A SPRAY TOWER For the Application of MICROBIAL AERIAL SPRAYS

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Abstract

An experimental spray tower for the application of aerial sprays is described. The construction, operation, and preliminary calibration are detailed.

INTRODUCTION

THE TRANSLATION of laboratory-acquired bioassay data into field dosage specifications has been a recurrent problem in insecticide research and development programs.

This problem is further complicated by the fact that microbial insecticides (with which we are experimenting) are: (1) usually formulated as water suspensions, thus creating an evaporation problem in the field that is not encountered in laboratory testing; (2) effective only when eaten, thus requiring thorough coverage of the food plant—a major problem in the forest, but of negligible consequence in laboratory testing; (3) presented to the test larvae in the laboratory by methods that bear little resemblance to the form of presentation under field conditions—macrofeeding or injection, incorporation of known concentrations into artificial diet, feeding of foliage dipped into known concentrations, or carefully controlled application by hand sprayer on individual leaves or small bouquets.

Laboratory data acquired by any of the above techniques are often extrapolated to field dosages. Microorganisms that were very promising in laboratory tests performed poorly or unacceptably in the field.

Extrapolation of laboratory data to field dosage selection can be improved by creating an artificial forest (placing potted trees in open fields) and spraying from aircraft, or by simulating aerial application.

We have constructed and tested a spray tower that simulates aerial spray deposit, distribution, penetration, and volume per acre.

It was developed from a rain simulator developed by Dr. Bohdan Maksymiuk *(1959)*. Four trees, 1 to 5 feet in height can be treated simultaneously.

TOWER SPECIFICATIONS

Construction

The tower is constructed of framing-grade lumber and sheet plywood covering (fig. 1). An enclosed operator's platform on the side houses the controls. A plexiglass observation window permits the operator to view the spray delivery and to adjust the controls as necessary. Samples are introduced to and removed from the chamber by double doors. The inside of the chamber is 8x8x11 feet.

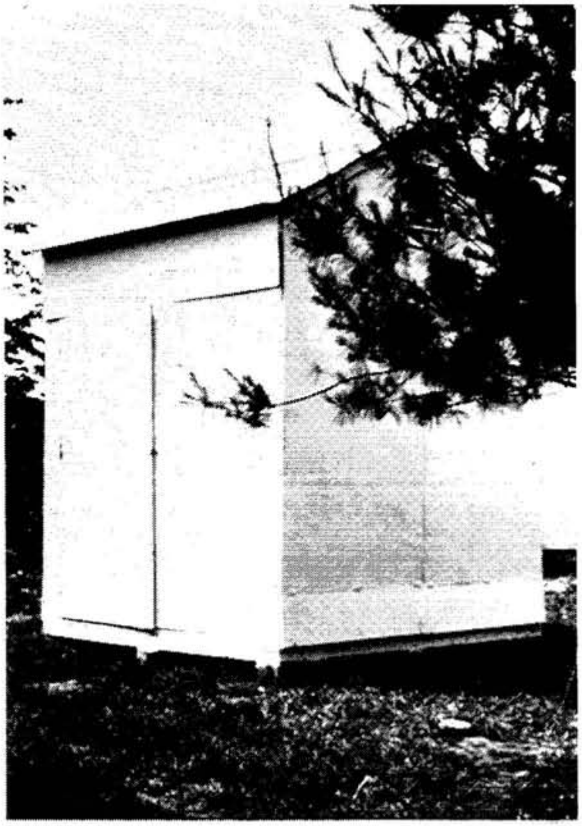


Figure 1.—Outside view of tower. Doors are shut while tower is in operation.

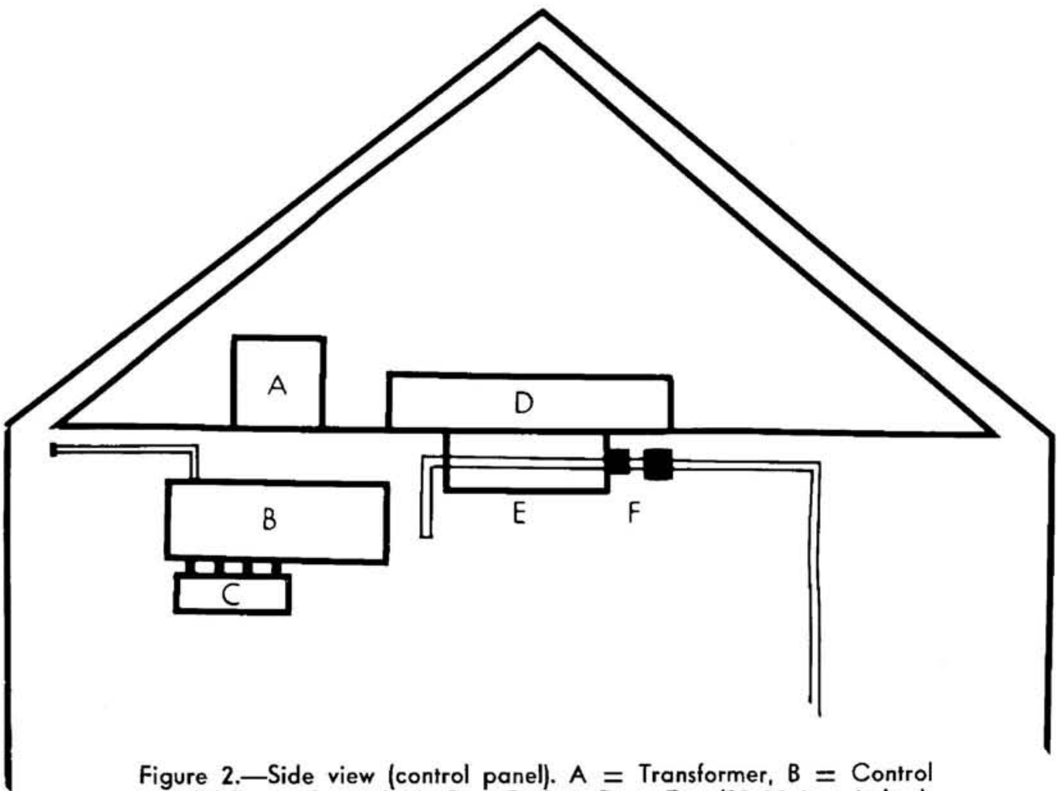


Figure 2.—Side view (control panel). A = Transformer, B = Control panel (electrical switches), C= Outlets, D = Fan (20x20 in. window), E = Observation window, and F = Control valves (air).

Power Controls and Equipment Outside Chamber

A control panel (figure 2) is built into the operator's platform near the plexiglass window. Air for spray delivery is piped through copper tubing to the control center on the tower and controlled by a pressure regulator with a gage and a shutoff valve within easy reach of the operator.

Equipment within the Chamber

An explosion proof lighting fixture is mounted at the top back of the chamber so that the spray drops can be seen.

A 20-inch window exhaust fan controlled by a rheostat is mounted in the top center of the chamber and baffled to produce a swirling airflow into which the spray is introduced.

The main equipment is a double turntable device for exposing test specimens equally to the spray (fig. 3 and 4).

It consists of a large turntable (72 inches in diameter) on which are mounted four smaller turntables (30 inches). The turntables were made of ¾-inch plywood covered with formica.

The large turntable is supported at four cardinal points by pillow blocks topped with rubber casters. A sheet-steel track on the underside of the turntable reduces friction between the turntable and the casters. These supports keep the turntable balanced when the load on it is unevenly distributed.

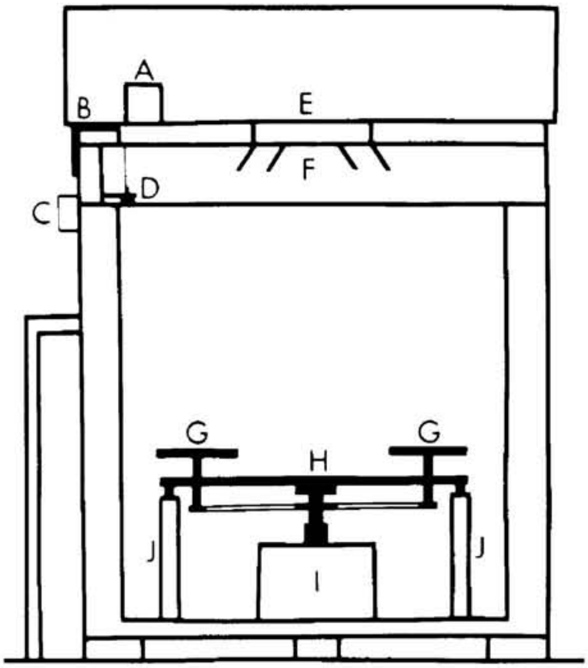


Figure 4.—Front view of tower. A = Transformer, B = Observation window, C = Control panel, D = Nozzle, E = Fan, F = Baffles, G = Small turntables, H = Large turntable, I = Gearbox drive, and J = Pillow blocks.

Figure 3.—Turntable, showing gear box, chain drive, and casters for support of turntable.

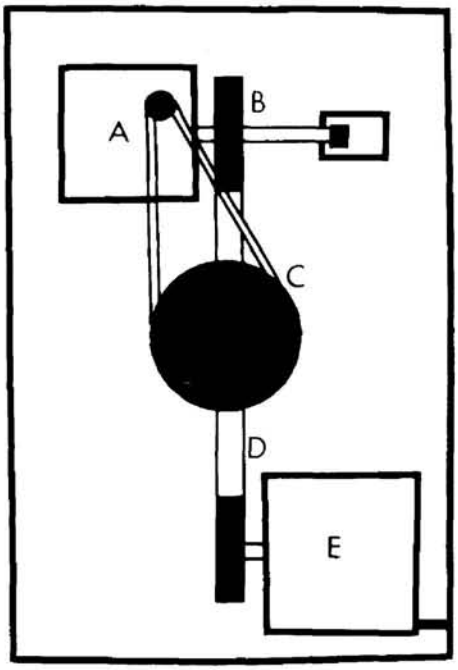
The four small turntables are mounted on the large turntable at 90° intervals. Their shafts pass through bearings on the large turntable. Sprockets welded on the shafts transmit power through bicycle-type chain from the big turntable shaft to the four small turntables.

The gear ratio is fixed so that the small turntables make three revolutions for each revolution of the large turntable. The chains have idler sprockets to keep tension constant at all times.

Main Power Gearbox

The motor, pulleys, and gears were mounted in a sheet steel box. A variable speed pulley on the gearbox allows the rota-

Figure 5.—Power system. A = right angle reducing gearbox, B = Variable speed adjustable pulley, C = Double v-belt and pulley drive to turntables, D = V-belt drive from motor to gearbox, and E = Motor.



tion of the large turntable to be adjusted from 0 to 3 r.p.m. (fig. 5).

From the output shaft of the gearbox, the power is transmitted to the main shaft by double pulleys and v-belts. Double idler pulleys keep the proper tension on the belts. This belt drive allows for slippage in starting to minimize damage to other parts. A list of parts is given in Appendix A.

Spray Delivery

The spray nozzle is mounted by the operator's window and pointed into the airflow from the fan. It produces a round spray pattern.

Because the air passing through this nozzle produces suction at the liquid entrance port, precise quantities as small as 1 milliliter of experimental spray materials can be introduced into the spray chamber. This system can deliver from 0.2 to 10 gallons per acre.

TOWER OPERATION

1. The plant material to be sprayed is placed on the small turntables. Usually, potted trees 1 to 4 feet high are used. Trees of about the same size are placed 180 degrees apart to help balance the turntables.
2. The air compressor is turned on, and air pressure is adjusted between 40 and 60 p.s.i. to give the desired droplet size range.
3. The speed of the large turntable is adjusted to give at least one full rotation during delivery of the selected volume of spray.
4. The operator takes his position in the operator's platform. The plastic line with cannula attached to the liquid entry port of the spray nozzle is placed in the container holding the spray to be delivered.
5. The turntable is switched on, and the air valve is opened. The spray is then delivered into the spray chamber.
6. When all the spray has been delivered, the air valve is closed. The plant material remains in the closed tower for an additional 3 minutes.

The tower is best operated with one man to place and remove the plant material while the operator remains in the platform to oversee the entire operation and to flush the system between spray changes. The spray system is disinfected by flushing with 0.5 percent sodium hypochlorite, and the inside of the tower is washed with the same solution.

The total cost of construction of the tower was about $750.

TOWER CALIBRATION

General distribution of the spray from the tower was measured by spraying four 3-foot trees with a water-soluble fluorescent dye (Fire Orange A-14). The trees were examined under ultraviolet light to determine the uniformity of the deposit. No attempt was made to size the droplets by this technique.

Droplet size distribution was evaluated, using the technique described by Fisher and

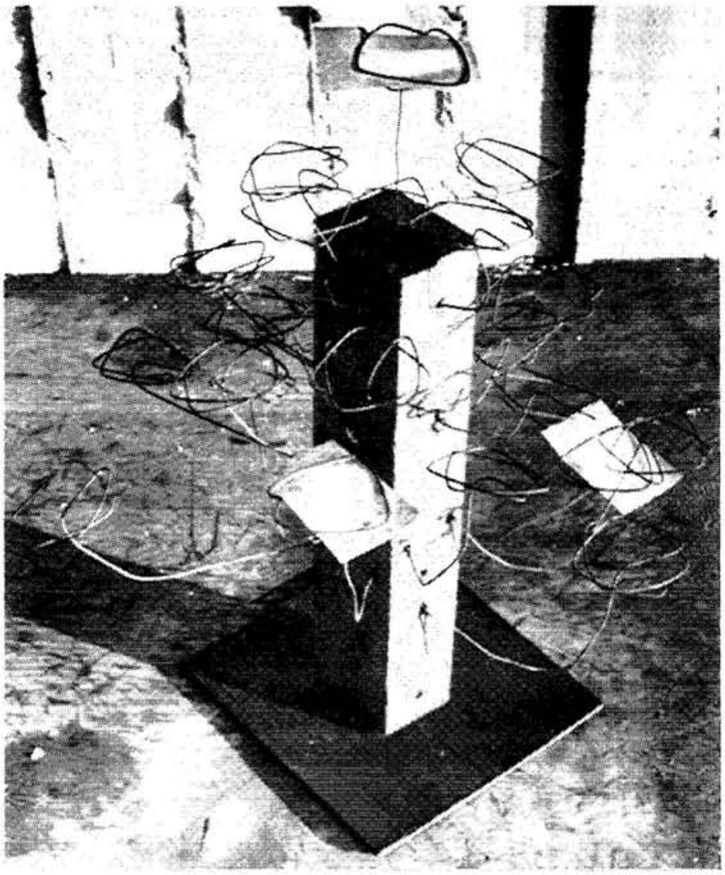


Figure 6.—Artificial tree for spray calibration.

Dougan *(1970)*. This system uses a very viscous butylene polymer[1] to trap the spray droplets and an image-splitting eyepiece to measure droplet size.

Polymer-coated slides were placed into wire holders *(Maksymiuk 1959)* and were introduced into a chamber. They were sprayed with 50 milliliters of a dye suspension which was left to settle for 3 minutes. The slides were removed; and polymer-coated cover slips were placed on top of them, trapping the spray droplets between the two layers of polymer.

[1]Indopol polybutene #1900, Amoco Chemical Corporation. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U. S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

A stand for the wire holders was constructed of a flat 12x12-inch plywood base with a 4x4-inch piece of lumber nailed in the center at 90 degrees to form an upright. Holes were drilled in the 4x4-inch board at a 45-degree angle. Any number of wire card holders can be placed on the stand at any one time. When all the wire holders are placed on the stand, it takes on the shape of a tree (fig. 6).

For the tower calibration, three wire holders were placed on the artificial tree at 10, 20, and 36 inches from the small turntable.

The droplets were sized in five categories (20μ or less, $21\text{-}40\mu$, $41\text{-}80\mu$, $81\text{-}160\mu$, and greater than 160μ). These data are presented in Appendix B. The cumulative number of drops and cumulative drop volume were plotted on log-log paper, and number median diameter (NMD) and mass median diameter (MMD) were read. MMD's produced in the tower ranged from 100 to 103 microns.

SUMMARY

As evidenced by the data on droplet volume and distribution (Appendix B), the spray tower produces very uniform spray patterns. The mass median diameters (MMD) at the three levels of sampling were very close and fell within the size range desired ($80\text{-}125\mu$).

The results of the construction and operation of the tower have met the planned objectives.

We have plans to further test this unit and make modifications as needed.

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1970. COLLECTION AND MEASUREMENT OF SPRAY DROPLETS WITH VISCOUS POLYBUTENE AND AN IMAGE-SPLITTING EYEPIECE. Canad. Entomol. 102: 31-35.

Maksymiuk, B.
1959. IMPROVED HOLDERS FOR SPRAY DEPOSIT ASSESSMENT CARDS. J. Econ. Entomol. 52: 1029-1030.

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APPENDIX A

List of Parts	*Quantity*
1-inch bore sprockets	4
1-inch bore sprocket	1
$1\frac{1}{4}$-inch bore sprocket	1
1-inch bore pillow blocks	4
$1\frac{1}{4}$-inch bore pillow block	1
1-inch shaft collars	4
$1\frac{1}{4}$-inch shaft collar	1
VS 113-300: 1 gear reductor mounting assembly	1
Eaton, Yale & Towne #6400M $\frac{1}{2}$-inch bore manually controlled pulley (with control v-belt)	1
$\frac{5}{8}$-inch bore pulley (v-belt)	1
$1\frac{1}{4}$-inch bore double pulley (v-belt)	1
$\frac{5}{8}$-inch bore double pulley (v-belt)	1
Roller chain	1
General Electric $\frac{1}{4}$ hp a.c. 1750 r.p.m. 115 v. 4.4 amp. motor	1
Morse Serial D8690131 Ratio 300 1/10 hp. 1750 r.p.m. gearbox	1
Spray Systems $\frac{1}{4}$ JP pneumatic atomizing nozzle, setup #11, fluid nozzle #2050, air nozzle #67147	1

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APPENDIX B

Table 1. — *Droplet number and volume distribution, series I*

Size class	Height of tree sample	Drops	Total volume	Volume as percent	Cumulative volume as percent	Number as percent	Cumulative number as percent	
Microns	*In.*	*No.*	*Cubic microns*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	
20	36	230	963,447.0	0.011	0.011	0.52	0.52	
40	"	123	4,122,357.3	.048	.059	.27	.79	
80	"	62	16,623,247.8	.193	.252	.14	.93	MMD 101.0
160	"	27	57,913,320.6	.673	.925	.06	.99	
>160	"	3	6,434,813.4	.075	1.00	.01	1.00	
Total	—	445	86,057,186.1					
20	20	207	867,102.3	.011	.011	.50	.50	
40	"	99	3,317,994.9	.043	.054	.24	.74	
80	"	82	21,985,585.8	.283	.337	.20	.94	MMD 101.2
160	"	22	47,188,631.6	.608	.945	.05	.99	
>160	"	2	4,289,875.6	.055	1.00	.01	1.00	
Total	—	412	77,649,189.7					
20	10	221	925,746.9	.010	0.10	.54	.54	
40	"	92	3,083,389.2	.035	.045	.22	.76	
80	"	66	17,695,715.4	.201	.246	.16	.92	MMD 103.1
160	"	29	62,203,196.2	.705	.951	.07	.99	
>160	"	2	4,289,875.6	.049	1.00	.01	1.00	
Total	—	410	88,197,923.3					

Table 2. — *Droplet number and volume distribution, series II*

Size class	Height of tree sample	Drops	Total volume	Volume as percent	Cumulative volume as percent	Number as percent	Cumulative number as percent	
Microns	*In.*	*No.*	*Cubic microns*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	
20	36	724	3,032,763.6	0.046	0.046	0.80	0.80	
40	"	106	3,552,600.6	.054	.100	.12	.92	MMD
80	"	51	13,673,961.9	.209	.309	.05	.97	100.3
160	"	19	40,753,818.2	.624	.933	.02	.99	
>160	"	2	4,289,875.6	.066	.999	.01	1.00	
Total	—	902	65,303,019.9					
20	20	600	2,513,340.0	.034	.034	.77	.77	
40	"	98	3,284,479.8	.045	.079	.12	.89	MMD
80	"	60	16,087,014.0	.219	.298	.08	.97	100.0
160	"	19	40,753,818.2	.556	.854	.02	.99	
>160	"	5	10,724,689.0	.146	1.00	.01	1.00	
Total	—	782	73,363,341.0					
20	10	511	2,140,527.9	.058	.058	.78	.78	
40	"	98	3,284,479.8	.089	.147	.15	.93	MMD
80	"	37	9,920,325.3	.270	.417	.06	.99	101.4
160	"	8	17,159,502.4	.466	.883	.01	1.00	
>160	"	2	4,289,875.6	.116	.999	.00	1.00	
Total	—	656	36,794,711.0					

Table 3. — *Droplet number and volume distribution, series III*

Size class	Height of tree sample	Drops	Total volume	Volume as percent	Cumulative volume as percent	Number as percent	Cumulative number as percent	
Microns	*In.*	*No.*	*Cubic microns*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	
20	36	728	3,049,519.2	0.023	0.023	0.65	0.65	
40	"	203	6,803,565.3	.052	.075	.18	.83	MMD
80	"	163	43,703,054.7	.334	.409	.14	.97	100.6
160	"	36	77,217,760.8	.590	99.9	.03	1.00	
>160	"	0	0	.0	.999	0	0	
Total	—	1,130	130,773,900.0					
20	20	466	1,952,027.4	.018	.018	.58	.58	
40	"	200	6,703,020.0	.061	.079	.25	.83	MMD
80	"	107	28,688,508.3	.260	.339	.13	.96	100.5
160	"	34	72,927,885.2	.661	1.00	.04	1.00	
>160	"	0	0	0	1.00	0	0	
Total	—	807	110,271,440.9					
20	10	395	1,654,615.5	.016	.016	.55	.55	
40	"	183	6,133,263.3	.058	.074	.25	.80	MMD
80	"	115	30,833,443.5	.286	.360	.16	.96	102.5
160	"	29	62,203,196.2	.592	.952	.04	1.00	
>160	"	2	4,289,875.6	.041	99.3	0	0	
Total	—	724	105,114,394.1					

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