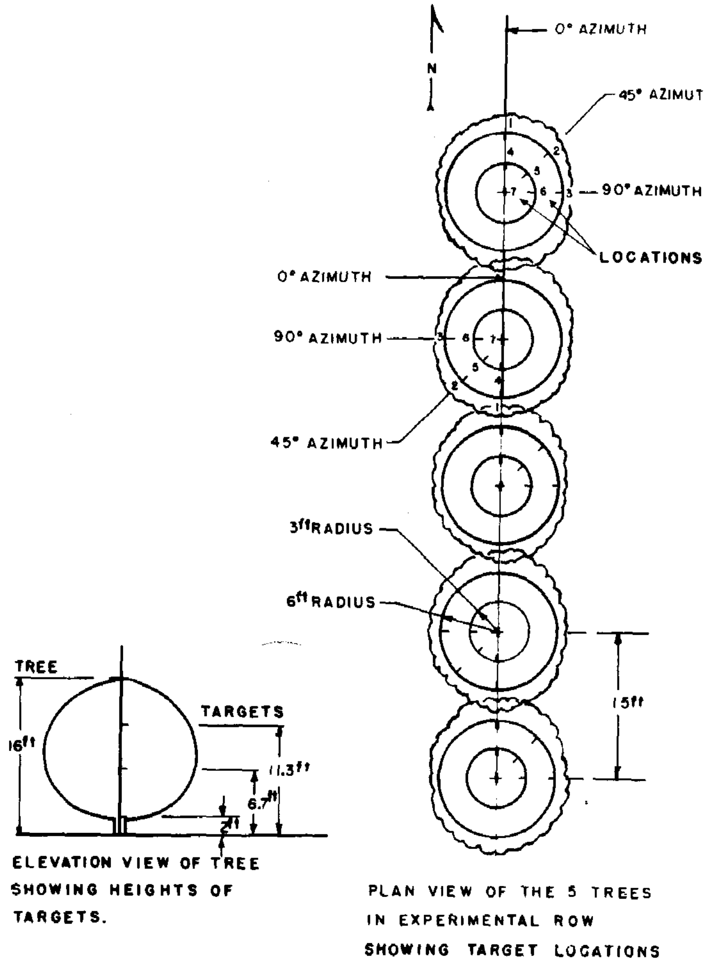

Fig. 1. Schematics showing heights and locations of artificial targets in trees for depostion studies.

above. This test established maximum deposition quantities for comparision with the sprayer deposition quantities. The best fit "least squares" regression equation with a coefficient of determination of 0.99 is given by Eq. [1] as follows:

$$D = -0.09 + 0.0094\ C \qquad [1]$$

Where D = copper deposit in oz per acre of target surface area

C = concentration of copper-water mix in ppm

Wind speed and direction were measured with a 3-cup anemometer placed approximately 5 ft above the top of the trees. Wind speeds during each test were taken every 5 sec and the average of 12 readings was recorded during successive 1-min intervals on a data logger. Deposition tests were not conducted when wind speeds just prior to the test exceeded 10 mph.

Each sprayer was calibrated to deliver 1 lb of tribasic copper sulfate (53% copper) per acre and not more than 125 gal per acre or 9.5 gal per min at 1.5 mph. The gal per acre delivered by each sprayer was specified by the sprayer representative. The copper-water mix in the tank was sampled and the copper concentration was measured on a Hach Model DR-100 colorimeter to verify that 1 lb of tribasic copper sulfate (0.53 lb of copper) was applied per acre. Copper concentration C, and gal per acre were related by Eq. [2] as follows:

$$C = 63850/(\text{gal per acre}) \quad [2]$$

All sprayers were operated at 540 PTO rpm, except for the AgTec 500 CS, in which case the manufacturer requested that it be operated at 600 PTO rpm. Sprayer power requirements were rechecked to verify the horsepower measurements described in the previous section. All sprayers with high/low speed gearboxes were operated in the high speed position. The Swanson sprayer used for the deposition study had fans driven from a gearbox (one-speed ratio), whereas the sprayer used in the horsepower test of the previous section had belt-driven fans. Also, the gearbox in the Air-O-Fan sprayer supplied for the deposition study had a higher ratio than the one used in the horsepower test in the previous section. The Hatsuta sprayer was tested once with Brazilian nozzles and again with Spraying Systems nozzles. The Kinkelder sprayer was tested without electrostatics and with electrostatics. The Berthoud Simoun 2000 was tested twice because of a problem with the copper concentration in the sprayer tank. Fan speeds were recorded and the maximum air velocities at the fan discharge were measured with a pitot tube and water manometer.

The Imperial and Victair sprayers, although tested for their horsepower requirements as described in the previous section, were not available for the deposition trials. Horsepower and spray depositions tests were conducted with the Agridynamics Model 8250 CP, but the manufacturer requested that the data not be published.

A statistical analysis was made on the deposition data obtained in the field trials.

Results and Discussion

Sprayer Power Requirements

Table 1 shows the results of the sprayer power requirement tests with the sprayers listed in alphabetical order. Listed with each sprayer is its pump type, fan type, and total area of air discharge. Seven sprayers had centrifugal pumps, while the remaining 6 had positive displacement (4 piston, 2 diaphragm) pumps. In general, liquid volume from the sprayer nozzles had little effect on horsepower requirements. The greatest effects were with the Myers sprayer (with Myers 2C95 centrifugal pump) in which case the horsepower increased an average of 8.3 hp when the nozzle output was increased from 11.3 to 72 gpm. The increase in liquid output resulted in a 75 to 85 psi decrease in pump pressure. The same Myers 2C95 pump was used in the Swanson sprayer, but horsepower change with nozzle output was barely measurable because the pump was driven at lower speeds and did not deliver as high a volume or pressure as that of the Myers sprayer. This resulted in considerably less effect on horsepower changes.

When the tractor PTO speed was increased from 540 to 600 rpm, an increase of 11%, the horsepower requirement increased an average 29% for all sprayers. This increase in power requirement was mainly to drive the sprayer fan and illustrates that horsepower requirements increase much faster than the fan speed. According to the fan laws, fan horsepower increases as the cube of the fan speed. With a 11% increase in fan speed, the fan laws predict a fan horsepower increase of 37% which is more than the 29% we measured. Some of this difference is due to pump, agitation, and other miscellaneous non-fan power requirements which were included in our horsepower measurements. If the non-fan power requirement was considered essentially constant and subtracted from our measurements, then the net increase in power with speed would have been closer to that predicted by the fan laws. For example, a sprayer required a total of 50 hp at 540 PTO rpm and 29% more or 64.5 hp at 600 PTO rpm. The non-fan power requirement is 11 hp at both speeds. The net percentage increase in fan horsepower from 540 to 600 PTO rpm would be 100 (53.5 – 39)/39 = 37%. A good "rule of thumb" for fan speed increases up to 10% is that fan horsepower consumption increases at 3 times the rate of fan speed, i.e., a 5% increase in fan speed results in a 15% increase in power consumption, etc.

Seven of the sprayers used in the trials had high/low gearboxes for changing fan speed. Two of the sprayers, the Berthoud Arbo 2000 and the Hatsuta, were only operated in the high gear setting. On the Air-O-Fan machine, the fan speed was increased 18% by shifting from low to high gear, resulting in an average increase in horsepower requirement of 52%. The gearbox on the FMC sprayer increased fan speed 10% from low to high position and was accompanied by a 21% horsepower increase. A 10% increase in fan speed on the Southwind sprayer resulted when the gearbox was shifted from low to high gear and the horsepower requirement increased an average of 26%. Changing from low to high gear on the Friend sprayer increased the fan speed by 9% and the horsepower requirement increased an average of 23%. On the Berthoud Simoun 2000 sprayer, the fan speed was increased 15% by shifting from low to high gear and the horsepower requirement increased an average of 99%.

The Berthoud Simoun 2000 sprayer required the least amount of power (8 hp) at 540 PTO rpm while the most power (approximately 80 hp) was required by the Swanson sprayer when operated at 600 PTO rpm.

Spray Deposition Trials

Tables 2-6 show the results of 14 field tests with the sprayers listed in alphabetical order in each Table.

Table 2 shows the spray application rates varied from a low of 25 gal per acre for the Kinkelder sprayer to a maximum of 125 gal per acre for 6 of the sprayers. The remaining sprayers varied from 80 to 122 gal per acre. Pump pressure varied from a low of 21 psi for the Kinkelder to a maximum of 300 psi for the Berthoud Simoun 2000. Weather conditions at the time of each test are also listed.

Table 3 shows the air delivery and horsepower measurements made during the field tests. Due to the higher gear box ratio, the horsepower and fan speed measured for the field trials on the Air-O-Fan sprayer were greater than the ones measured in the initial horsepower test (Table 1). Maximum air outlet velocities were lowest for the Berthoud sprayers (76 to 80 mph) and highest for the Kinkelder and AgTec sprayers (163 mph). The discharge outlet area and air volume was smallest for the Kinkelder (79 inch^2 and 8000 cfm), and largest for the Myers (960 inch^2 and 53000 cfm). As operated in the field tests, the

Table 1. Horsepower of PTO airblast sprayers tested in 1985.

Sprayer make and model pump, fan, discharge area	PTO speed (rpm)	Pump pressure (psi)	Nozzle output (gal/min)	Gearbox position[y]	Ratio[z] fan speed / PTO speed	Fan speed (rpm)	Horsepower required
AgTec 500 CS with cent. pump, 1 cent. fan w/20 inch wheel diam., 112 inch² discharge area	540	23	11.5	NA	3.46	1870	37.2
	540	25	1.3	NA	3.46	1870	38.3
	600	28	11.5	NA	3.46	2085	50.3
	600	31	1.3	NA	3.46	2080	49.3
Air-O-Fan GB34 w/ID 1400 diaphragm pump, 1 axial fan w/34 inch wheel diam., 564 inch² discharge area	540	160	32.4	Low	3.47	1880	33.6
	540	160	32.4	High	4.11	2220	52.6
	540	160	9.7	Low	3.47	1870	30.8
	540	160	9.7	High	4.11	2198	47.5
	600	160	32.4	Low	3.47	2075	43.7
	600	160	32.4	High	4.11	2480	65.4
	600	160	9.7	Low	3.47	2092	42.6
	600	160	9.7	High	4.11	2475	63.4
Berthoud Arbo 2000 piston pump, 1 axial fan w/33 inch wheel diam., 638 inch² discharge area	540	140	8.9	High	3.65	1970	35.7
	600	175	8.9	High	3.65	2200	40.3
Berthoud Simoun 2000 piston pump, 1 axial fan w/32 inch wheel diam., 462 inch²	540	300	7.5	Low	2.95	1595	8.2
	540	300	7.5	High	3.40	1835	16.3
	600	300	7.5	Low	2.95	1760	11.0
	600	300	7.5	High	3.40	2020	18.6
FMC 352-S w/JB 135 V-DS piston pump, 1 axial fan w/31 inch wheel diam., 550 inch² discharge area	540	195	38.0	LOw	4.00	2160	41.0
	540	220	38.0	High	4.40	2380	49.7
	540	220	9.2	Low	4.00	2140	39.6
	540	220	9.2	High	4.40	2370	46.5
	600	200	38.0	Low	4.00	2415	46.5
	600	220	38.0	High	4.40	2645	63.1
	600	210	9.2	Low	4.00	2425	52.2
	600	220	9.2	High	4.40	2645	62.0
Friend Airstar 375 w/Myers 2C95 cent. pump, 1 axial fan w/36 inch wheel diam., 672 inch² discharge area	540	105	9.5	Low	3.54	1910	48.0
	540	107	9.5	High	3.85	2080	59.0
	600	110	9.5	Low	3.54	2122	61.0
	600	110	9.5	High	3.85	2311	77.0
Hatsuta SS 2000 w/ piston pump, 1 axial fan w/34 inch wheel diam., 360 inch² discharge area	540	320	25.0	High	4.39	2370	38.3
	540	320	10.3	High	4.39	2370	37.6
Imperial 1000 w/cent. pump, 1 cent, fan w/ 20 inch wheel diam., 116 inch²	540	10	11.3	NA	3.70	2000	47.2
	540	44	2.1	NA	3.70	2000	44.5
	600	13	11.3	NA	3.70	2200	59.7
	600	54	2.1	NA	3.70	2210	57.6
Kinkelder R-250 w/cent. pump, 1 cent. fan w/ 18 inch wheel diam., 79 inch² discharge area	540	21	6.3	NA	6.71	3625	33.6
	540	21	0.8	NA	6.71	3625	37.2
	600	21	6.3	NA	6.71	4030	48.6
	600	21	0.8	NA	6.71	4010	46.5
Myers A42TR5 w/Myers 2095 cent. pump, 1 axial fan w/42 inch wheel diam., 960 inch² discharge area	540	150	72.0	NA	3.76	2030	57.1
	540	225	11.3	NA	3.76	2050	48.8
	600	180	72.0	NA	3.76	2220	71.7
	600	265	11.3	NA	3.76	2275	63.4
Southwind 836 SS w/ HYPRO diaphragm pump, 1 axial fan w/ 36 inch wheel diam., 204 inch² discharge area	540	175	57.0	Low	3.58	1910	40.2
	540	175	57.0	High	3.93	2100	55.9
	540	175	14.0	Low	3.58	1920	42.7
	540	175	14.0	High	3.93	2110	50.1
	600	175	57.0	Low	3.58	2185	52.6
	600	175	57.0	High	3.93	2380	66.7
	600	175	14.0	Low	3.58	2160	53.8
	600	175	14.0	High	3.93	2380	65.9
Swanson DA-500 A w/ Myers 2C95 cent. pump, 2 cent, fans w/26 inch wheel diam., 318 inch² discharge area	540	85	47.9	NA	3.50	1870	61.0
	540	115	11.3	NA	3.50	1890	60.5
	600	105	47.9	NA	3.50	2100	80.9
	600	140	11.3	NA	3.50	2100	79.5
Victair Mistifier w/ cent. pump, 2 cent. fans w/15 inch wheel diam., 136 inch² discharge area	540	90	26.0	NA	3.57	1930	24.2
	540	90	14.0	NA	3.57	1940	24.6
	600	90	26.0	NA	3.57	2140	30.0
	600	90	14.0	NA	3.57	2150	29.6

[z]Ratio was determined by rotating the PTO shaft by hand and counting the fan and PTO revolutions.
[y]NA indicates sprayer did not hav high/low gearbox.

Table 2. Sprayer volume output, pump pressure and weather conditions for field tests.

output Sprayer	Volume pressure (gal/acre)	Pump wind speed [psi]	Average direction[z] (mph)	Wind temp (degrees)	Dry bulb humidity (°F)	Rel. (%)
AgTec 500 CS	80	40	6.2	90	80	68
Air-O-Fan GB34	125	175	6.5	340	81	75
Berthoud Arbo 2000	117	140	6.8	60	79	60
Berthoud Simoun 2000 (1)	98	300	6.6	170	58	63
Berthoud Simoun 2000 (2)	98	300	6.2	130	77	63
FMC 352 S	117	130	2.0	50	90	91
Friend Airstar 375	125	105	5.8	80	82	79
Hatsuta SS 2000 w/ Brazilian nozzles	122	125	5.2	120	83	80
Hatsuta SS 2000 w/ Spraying Systems nozzles	125	150	6.7	170	83	80
Kinkelder R-250 w/o electrostatics	25	21	7.1	10	86	74
Kinkelder R-250 w/ electrostatics	25	21	7.1	10	86	74
Myers A42TR5	125	230	7.1	70	88	71
Southwind 836 SS	125	200	6.4	160	88	75
Swanson DA-500-A	125	100	5.2	250	76	91

[z]Wind from the north had a direction of zero degrees. Wind from other directions were measured clockwise relative to north.

Table 3. Sprayer air delivery and horsepower characteristics as measured during field tests.

Sprayer	Fan speed (rpm)	Max. outlet velocity (mph)	Discharge outlet area (inch²)	Output[u] (cfm)	Horsepower required
AgTec 500 CS[v]	2070	163	112	11,000	44.3
Air-O-Fan GB34[y]	2400	110	564	38,000	62.3
Berthoud Arbo 2000[w]	1970	76	638	30,000	35.7
Berthoud Simoun 2000 (1)[x]	1835	80	462	23,000	16.3
Berthoud Simoun 2000 (2)[x]	1835	80	462	23,000	16.3
FMC 352 S	2300	125	550	36,000	43.1
Friend Airstar 375[z]	2070	97	672	40,000	59.0
Hatsuta SS 2000 w/ Brazilian nozzles	2275	89	396	21,000	33.0
Hatsuta SS 2000 w/ Spraying Systems nozzles	2275	89	396	21,000	33.0
Kinkelder R-250 w/o electrostatics	3700	163	79	8,000	35.5
Kinkelder R-250 w/ electrostatics	3700	163	79	8,000	35.5
Myers A42TR5	2080	91	960	53,000	46.7
Southwind 836 SS	2150	100	561	34,000	52.0
Swanson DA-500-DW	1890	133	318	26,000	56.5

[z]37 inch diameter axial fan and Myers 2C95 centrifugal pump.
[y]Hign gearbox ratio was 4.44 to 1 as compared to 4.11 to 1 in Table 1.
[x]32 inch diameter axial fan and GAMA 82 piston pump.
[w]33 inch diameter axial fan and Berthoud piston pump.
[v]Sprayer operated at 600 PTO rpm at the request of the manufacturer. All other sprayers operated at 540 rpm.
[u]Estimated cubic feet per minute (cfm) calculated as the product of maximum outlet velocity and discharge outlet area.

Berthoud Simoun required the least horsepower (16.3 hp) and the Air-0-Fan the most (62.3 hp).

The left side of Table 4 shows the sprayer gal per acre and copper concentration measured in the tank. The expected values of copper concentration can be calculated from Eq. [2]. Concentrations for all sprayers were reasonably close to the expected values except for the Berthoud Simoun. When the Berthoud Simoun was first tested (No. 1), it was calibrated at 98 gal per acre, and its tank concentration was 560 ppm. According to Eq. [2], it should have been 650 ppm. It was thought an error may have been made such as placing less than the required amount of tribasic copper sulfate in the tank. The test was repeated (No. 2) and concentration increased to 600 ppm. Further investigation into the low concentration reading revealed when approximately 100 gal of water were in the tank, the tank level was slightly above flat ledges molded into the sides of the tank. When the copper mix was flushed out of the tank after spraying, it was noted that some of the copper had settled out on the ledges. In addition, agitation was considered poor with less than 100 gal in the tank.

The next column in Table 4 shows the dipped target depositions corresponding to the copper concentrations in the tank as given by Eq. [1]. The very next column to the right shows the mean values of copper deposit for each sprayer. Statistical significance of the means is indicated with letters following the means. Numerically, the Berthoud Arbo 2000 had the highest mean deposit (1.01) and the Swanson had the lowest (0.67). The 4 sprayers with the highest mean deposits (followed by letter a) were not statistically different and the 5 sprayers with the lowest mean deposits (followed by letter g) were not statistically different.

The last 4 columns in Table 4 deal with deposition uniformity among targets in the trees, which is also important. The coefficient of variation (CV) of deposits, i.e. the ratio of the standard deviation of the deposits to the mean deposit among the 105 targets (21 targets per tree x 5 trees) for each sprayer is an indicator of uniformity. Lower ratios indicate better uniformity. The Berthoud Arbo 2000 had the lowest ratio (0.38) which meant the standard deviation among the 105 targets was 38% of the mean deposit. The highest ratio was the Kinkelder with electrostatic. Both Kinkelder sprayer treatments (with and without electrostatics) had the highest ratios, 0.74 and 0.73, respectively.

The ratio of maximum to minimum mean deposits of the 21 targets in tne trees is another indicator of uniformity. To obtain these means, the deposits for each of the 21 targets were averaged over all 5 trees and are shown in the last column of Table 4. The Swanson sprayer had the

Table 4. Effect of PTO sprayer on tribasic copper deposition on targets in 'Valencia' orange trees.

Sprayer	Gallons per acre	Cu conc in tank (ppm)	Dipped target dep. (oz per acre)	Mean[z] Cu dep. (oz per acre)	Ratio of SD to mean	Cu dep. (oz per acre) Min	Max	ratio max/min
AgTec 500 CS[y]	80	850	7.90	0.83 cdef	0.55	0.27	1.88	6.9
Air-O-Fan GB34	125	550	5.08	0.83 cdef	0.41	0.37	1.32	3.7
Berthoud Arbo 2000	117	580	5.36	1.01 a	0.38	0.46	1.68	3.7
Berthoud Simoun 2000 (1)	98	560	5.17	0.73 efg	0.51	0.29	1.28	4.5
Berthoud Simoun 2000 (2)	98	600	5.55	0.74 defg	0.48	0.27	1.44	5.3
FMC 352 S	117	540	4.99	0.71 fg	0.50	0.36	1.22	3.4
Friend Airstar 375	125	560	5.17	0.88 abcd	0.60	0.26	1.71	6.7
Hatsuta SS 2000 w/ Brazilian nozzles	122	550	5.08	0.73 efg	0.45	0.31	1.21	3.9
Hatsuta SS 2000 w/Spraying Systems nozzles	125	540	4.99	0.77 cdefg	0.59	0.23	1.28	5.6
Kinkelder R-250 w/o electrostatics	25	2450	22.94	0.84 bcdef	0.73	0.27	2.85	10.5
Kinkelder R-250 w/ electrostatics	25	2500	23.41	0.87 bcde	0.74	0.23	2.62	11.5
Myers A42TR5	125	550	5.08	0.90 abc	0.40	0.51	1.64	3.2
Southwind 836 SS	125	550	5.08	0.97 ab	0.40	0.46	1.55	3.4
Swanson DA-500/DW	125	560	5.17	0.67 g	0.45	0.40	1.15	2.9

[z]Means separation in column by Duncan's multiple range test, 5% level.
[y]Operated at 600 PTO revolutions per minute at the request of the manufacturer. All other sprayers operated at 540 PTO revolutions per minute.

lowest ratio (2.9) while the Kinkelder with electrostatics with highest ratio (11.5).

The uniformity of spray deposits can also be expressed in terms of variability between target heights and location in the tree (Table 5). Height had a significant effect for all except the Swanson sprayer. The 11.3 ft target height received the lowest mean deposit for all except the Myers, Friend, FMC, and Berthoud Arbo 2000 sprayers. The Myers, Friend, and FMC sprayers deposited the lowest mean deposit at the 2 ft height, and the Berthoud Arbo 2000 deposited equal amounts of spray at the 2 and 11.3 ft height and higher amounts at the 6.7 ft height. Location had a significant effect on deposits for all sprayers. Location 3, nearest the sprayer discharge, had the highest mean deposit while location 7 or 4, on the tree row centerline, had the lowest mean deposit.

The variability in spray deposits for different locations was also partitioned into 2 parts—radius from the tree trunk and azimuth from tree row centerline (Table 6). Location 7 was not included when analyzing the azimuth data since that location did not have an azimuth. The deposits of all sprayers decreased significantly from the outside radius to the center of the tree. With exception of the Hatsuta w/Brazilian nozzles, the deposits of the sprayers decreased significantly from the 90 degree to the 0 degree azimuth.

Summary

A number of power-take-off (PTO) tractor driven airblast sprayers were tested for power requirements and spray deposition. A Ford, Model TW-10 diesel tractor, was used to determine the power requirements at 540 and 600

Table 5. Copper deposition in relation to height and location in 'Valencia' orange trees.

Sprayer	Mean copper deposit (oz per acre)[z]: Height above ground (ft) 2.0	6.7	11.3	Number of location 1	2	3	4	5	6	7
AgTec 500 CS	1.15 a	0.80 b	0.51 c	0.84 c	1.11 b	1.32 a	0.61 d	0.58 d	0.70 cd	0.57 d
Air-O-Fan GB 34	0.98 a	0.88 a	0.63 b	0.74 c	0.97 b	1.24 a	0.71 c	0.78 bc	0.77 c	0.60 c
Berthoud Arbo 2000	0.88 b	1.27 a	0.88 b	0.90 d	1.22 ab	1.31 a	0.87 d	1.11 bc	1.03 cd	0.64 e
Berthoud Simoun 2000 (1)	0.93 a	0.80 b	0.48 c	0.60 b	1.00 a	1.14 a	0.58 b	0.64 b	0.61 b	0.54 b
Berthoud Simoun 2000 (2)	0.95 a	0.80 b	0.48 c	0.64 b	0.94 a	1.12 a	0.61 b	0.71 b	0.64 b	0.51 b
FMC 352 S	0.63 b	0.80 b	0.70 bc	0.60 b	1.01 a	10.4 a	0.48 b	0.67 b	0.64 b	0.51 b
Friend Airstar 375	0.41 c	1.39 a	0.84 b	0.88 bc	1.07 b	1.31 a	0.70 c	0.81 c	0.73 c	0.70 c
Hatsuta SS 2000 w/ Brazilian nozzles	0.84 a	0.87 a	0.50 b	0.75 bc	0.87 ab	0.98 a	0.67 bc	0.63 c	0.67 bc	0.56 c
Hatsuta SS 2000 w/Spraying Systems nozzles	0.87 a	0.78 ab	0.64 b	0.73 c	0.97 b	1.18 a	0.61 c	0.71 c	0.67 c	0.50 c
Kinkelder R-250 w/o electrostatics	1.31 a	0.77 b	0.46 c	0.58 c	1.12 b	1.48 a	0.67 c	0.77 c	0.74 c	0.57 c
Kinkelder R-250 w/ electrostatics	1.40 a	0.81 b	0.38 c	0.73 c	1.11 b	1.44 a	0.71 c	0.77 c	0.74 c	0.56 c
Myers A42TR5	0.74 c	1.08 a	0.87 b	0.78 bc	1.24 a	1.27 a	0.77 bc	0.85 b	0.73 bc	0.63 c
Southwind 836 SS	1.12 a	1.07 a	0.73 b	0.81 bc	1.32 a	1.37 a	0.91 b	0.88 bc	0.83 bc	0.68 c
Swanson DA-500/A	0.66 a	0.71 a	0.64 a	0.61 c	0.87 b	1.05 a	0.54 c	0.63 c	0.53 c	0.47 c

[z]Mean separation in rows within heights or locations by Duncan's multiple range test, 5% level.

Table 6. Copper deposition in relation to radius and azimuth from 'Valencia' orange trees.

	Mean copper deposit (oz per acre)[z]					
	Radius from tree trunk (ft)			Azimuth from row center-line degrees		
Sprayer	0	3	6	0	45	90
AgTec 500 CS	0.58 b	0.64 b	1.10 a	0.73 b	0.85 b	1.01 a
Air-O-Fan GB34	0.60 c	0.75 b	0.98 a	0.73 b	0.88 a	1.00 a
Berthoud Arbo 2000	0.64 b	1.01 a	1.14 a	0.88 b	1.17 a	1.17 a
Berthoud Simoun 2000 (1)	0.54 b	0.61 b	0.91 a	0.61 b	0.83 a	0.88 a
Berthoud Simoun 2000 (2)	0.51 c	0.66 b	0.90 a	0.63 b	0.83 a	0.88 a
FMC 352 S	0.51 b	0.60 b	0.88 a	0.54 b	0.84 a	0.84 a
Friend Airstar 375	0.70 b	0.74 b	1.08 a	0.78 b	0.94 a	1.01 a
Hatsuta SS 2000 w/ Brazilian nozzles	0.56 b	0.66 b	0.87 a	0.71 a	0.74 a	0.83 a
Hatsuta SS 2000 w/ Spraying Systems nozzles	0.50 b	0.67 b	0.95 a	0.47 b	0.84 ab	0.65 a
Kinkelder R-250 w/o electrostatics	0.57 b	0.73 b	1.05 a	0.63 c	0.94 b	1.11 a
Kinkelder R-250 w/ electrostatics	0.56 a	0.74 b	1.08 a	0.71 b	0.94 a	1.08 a
Myers A 42TR5	0.63 c	0.78 b	1.10 a	0.77 b	1.00 a	1.05 a
Southwind 836 SS	0.68 c	0.88 b	1.17 a	0.87 b	1.10 a	1.10 a
Swanson Da-500-DW	0.47 b	0.57 b	0.84 a	0.57 b	0.75 a	0.80 a

[z]Mean separation in rows within radius or azimuth by Duncan's multiple range test, 5% level.

PTO rpm and at high and low gpm outputs of the sprayer. An increase in PTO speed from 540 to 600 rpm resulted in an average increase in horsepower requirements of 29% for all sprayers. The change in gal per min output had little effect on horsepower requirements. Horsepower requirements varied from 8 hp to 81 hp depending on the sprayer and PTO speed.

A field experiment was conducted in Valencia orange trees approximately 16 ft high to measure uniformity and quantity of spray deposition. A copper-water mix was applied between 25 and 125 gal per acre, depending on the sprayer. Artificial targets were placed in the trees to collect the copper deposition, which was washed off and measured in a colorimeter. There were significant differences in mean deposition levels among 14 sprayer treatments. The highest mean deposition level (1.01 oz per acre) was significantly higher than 9 of the other sprayer treatments.

The coefficient of variation of the deposits ranged from a low of 0.38 to a high of 0.74. Height of target in the tree had a significant effect on all but one sprayer treatment. Deposits decreased significantly for all sprayer treatments from the outer tree canopy to the center of the tree.

Literatuare Cited

1. Potter, H. S., and R. C. Ryan. 1979. Measuring aerial spray deposition. Agrichemical Age, November-December.