EFFECT OF DROPLET SIZE AND SPRAY VOLUME ON CONTROL OF THE COTTON BOLLWORM *HELIOTHIS ZEA*

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EFFECT OF DROPLET SIZE AND SPRAY

VOLUME ON CONTROL OF THE COTTON

BOLLWORM <u>HELIOTHIS ZEA</u>

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CHAPTER I

INTRODUCTION

The usefulness of any pesticide depends in a very large measure upon its proper application, and this is determined by the properties of the pesticide, the nature of the pest or pests complex to be controlled and the site to which the application is to be made.

Thirty years ago when row crops were sprayed at application rates varying between 100 and 200 gal./acre and at pressures from 300 to 500 psi., there was less reason to be concerned about the size of the spray droplet than with the gallonages used today, since the larger volumes and pressures afforded a much greater potential for coverage of the plants.

With the advent of low-gallonage, low pressure spraying and spray formulations of high toxicant concentration, the question of droplet size as it might affect patterns of spray distribution and coverage of the leaf surface began to assume added importance, especially on the control of agricultural insect pests.

One of the most critical factors affecting drift of pesticides is the size of the droplets that are dispersed from the applicator. If a method of application could be devised that would disperse a more uniform range of droplet sizes it is possible that drift hazards could be reduced.

Little data are available on optimum droplet sizes for control of the cotton pests. Due to the lack of necessary equipment to produce droplets of uniform size little attention has been given to the comparative effects of different droplet sizes.

In this research, application was made with jet stream atomization ground equipment equipped with various devices to produce mechanical disturbance of the stream and different sizes of tip orifices to obtain the required droplet sizes.

The purpose of this study was to see if there were any differences in insect mortality due to various droplet sizes and different amounts of total volume per acre applied with a low volume ground sprayer. The rate of insecticide was kept constant in all treatments and the size of the droplets and spray volume were varied.

The bollworm <u>Heliothis</u> sp. was chosen as the insect for bioassay because of its importance in cotton production.

CHAPTER II

REVIEW OF LITERATURE

Spraying is the most common means of insecticide application. Sprays are made up of solutions, emulsions, or suspensions of the toxicant. The liquid phase is usually water but light oils and air are also used.

One of the inherent problems in spray applications with aircraft or ground equipment is that of droplet size control. As mentioned above relatively few reports are available in the literature on optimum droplet sizes for control of the cotton pests. It is not generally known which droplet sizes or ranges of droplet sizes are the most effective biologically for controlling insect pests.

The information available is summarized below under three separate headings: droplet size studies, devices to control uniformity in droplet size and distribution, spray nozzles and spray volume studies.

Droplet Size Studies

Smith (1946) in a study of the growth inhibition quality of 2, 4- dichlorophenoxyacetic acid, when applied in aqueus sprays of different droplet size to young kidney bean plants, concluded that sprays of relative large droplet sizes: 250 to 560 microns average diameter were more effective than those of smaller size 30 microns average in diameter. He found that more solution was deposited and retained on the plants when sprays of the larger droplet sizes were used.

Potts (1946) reports that under field conditions extremely minute individual particles of finely ground dusts, insecticidal smokes, finely atomized aerosols, and concentrated sprays are not deposited on the surface of the plants, insects or other objects. Apparently such objects are surrounded by a film, or field of resistance, through which minute particles cannot penetrate. Microclimatic conditions caused by difference in temperature, humidity, or weight of air near such objects produce air currents which carry away minute particles. Less deposits have been noted on the underside of leaves than on the upper surface. Larger particles, whether dry or liquid, are heavy enough to penetrate the film of resistance and make contact with the surface of leaves, insects, and other objects. With pesticide sprays the droplets must be large enough to give a satisfactory deposit on foliage and on insects. There is little deposit of droplets less than 20 microns in diameter; very few are deposited unless their diameter exceeds 30 microns.

Potts (1958) reports that for the application of concentrated sprays with ground equipment the optimum range for diameter of droplets is 30 to 80 microns and for aerial application 70 to 100 microns; both depending upon the density and type of the insecticide, the volatility of the carrier, the plant growth, the kind of insect, the type of distribution device, and the atmospheric conditions.

La Mer et al. (1947) in a study of the effect of particle size of insecticidal aerosols on mortality of the salt marsh mosquito, Aedes taeniorhynchus (Weid) in confined atmosphere, found that the toxicity of DDT increased by 250 or more times by increasing the diameter of the particle from 0.33 to 11.00 microns.

Sebora et al. (1946) working with various types of aerial spray equipment, reported that DDT sprays were effective against insects over a range of diameters from 10 to 460 microns of droplet sizes. They suggested there is probably no ideal particle size, and recommended as the most practical approach to have a range of droplet sizes that can be controlled under the most adverse conditions of wind velocity, wind direction, and negative lapse rates.

Latta et al. (1947) found that the deposition of moving aerosols particles on mosquitoes varies with the product of the diameter squared and the velocity, up to the point of maximum efficiency. They reported the optimum particle diameter for mosquitoes to be 12 microns in a wind of 2 mph.

Fulton et al. (1949) reported control of spider mites on tomato plants with hexaethyl tetraphosphate in aerosol solution with particles less than 10 microns in diameter. Injury to the tomato plants was reported with aerosol particles 20 microns or more in diameter.

In studies with DDT aerosols Yeomans and co-workers (1949) demonstrated that the optimum particle size to use on insects increases with the size of the insect; being 15.81 microns for mosquitoes and 22.4 microns for house flies.

One of the main difficulties when working with the effects of different droplet sizes is the wide spectrum of drop sizes produced by the standard nozzles used in agricultural sprays. Akesson (1952) reported a spectrum from 25 to 400 microns in diameter from a flat fan nozzle with an orifice of 115 microns in diameter at a pressure of 20 psi. This variation is even greater with hollow cone-type nozzles commonly used on aircraft.

As none of the various methods used to atomize liquids give homogeneous particle sizes, a representative value must be used. The most commonly used in literature is the mass median diameter, which refers to the condition in which half the spray volume is of drops larger, and half is of drops smaller than the size stated. If the spray must be described more completely, this may be done by breaking down the particle size range into several divisions and reporting the accumulative percentage to the mass of the spray according to each division.

Akesson and Yates (1964) considered the droplet size as the basic factor for drift control, coverage, and control of insect pests. They concluded that with the available equipment it is impossible to make a pest control application without some drift of the chemical used. They report relative distance of drift of several droplet sizes while falling 10 ft. through air which was moving three mph. The drift distances ranged from 5 ft. for 500-micron drops to 1 mile for drops 10 microns in diameter. They recommended the use of a solid stream ejection system on aircraft applying hazardous materials in order to obtain a larger droplet size and the consequent reduction in the drift hazard.

Yeomans (1952) in studies of airplane sprays recommended a mass median diameter droplet size of 275 microns for control of forest defoliators and 100 to 125 microns for mosquito control where penetration below heavy foliage is required. He found that larger particles gave more effective residue over a longer period than did fine particles.

Yeomans and Rogers (1953) recommended a mass median diameter of 50 microns or above to reduce the drift from undeposited spray and concluded that the distance between nozzles and surface must be limited to one that will permit

75% or more of the spray to be deposited on the treated area.

Behrens (1957), using droplet sizes of 200, 400, 600, or 800 microns, concluded that the different droplet sizes did not have any direct influence on the herbicidal effectiveness of spray applications.

Wilson and Hedden (1957) indicated that when the droplet size varied from 100 to 500 microns there was little variation in the degree of control of Alternaria on potato and tomato plants.

Wilkes (1961), studying the effects of particle size on cotton insect control, obtained results indicating that nozzles producing a mean number of 50 micron particles were significantly better for controlling the boll weevil than nozzles producing 150 microns in diameter, however, there was no significant difference on the control of bollworm with these two droplet sizes.

Ennis and Williamson (1962) reported that droplets of 100 microns or less, were more inhibitory to five different species of plants than droplets of 500 microns. They concluded that this difference was due to a more efficient absorption by the plant of the smaller droplets.

Wilson et al. (1963) carried on extensive research during a 10 year period on the relationship between spray droplet size and disease and insect control. They conclude that droplets with a mass median diameter of 400 to 500 microns gave the same results as 120-micron droplets on the control of potato flea beetle, two spotted spider mites on eggplants, and the imported cabbageworm and the cabbage looper on cabbage. On the other hand for control of fruit and foliage diseases on tomatoes, droplets of 100 to 135 microns mass median diameter gave better control than droplets in the range of 300 to 400 microns. This was due probably to the mobility of insects over the surface of the treated area thus enabling them to encounter insecticides while the fungicidal toxicants must be closely spaced if infection of the fungus is to be prevented.

Brazzel et al. (1968) indicated that the most important factor for drift control will be an adequate control of the droplet size spectrum. They obtained results showing considerable increase in efficiency of application to a specific target area with an increase in droplet size from 100 to 150 microns in diameter.

Polles and Vinson (1969) stated that during a rainfall, 600-micron droplets were more easily washed from the leaf surface of cotton plants than those of 100- or 200-micron sizes. Small droplets of ultra low volume malathion spray of 100- to 300 micron in diameter caused higher mortality to larvae of *H. virescens* (F) than the 700-micron droplets. In laboratory studies they observed that 3rd instar larvae of *H. virescens* could detect and avoid the larger droplets but more frequently made contact with the smaller particles.

Burt et al. (1970), after using ultra low volume sprays of Azinphosmethyl, reported better control of cotton boll weevil A. *grandis* with droplet sizes of 100 and 140 microns than with 200- or 300-micron.

Smith and Burt (1970) concluded that 140-micron droplets is the minimum size that can be released and deposited in or near the target area. The 200- and 300-micron droplets had essentially no downwind drift beyond one row (40 inches) at wind velocities of 2.68 mph.

Spray Nozzles and Volumes

Research on the application of concentrated spray materials for the control of cotton insects has been in progress for several years. Studies by Brown and Hanna (1954) have shown that the boll weevil and the bollworm can be controlled with 2 gallons of insecticide spray per acre.

Smith and Hanna (1955) and Smith et al. (1956) over a 5 year period found that one nozzle directly over each row is as effective as more complex nozzle arrangements in applying sprays to control bollworms and boll weevils on cotton plants. They reported higher yields using one cone nozzle per row; however, there were no significant differences in yields between nozzles producing a hollow cone pattern and those producing a flat fan pattern.

Magee and Davenport (1959) found that one nozzle centered over the row, delivering 2 gallons of insecticide spray per acre, was as effective in controlling pink bollworm as more complicated nozzle arrangements using up to five nozzles per row and gallonages up to 30 gallons of insecticide spray per acre.

Wilkes (1961) found that conventional low gallonage type nozzles maintained a lower infestation of boll weevils than boomless-type nozzles. He found that one No. 6 cone nozzle per row gave a significantly better control of boll weevils than a two nozzle arrangement. When using boomless type nozzles, the yields decreased progressively from the center of the plot towards the outer edges of the swath. He concluded that the primary reason for the lack of control of boll weevil with the boomless type nozzles was due to the larger droplets (1000 microns) discharged on the outer edges of the swath.

Hedden (1960) reports a wide variation in droplet sizes with the flat fan and cone nozzles. The greatest numbers of droplets collected over 98% of the total number of particles were drops under 100 microns in diameter but this group contained only approximately 4% of the total volume of the spray. Large drops over 300-micron contained the greatest portion of the spray volume but they only represented 0.14% of the total number of droplets.

In the relationship of total volume to droplet size Ennis and Williamson (1962) reported that herbicide formulations of aqueous and non-aqueous low volume sprays (100 to 250 ml./acre) were more inhibitory when the droplets were below 100 micron in diameter than when they were the 300-micron size.

Wilson et al. (1963) reported less control of potato flea beetle with spray volume of 10 gal/acre than with 20 or 35 gal. This was also true for control of early blight on the foliage and anthracnose fruit rot on tomato plants.

Bode et al. (1968) found no significant difference in percent of area covered by low volume spraying with fan or cone nozzles at 25, 30, or 40 psi or with a pneumatic atomizing nozzle at 10, 20, or 30 psi.

Tate and Janssen (1966), using an immersion sampling technique to measure droplet size distribution for cone and fan nozzles, found great similarity in atomization qualities of both nozzles. Variations in droplet size across the spray pattern indicated, however, that in the hollow cone pattern droplet size increased from the center to the exterior, of the spray pattern, while in the fan discharge the droplet size distribution was about the same through the pattern. Their data show that droplet sizes produced by conventional agricultural spray nozzles would range from 6.5 to 647.0 microns in diameter.

Recent trends in spray application have been toward the use of concentrated or low volume sprays, in which the concentration of the toxicant in increased and the spray volume is correspondingly reduced.

Since the first use of ultra low volume spray for control of the desert locust Schistocera gregaria (Forskal) by Sayer in 1959 more concentrated insecticides have been formulated and are being applied by this method. The new concentrates have successfully controlled some insects by applying as little as 6 to 8 oz. of active ingredient / acre (Messenger, 1964).

From laboratory and field evaluations of low volume sprays for cotton insect control Adkisson and Nemec (1966) reported that if an insecticide is effective against bollworms or tobacco budworms at a given rate in a water emulsion, it was equally effective as a low volume spray.

Hanna and Walker (1966) reported that low volume aerial treatments of toxaphene-DDT-methyl parathion, strobane-DDT-malathion, malathion-TDE, and Azodrin® at 16-42 oz. total spray per acre resulted in adequate control of bollworm Heliothis sp. and were not different in effectiveness from the standard emulsion spray of toxaphene-DDT-methyl parathion.

Isler (1966) published studies made with aircraft application using a flat spray nozzle and a Mini-spin® device.

He observed a mass median diameter range from 120 to 270 microns by varying the speed of the Mini-spin® from 4000 to 8000 rpm producing a lower percent of both the fine and coarse droplets than the fan nozzle.

Devices to Control Uniformity in Droplet Size and Distribution

The studies reviewed above indicate that conventional and available spray equipment does not produce particles of uniform size nor does it distribute the various sized droplets uniformly within the spray pattern. Because of these inadequacies researchers have attempted to develop devices that more closely control droplet size and distribution.

Lane (1947) described a microburette to produce drops of uniform size. The drops are formed at the round tip of a hypodermic needle through which is flowing a concentric stream of air. The size of the droplets were varied by varying the speed of the air. Measurements showed that the droplet sizes fluctuated no more than 3%. Another device was described by Ennis and James (1950) for laboratory and greenhouse work capable of producing droplets from 400-1400 microns in diameter by varying the air pressure.

Davis (1951) developed a vibrating apparatus to study the behavior of droplet sizes within the size normally encountered in insecticide sprays by aircraft. The drops were formed on and removed from a capillary by a vibrating finger at a rate of 60 droplets per second. The measurements under the microscope revealed no variation in size. Using various sizes of capillaries and different pressures it was possible to obtain oil drops of any desired diameter between 6 and 140 microns.

Mullison (1953) reported laboratory data on the effect of droplet sizes upon herbicidal action to bean leaves using a micrometer-driven syringe to apply droplets of known size. Rayner and Haliburton (1955) described a rotary device that produces uniform drops of liquids in range of diameter of 50-700 microns. It is based on the rotating movement of a blade that detaches drops from a stabilized liquid mass fed to a stationary capillary.

Roth and Reins (1957) developed a rotating disk device in which uniform droplet sizes can be obtained by different rotational speed and different diameters of the disk. This equipment presents the disadvantage for field use that the droplets are deposited in a narrow band insufficient in width to cover the plants.

Harrel et al. (1966) designed equipment to emit spray through a fan-type nozzle or through a pneumatic nozzle; the spray material is atomized by an air jet. Taft and Hopkins (1966) developed an experimental mist blower to drive Mini-spin® nozzles with the outlets eight feet above the ground and using the air principle to force the material down to the plants. They reported excellent control of cotton boll weevil with 6 oz. of technical malathion per acre.

Burt et al. (1966) used ground equipment in which the liquid material is metered through a solid stream nozzle and dispersed with a rotary disk by centrifuge force. Their data also show that there is not significant difference between the rotary disk, the mist blower developed by Taft, and a conventional sprayer on the control of the boll weevil. The size of the droplets from the mist blower appeared to increase at higher concentrations of insecticide but the rotary disk applicater remained constant and thus provided better control of drift.

Leeper (1967), using the equipment developed by Burt et al. (1966), reported that different droplet sizes do have an effect on insect control and although he found better control of cotton boll weevil with droplets of 100 micron in diameter, he suggests that 200 micron size droplets can be utilized to give satisfactory control with much reduced drift hazard. He also concluded that for control of the bollworm _H. zea_ it is possible to use sizes of 400-600-micron droplets and further reduce drift.

In 1967, Taft et al. (1969) developed a new ground sprayer for ultra low volume that used the same principle of air blast as their earlier model but gave a better deposit on the plant by placing a single atomizer per row 12 inches from the top of the plants. Results against the boll weevil, the bollworm, and the spider mite, Tetranychus cinnabarihus (Boisduval), were as good as those with a conventional sprayer. They reported better deposition of small droplets using an auxiliary airstream.

Harrel and Hare (1969) and Harrel et al. (1970) developed an experimental ultra low volume ground equipment for spraying corn and modified it to spray cotton using a wide angle nozzle tip (160 degrees) to give lateral coverage to the cotton plants. This equipment uses a Spraying Systems® F-1 pneumatic nozzle inside a 3 x 4 inch air nozzle. The pneumatic nozzle atomized the pesticide and air from the air nozzle at 20 mph placed the insecticide on the area to be treated. This equipment was as effective as a conventional sprayer in the control of boll weevil.

Burt et al. (1970) and Smith and Burt (1970) used equipment for ultra low volume application, that consisted of a spinning disk and a collection chamber for removal of small satellite droplets. Their data also show that with this equipment it is possible to spray droplets of predictable size with an accuracy of 90.5 to 97.2%. Tests on the boll weevil with Azinphosmethyl at 0.0625 lb/acre in droplet sizes of 100-140-micron were as effective as when the insecticide was applied in a wide spectrum of droplet size. The

200-micron droplets gave marginal control and that of 300-micron droplets was inadequate. They reported that uniformity of deposits in the treated area increased by both; control of droplet size and by increasing the size of the droplets being the 140 microns diameter the minimum size that can be applied properly.

Many spray mechanisms have utilized the principle studied by Rayleigh (1879) that causes a continuous stream to break into droplets in a regular manner when the region of drop formation is modulated by mechanical vibration.

Dimmock (1950) evolved an apparatus which generated a stream of droplets from 10-to 300-micron in diameter. The liquid flowed through a capillary tube with a small armature moved by an electromagnet energized by an alternating current. The uniformity of droplet size obtained was greater than that obtained with a spinning disk type sprayer but it had the disadvantage of producing only very limited quantities. Mason et al. (1963) described a similar vibrating capillary device, consisting of a hypodermic needle vibrated by an electromagnetically driven diaphragn, that produced controllable and uniform droplet sizes of any desired diameter between 280 and 400 microns. They selected a stable satellite stream in which they were able to obtain droplets down to 30 microns in diameter.

Schneider and Hendricks (1964) described a method which was capable of producing droplets ranging from 50- to 2000-micron using a piezoelectric transducer to produce a mechanical disturbance to the stream.

Roth and Porterfield (1965) described an atomization method using three cone nozzles (with cores removed) with circular orifices 279-, 483-, and 1016-micron in diameter under operating pressures less than 5 psi. The jet streams disintegrated into uniform large drops, approximately twice the diameter of the nozzle orifices, plus small droplets that made up less than 1% of the liquid volume. About 80% of the spray from a horizontal jet was deposited in a band 2 inches wide. They suggested that this could be improved by angling the jet streams 10 to 15 degrees from the direction of traveling.

Improvement of the distribution pattern was made (Roth and Porterfield 1966) using 10 nozzles on a 2 inch spacing at an angular position of 10 to 15 degrees in which overlapping of adjacent spray bands resulted in a uniform spray pattern. Removal of the small drops was made with a charged tube to produce electrostatic dispersion. A similar sprayer called "Vibro Boom" utilizing jet stream atomization was used by Reimer (1964). He reports a higher degree of drift control than with a conventional sprayer.

Roth and Porterfield (1969) reported remarkable drop size uniformity when a magnetostrictive induced vibration is applied to liquid just prior to flowing through an orifice.

CHAPTER III

MATERIALS AND METHODS

1969 Test

The self propelled sprayer used in 1969 was developed by the Agricultural Engineering Department, Oklahoma State University. It consisted of a Hagie high clearance chassis, upon which sprayer components were mounted.

Spraying Components

The sprayer was equipped with a platform and a bench to provide support to the insecticide pressure tank, the flushing tank, instruments for the electrostatic dispersion, the nozzle support boom, and space for an operator who maintained constant pressure in the insecticide tank and turned off and on the system while spraying the different plots.

The primary components of the spraying system are shown schematically in Fig. 1 and can be identified with some detail in Fig. 2. It contained an engine-driven air compressor to supply pressure energy to enforce the liquid to the nozzles for both insecticide and flushing systems. The 10

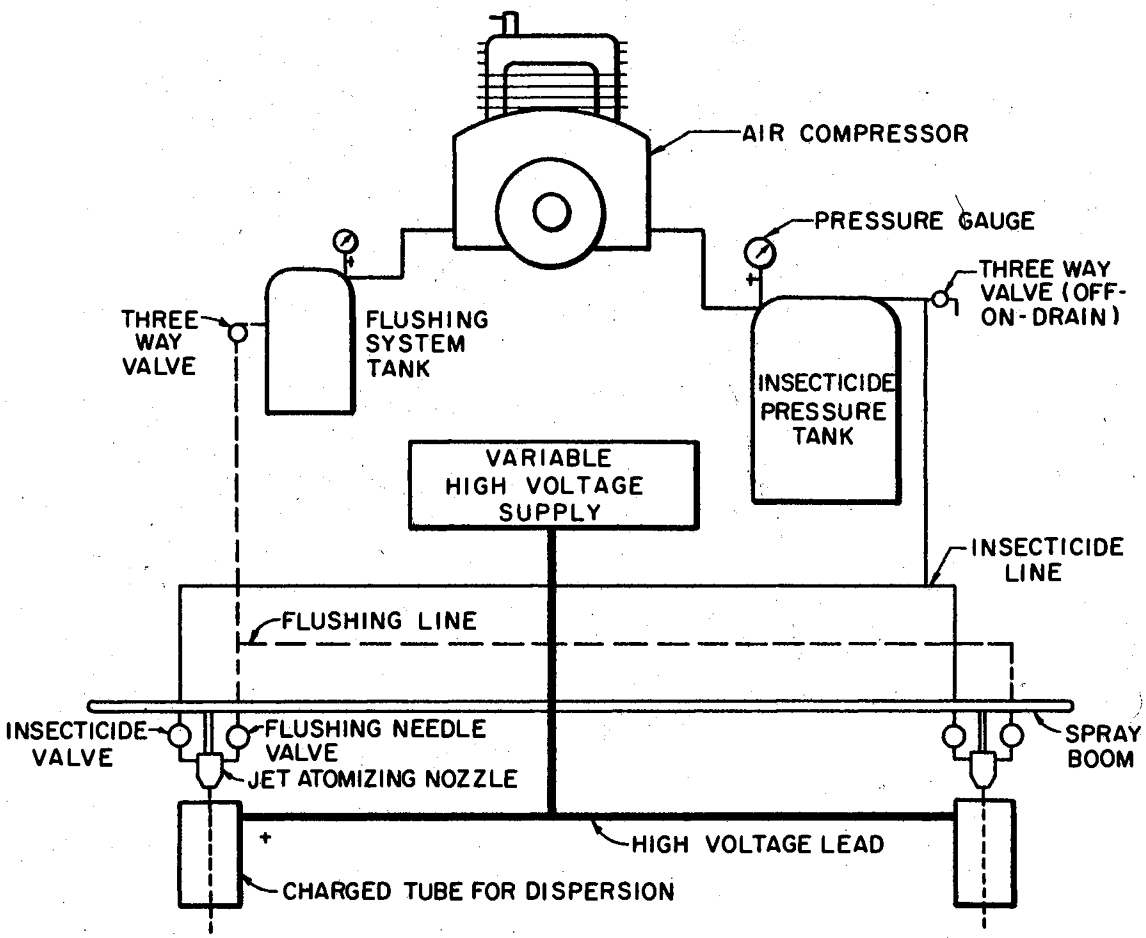


Figure 1. Spraying System 1969

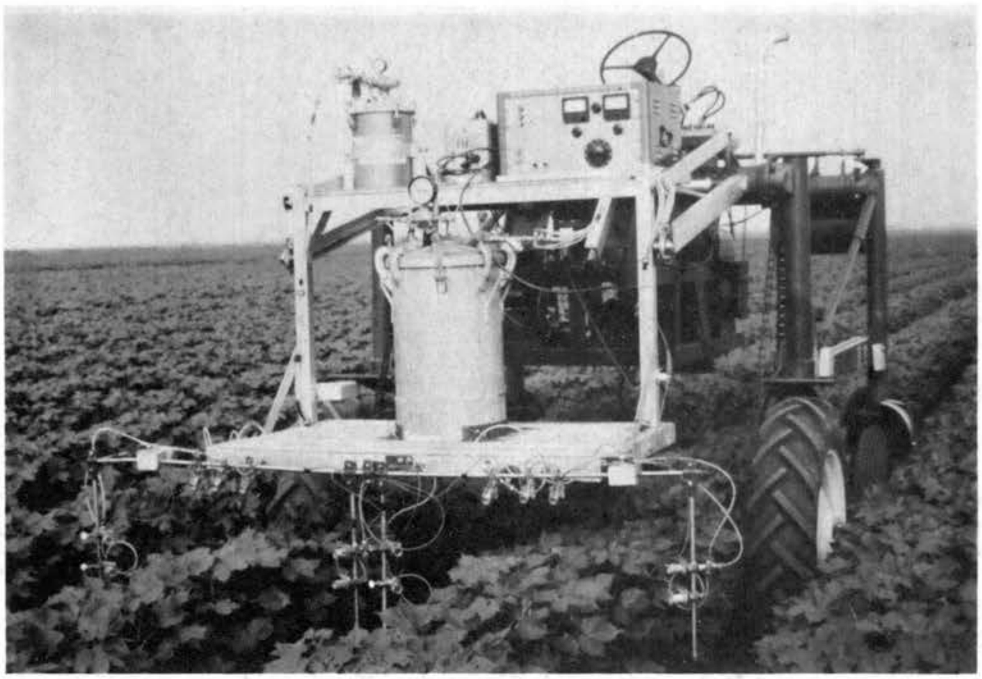


Figure 2. 1969 Hagie modified sprayer

gal. insecticide pressure tank had a stainless steel liner, pressure regulator, pressure gauge and a three way control valve, off, on and drain or pressure release to prevent nozzle dripping when the lines were shut off between plots.

A parallel system to the insecticide was used to flush the nozzle assemblage before changing the orifice plates for each droplet size treatment. This sytem was composed of a 2-gal. tank with pressure regulator, pressure gauge and a three way control valve. These 2 systems were combined at the nozzle assemblage by means of 2 needle valves.

The nozzle support boom was adjustable with two row nozzle assemblages, one for each row attached to the boom with flexible connections of brass brackets. The adjustable boom and flexible connections between the support boom and the outlets permitted adjustments for treatment of cotton at various sizes.

The electrostatic dispersion was obtained with a charging apparatus shown in Fig. 3 similar to that described by Roth and Porterfield (1966). It is composed of a variable high voltage supply and a high voltage lead attached to an insulated metallic tube (2 x 1 inches) on each nozzle.

The objective of this device was to impose an electric charge to the droplets so they would repel one another and to obtain better dispersion of the droplets. It was observed by Roth and Porterfield (1966) that some of the small

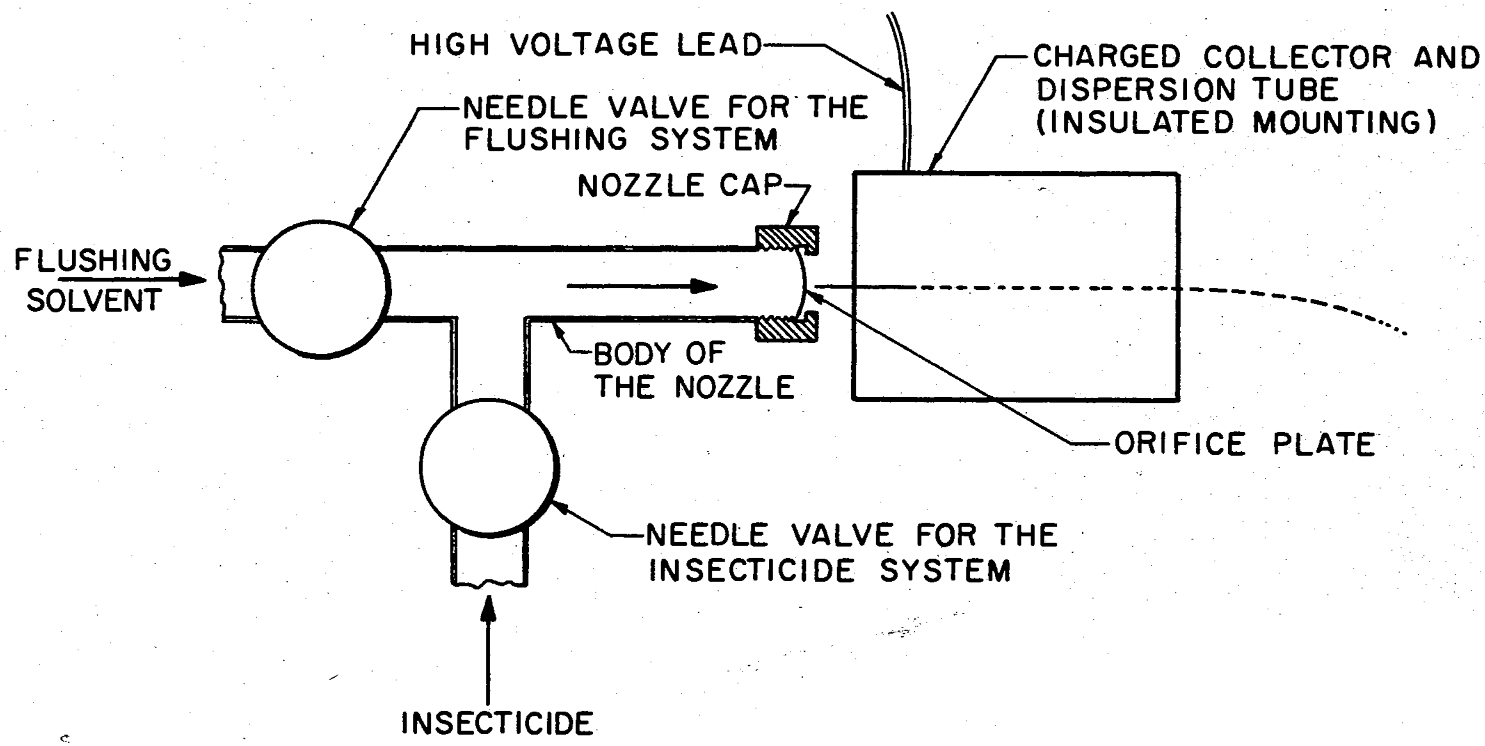


Figure 3. Jet Stream Atomization Nozzle 1969

satellite drops were collected in the inner surface of the tube.

Commercial nylon tubing of 3/16 inches outside diameter was used to carry the insecticide from the pressure tank to the outlets, the solvent in the flushing system, and the air pressure from the air compressor to the insecticide and flushing tanks.

Two line strainers 100 and 200 mesh were placed in the insecticide system to prevent possible clogging of the nozzle tips by small particles of foreign matter.

Droplet Sizes and Volumes

The droplet sizes applied during the 1969 test were 254-, 396-, and 556-micron average size in diameter obtained with microdrilled brass nozzle tips of 100-, 200-, and 300-micron diameter, respectively.

The principle of jet stream atomization has been described by Roth and Porterfield (1965) and Vehe (1969). It consists in allowing the liquid to discharge from a circular orifice as a jet stream. Under conditions of minimum turbulance, liquid emerges as a cylindrical filament that is broken to rather uniform drops of two basic size groups. Small drops smaller in diameter than the diameter of the circular orifice are formed between larger drops that average about twice the orifice diameter in size. Roth and Porterfield

(1966) reported that 0.2% of the liquid volume was formed as the smaller drops.

The equipment was operated at a constant pressure of 15 psi. The three sizes of drops were applied at three different rates of total volume of 1, 2, or 3 gallons per acre for each droplet size. The volumes were obtained by using from 1 to 9 orifices per nozzle tip, by varying the number of outlets per row from 2 to 7, and by calibrating the total amount of liquid output changing the ground speed of the applicator from 2.1 to 3 mph. The arrangement of outlets, number of holes per nozzle tip, and ground speed for each treatment are shown in Table I. The nozzle arrangement for the 254-micron diameter droplets applied at 3 gal. per acre are shown in Fig. 4.

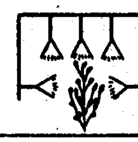
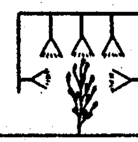
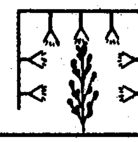
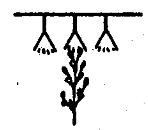
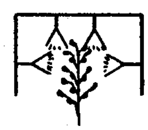
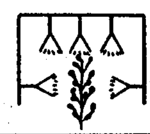
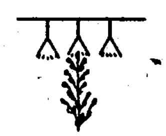
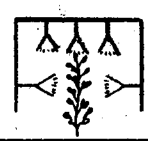
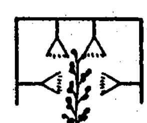
Application Methods

Cotton was planted on April 24, 1969, with 30 lbs. of Deltapine 16 per acre. A complete randomized block design with 4 replicates having a total of 9 treatments per replicate was used. The plots were 200 feet long and 12 rows 40 inches apart. An 8 row wide buffer was allowed between plots to avoid contamination from adjacent treatments.

Cotton plants were sprayed 5 times at approximately weekly intervals from July 16 to August 20. The insecticide used was Azodrin® (dimethyl phosphate of 3- hydroxy-N-

TABLE I

NUMBER OF NOZZLES, NOZZLE ARRANGEMENT FOR 1969 TREATMENTS

DROPLET SIZE (MICRON)	TIP ORIFICE DIAMETER (MICRON)	TOTAL VOLUME GALLONS PER ACRE	NUMBER OF ORIFICES PER NOZZLE	NUMBER OF NOZZLES PER ROW	GROUND SPEED MILES PER HOUR	NOZZLE ARRANGEMENT PER ROW
254	100	1.00	5	5	2.4	
		2.00	9	5	2.2	
		3.00	9	7	2.1	
396	200	1.00	2	3	3.0	
		2.00	3	4	3.0	
		3.00	3	5	2.5	
556	300	1.00	1	3	3.2	
		2.00	1	5	2.7	
		3.00	2	4	2.8	

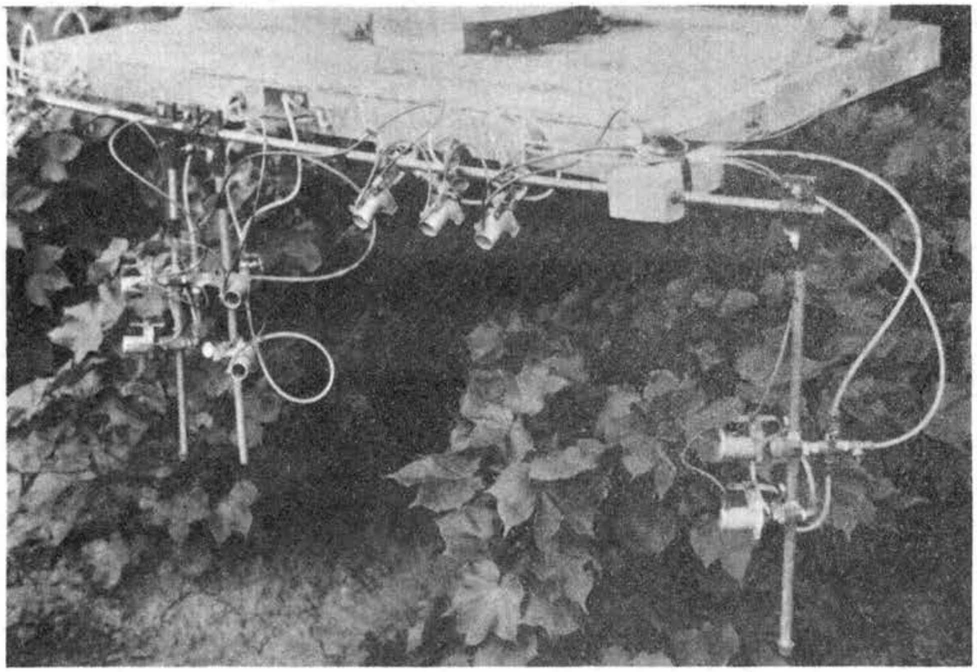


Figure 4. Arrangement of nozzles in the test of 254-micron droplets at 3 gal. volume per acre in 1969

methyecis-crotonamide) also designated at Monocrotophos or SC 9129. It was used in a water soluble formulation of 5 lbs. per gallon of active material. Previous work with this compound has shown its effectiveness in controlling cotton insects (Adair et al. 1967). Nemec et al. (1968) reported good control of the bollworm on cotton with ultra low volume application of 0.6 to 1.00 pounds of active material per acre. Furr and Davis (1969) reported excellent control of the two-spotted spider mite <u>Tetranychus</u> <u>urticoe</u> Kock, with Azodrin® at 1.0 pound per acre of active ingredient of the water soluble formulation.

The amount of active material of Azodrin® was varied during the season being 0.15 pounds per acre for the two first sprays of July 16 and July 30. This low rate was applied in order to increase bollworms in the field. Subsequent to these applications the percent of damaged squares increased to 44.58% by August 5. This increase in damaged squares by bollworm was supposedly due to the elimination of beneficial anthropods and therefore an increase on the bollworm population. The amount of insecticide applied per acre was increased to 0.6 pounds of active material on August 6, and to 1.00 pounds per acre on August 13 and August 20. This increase in amount of active material per acre met the recommendations indicated by Young and Price (1969) for bollworm control in Oklahoma.

Tap water was used as the carrier in all treatments except in the 254-micron droplet test where distilled water was used to avoid possible clogging of the small (100-micron) tip orifices.

Estimates of bollworm populations were made at approximately one week intervals from July 24 until September 9. In each plot 100 squares from the upper one-third of the plants were pulled at random and the percent of damaged squares was determined.

Effectiveness of the different treatments was further evaluated by determination of yields from the entire 8 center rows on each plot. A sample of 20 bolls pulled at random was obtained to determine the main fiber characteristics. The fiber characteristics were determined for each harvest on November 26 and December 16, 1969 by the Fiber Laboratory, Department of Agronomy, Oklahoma State University. Analysis of variance and Duncan's multiple range tests (Duncan, 1955) were made to determine if there were any significant differences between treatments.

1970 Test

The ground sprayer used in 1970 was a modification of the Hagie high clearance chassis used in 1969. Improvements made by the Agricultural Engineering Department of Oklahoma State University included replacement of the 2-row boom used in 1969 with a 4-row boom and the addition of an auxiliary transmission to provide ground speeds from 0.5 to 8.0 mph.

Spraying Components

The primary components of the new sprayer used in 1970 are shown schematically in Fig. 5 and can be identified with some detail in Fig. 6 and 7. The components were as follows:

a. A gasoline engine generator set of 2500 watts capacity to provide electricity for the air compressor, the instruments for the magnetostrictive device and for the electrostatic dispersion equipment.

b. An air compressor to supply pressure energy for the liquid to be enforced to the jet atomizing nozzles.

c. A 10 gal. pressure insecticide tank with a stainless steel liner, pressure gauge, pressure regulator, a three-way valve (off, on, and drain), and a 100-mesh line strainer.

d. A 2-gal. flushing tank with pressure regulator, pressure gauge, and a three-way valve.

e. A Hewlett Packard audio oscillator model 200 AB adjustable from 20 to 40,000 Hz to generate the frequency. It was run at 12,000 Hz.

f. A Bogen 100-watt amplifier model MT100, 15 to 35,000 Hz. to amplify electric impulses.

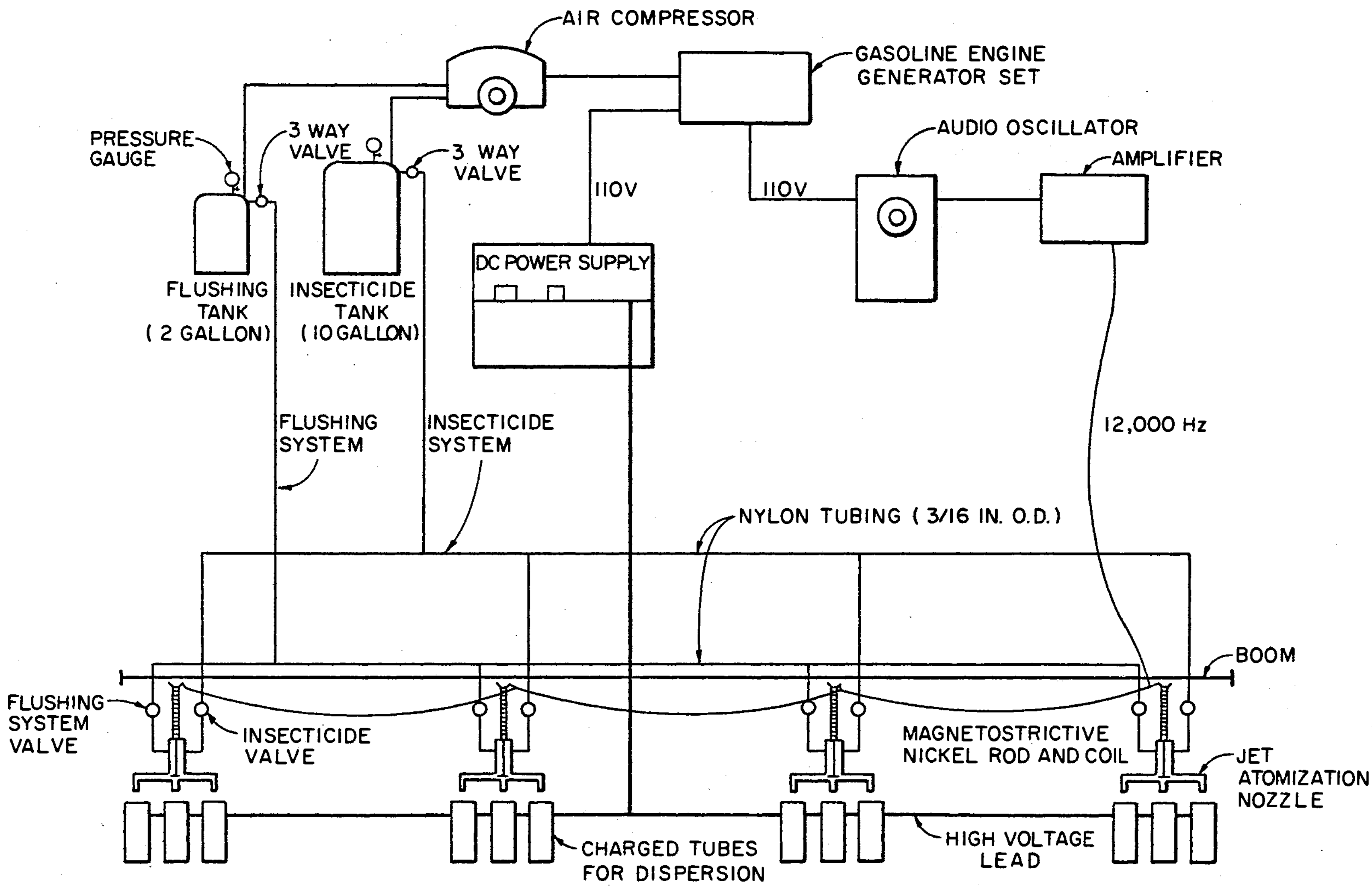


Figure 5. Spraying System 1970

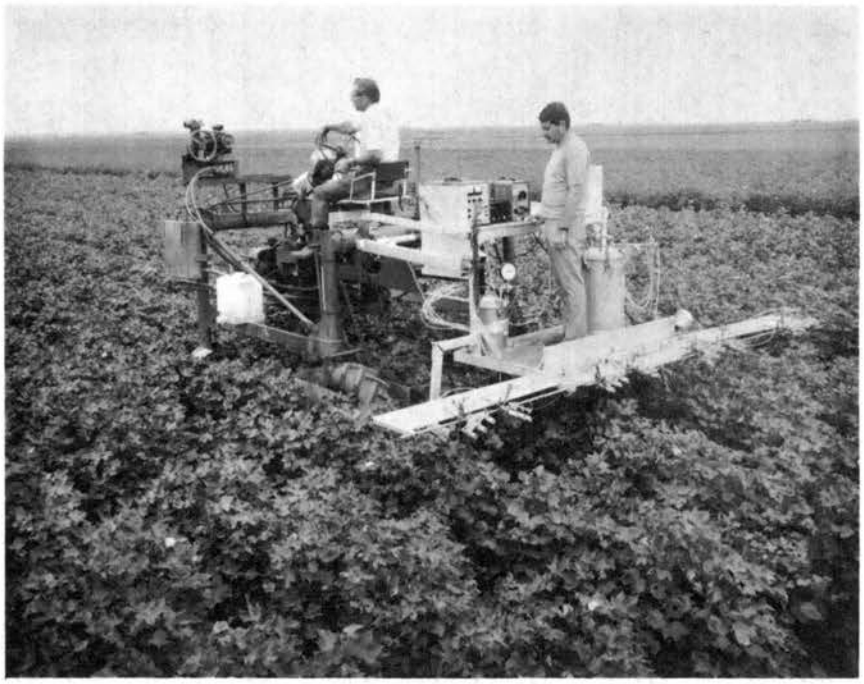


Figure 6. 1970 Four rows ground sprayer

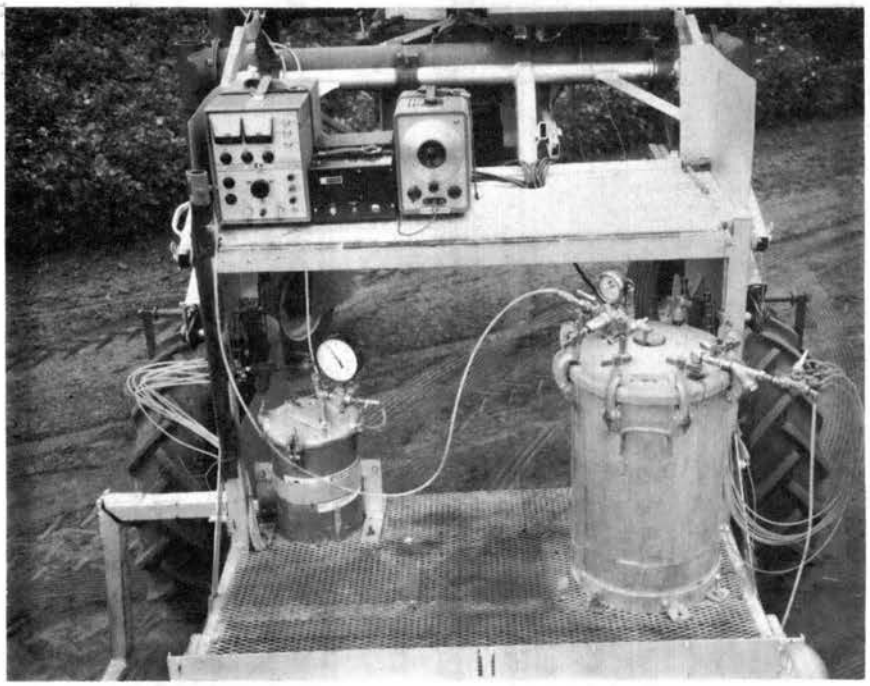


Figure 7. Audio oscillator, amplifier, high voltage D. C. power supply, insecticide pressure tank and flushing 2 gal. tank on the 1970 sprayer

g. A Sorensen DC power supply model 230 3/12 P to provide high voltage to the lead and to the charged tube to produce electrostatic dispersion.

h. Nozzle support boom made of ½-inch tubing 160 inches long to provide support for the 4-row nozzle assemblage.

i. Eight brass nozzle assemblages, with 3 outlets each, attached to the boom with flexible connections of brass brackets.

Electronic dispersion was obtained with the same type of equipment described for the 1969 test, composed of a variable high voltage DC power supply, a high voltage lead and metallic insulated charged tubes.

In order to obtain more uniform droplets the jet stream atomization system was provided with magnetostrictive rod transducer nozzles, similar to that described by Vehe (1969). The magnetostrictive nozzle design shown in Fig. 8 exhibits the following components: a magnetized nickel rod, a nylon rod and coil sheath to provide guide for the nickel rod and mount for the field coil, a field coil wound onto the nylon sheath at a density of 40 turns per inch, a vibrating surface and a spherical orifice plate.

The basic principle of magnetostriction is that magnetization of a nickel rod by passing an alternative current through a coil surrounding the rod causes dimensional changes in the rod. Lengthwise vibration of the rod imparts cyclic

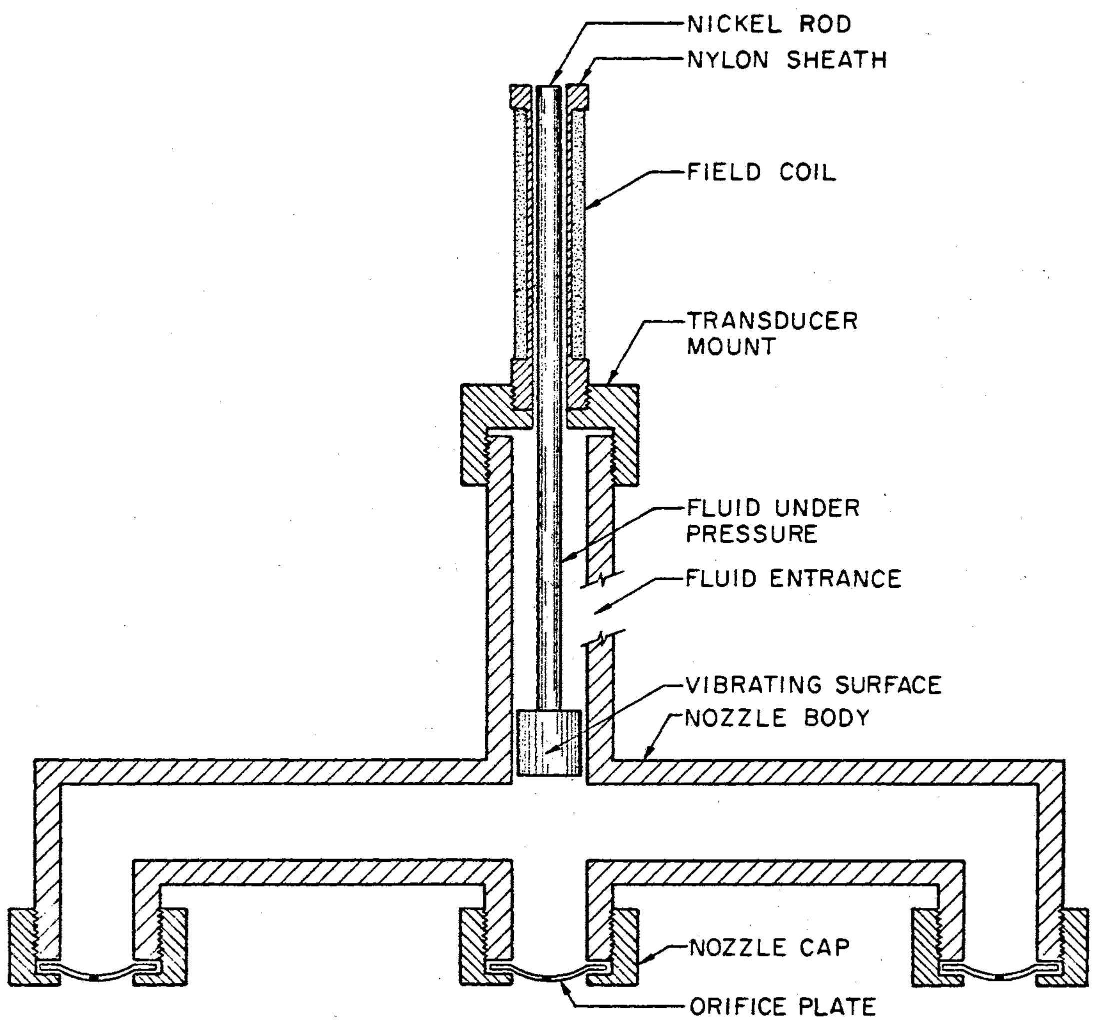


Figure 8. Magnetostrictive Rod Nozzle

pulses to the column of liquid emerging at the orifice of the spherical plate (Roth and Porterfield, 1969).

<u>Droplet Sizes and Volumes</u>

The brass spherical plates were drilled to nominal orifices of 200-, 400-, and 600-micron in diameter to produce droplets with diameters averaging 418 (σ=25), 706 (σ=34), and 950 (σ=44) microns, respectively.

In order to have a better distribution of the atomized spray the number of outlets was varied for the different droplet size treatments.

The arrangement of outlets and streams is shown in Fig. 9, 10, and 11. The 418 micron droplets were sprayed with 6 nozzles spaced 2.5 inches apart, per row having one stream/nozzle. The 706 micron droplets were sprayed using one outlet with two streams per row and the 950 microns croplets with one outlet with one stream per row.

The volumes tested were 1, 4, and 8 gallons per acre for each droplet size. The amount of output of the sprayer was calibrated by changing the ground speed from 0.40 to 7.88 mph as indicated in Table II.

<u>Application Methods</u>

Cotton was planted on May 7 with 25 lbs. per acre of Deltapine 16. A complete randomized block design with 4

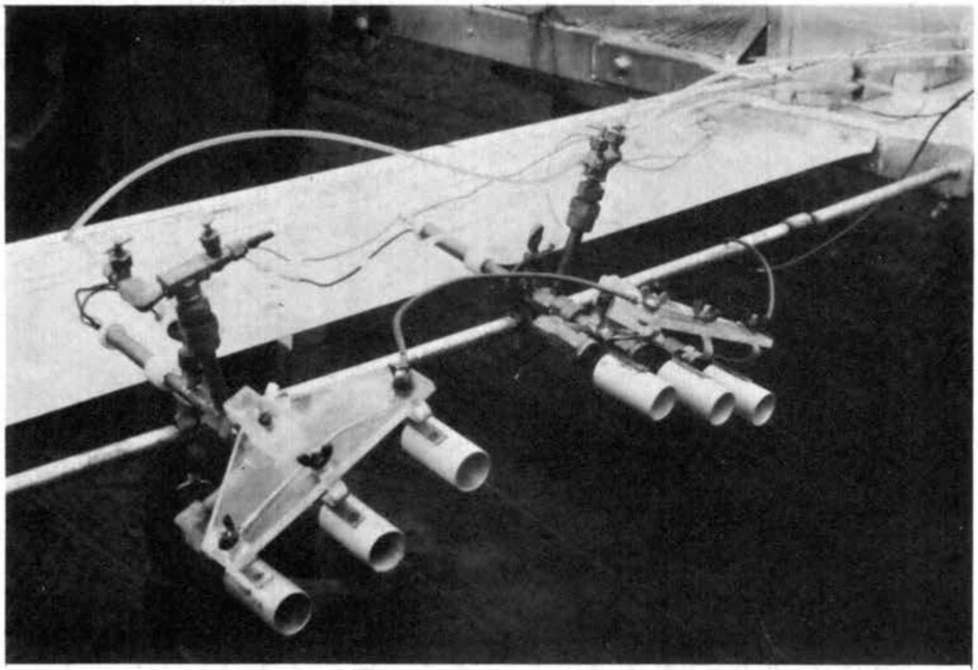


Figure 9. Nozzle arrangement per row for the 418-micron droplets 1970 treatment

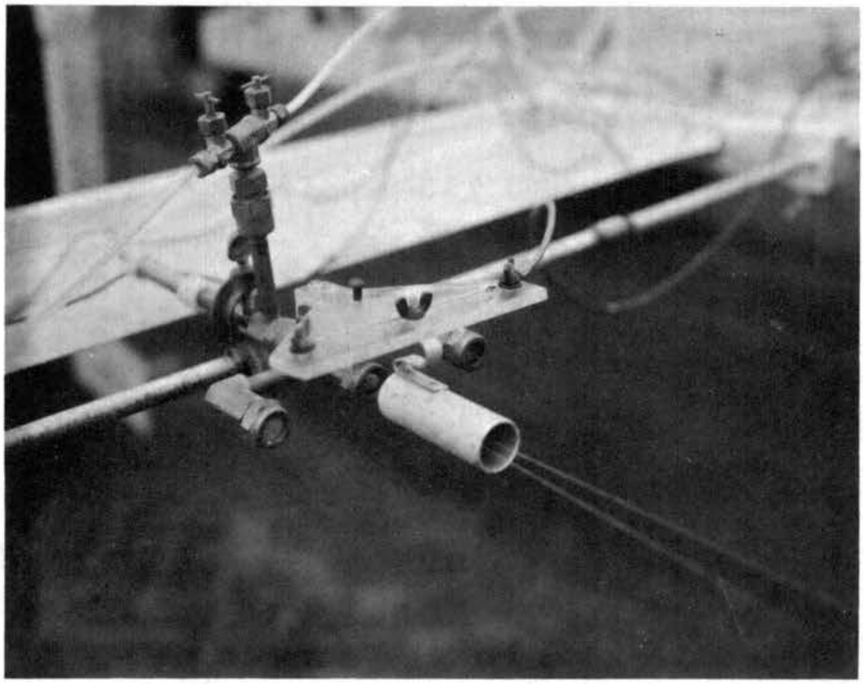


Figure 10. Arrangement of nozzle per row of the 706-micron droplets treatment 1970

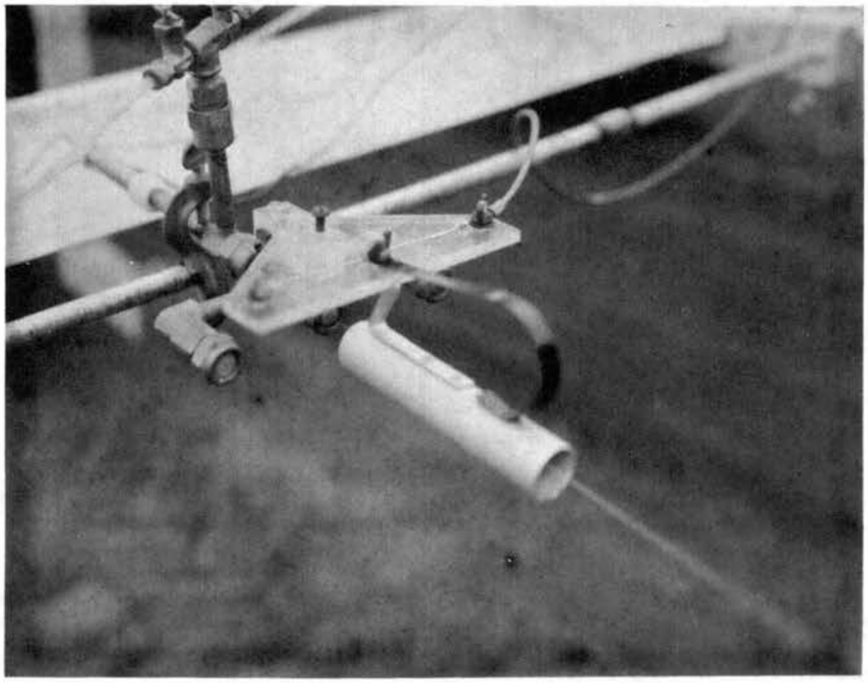


Figure 11. Nozzle arrangement per row for the 950-micron droplets treatment 1970

TABLE II

SIZES, VOLUMES, AND GROUND SPEED DURING 1970 SPRAY TESTS

Droplet size (microns)	Orifice size (microns)	Total volume gal/acre	Ground speed miles per hour
418	200	1.0	3.24
		4.0	0.81
		8.0	0.40
706	400	1.0	7.32
		4.0	1.82
		8.0	0.92
950	600	1.0	7.88
		4.0	1.97
		8.0	0.98

replicates was used. The plots were 200 ft. long and 12 rows (40 inches apart) wide. An 8-row untreated buffer separated plots to avoid possible influence of adjacent treatments.

The plants were sprayed 6 times at approximately weekly intervals from July 28, 1970 to September 8, 1970. Azodrin® 5 lbs. of active ingredient per gallon of water soluble formulation at rate of 0.8 lbs. of active material per acre was sprayed in all treatments.

Distilled water was used as carrier for the 418-micron droplets treatments and tap water for the 706-and 950-micron droplet treatments.

Estimates of bollworm populations were made in the manner described for 1969 from August 3 to September 14. Yields were computed by picking the entire 8 center rows in each plot on October 29, 1970 and November 30, 1970. Studies of fiber characteristics and analysis of variance were made in the same manner as in 1969.

CHAPTER IV

RESULTS AND DISCUSSION

1969 Test

Data for the percent of squares damaged by bollworms in each treatment for the 1969 season are shown in Table III. On July 24 after one low rate application of Azodrin® of 0.15 lb. active ingredient per acre the overall percent on July 24 was similar in all treatments due to the low population of bollworms. By the second application of 0.15 lb/acre on July 30 a considerable increase in damaged squares was observed when the peak of the first generation of bollworms occurred on cotton.

On August 5, the percentage of damaged squares ranged from 30.5 in the 556 micron 3 gal. treatment to 54.2 in the 396 micron 1 gal. treatment. The overall damage was decreased from 44.6% on August 5 to 32.1% on August 12 following an application of 0.6 lbs. of Azodrin® on August 6. The 4th and 5th applications of 1.0 lb/acre on August 13 and 20 considerably reduced the bollworm population.

The percent of squares damaged for each treatment are

TABLE III

PERCENTAGE OF SQUARES DAMAGED BY BOLLWORMS IN SPRAY TESTS 1969

Droplet size micron	Gallons/acre	July 24	August 5	August 12	August 19	August 26	September 2	September 9	Mean
556	3.0	0.7[a]	30.5	30.0	7.5	5.0	16.2	12.5	14.6
396	1.0	1.7	54.2	25.7	8.2	7.5	17.5	11.0	18.0
396	2.0	0.7	39.0	34.7	11.2	5.5	11.0	14.2	16.6
556	2.0	0.5	42.2	29.7	9.0	3.5	8.2	15.0	15.4
254	2.0	0.7	38.5	34.7	10.0	7.7	14.0	17.0	17.5
254	1.0	1.5	49.0	38.5	8.5	5.7	13.0	11.7	18.3
396	3.0	1.0	49.0	27.2	8.5	4.7	21.0	19.2	18.7
254	3.0	0.5	49.0	35.2	9.5	7.2	17.5	18.0	19.6
556	1.0	1.2	49.7	33.0	13.0	6.2	15.7	19.7	19.8

[a] Average of four replicates

presented in Fig. 12, 13, and 14. Two peaks in damage occurred on August 5 and on September 2-9, which indicate two generations at approximately 30 days apart. The second generation was considerably reduced by the 3 applications of Azodrin® on August 6, 13, and 26.

There were no differences among the 9 treatments through August 26. On September 2, the 2 gal. treatments had significantly less squares damaged than the 3 gal. plots (Table IV).

Droplet Size

Data of squares damaged by bollworm for each droplet size applied are shown in Table V and Fig. 15. The 556-micron in diameter droplets had an overall mean of 16.64% squares damaged, the 396-micron had 17.77% and the 254-micron 18.46%. Statistical analysis of the percentage of squares damaged by bollworm shows no significantly different at P=0.05.

The yield of seed cotton for each treatment are reported in Table VI. Other treatments had significantly more seed cotton than the 254-micron 1 gal. treatment. The 556-micron 3 gal. total volume per acre had yielded significantly more seed cotton than other treatments except the 396-micron 1.0 gal. and the 556-micron 2 gal. treatments.

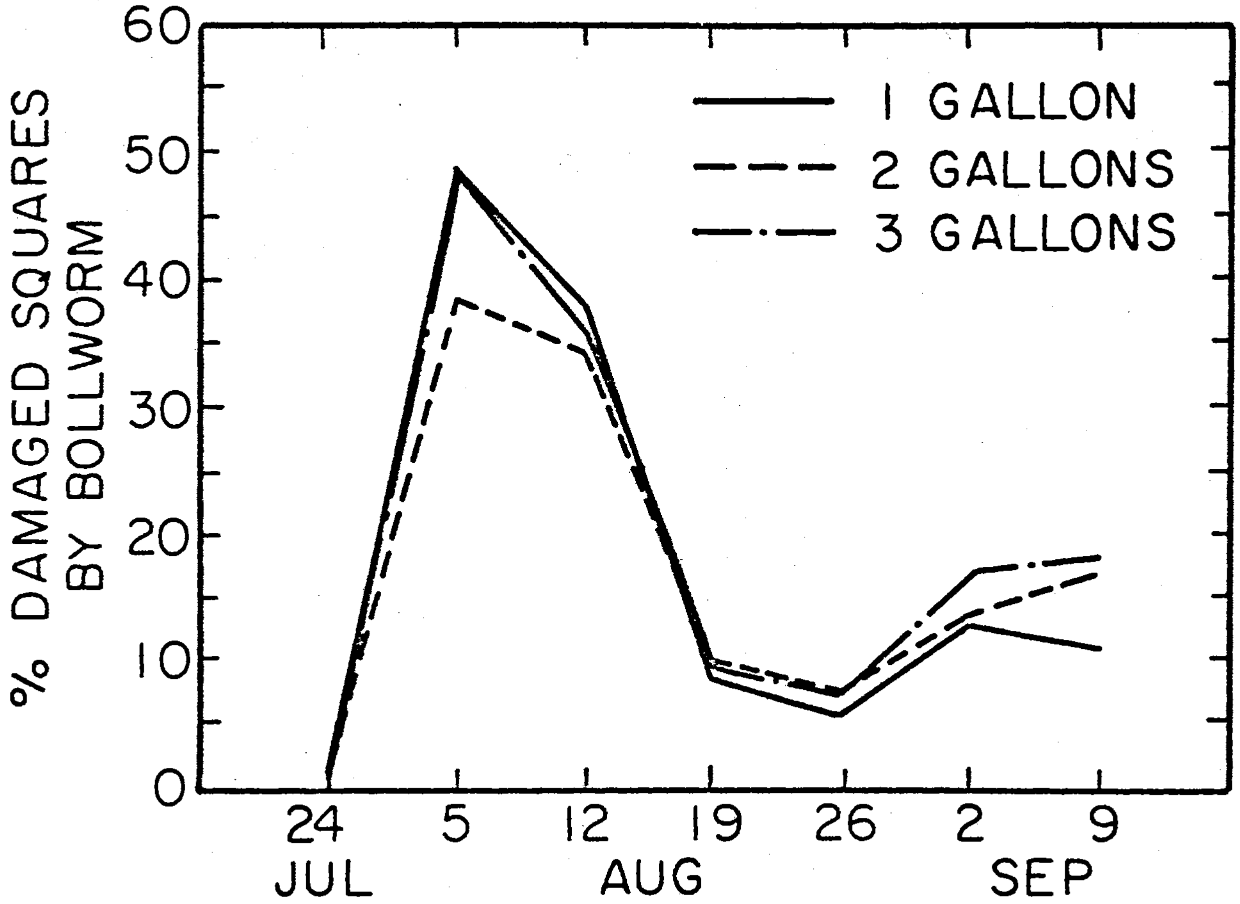


Figure 12. Percentage of squares damaged by bollworms in the 254-micron droplets treatment 1969

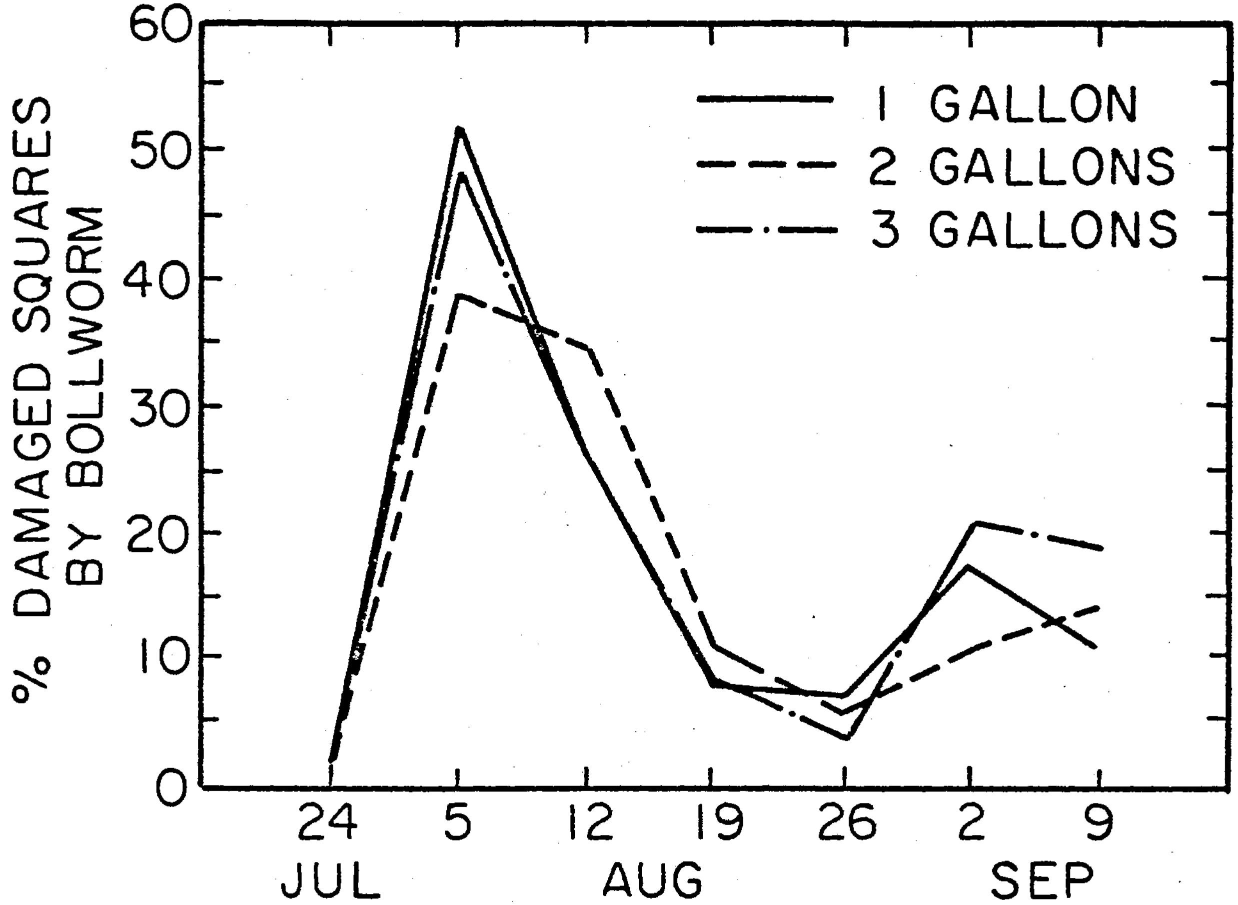


Figure 13. Percentage of squares damaged by bollworms in 396-micron droplets treatment 1969

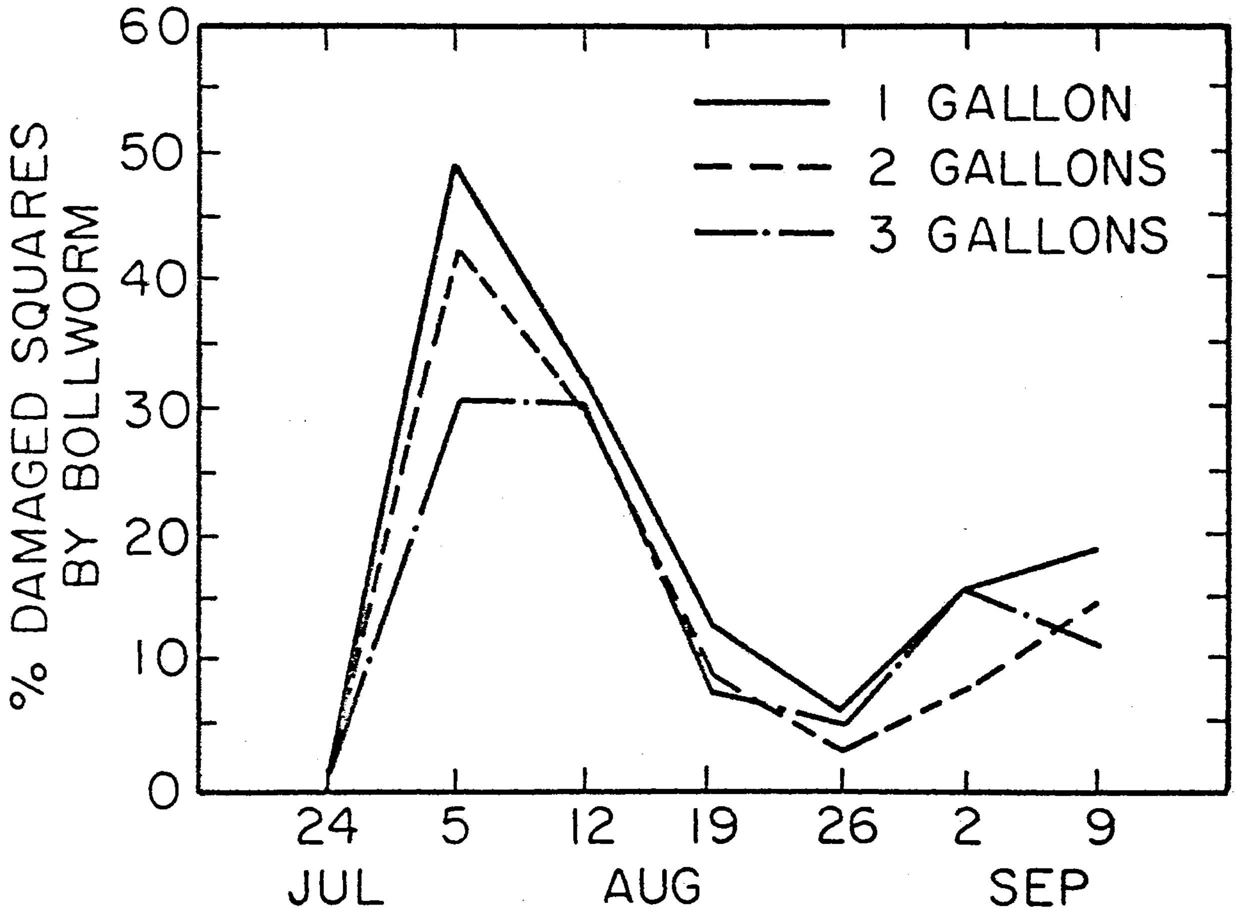


Figure 14. Percentage of squares damaged by bollworms in 556-micron droplets treatment 1969

TABLE IV

PERCENTAGE OF SQUARES DAMAGED BY BOLLWORM IN SPRAY TESTS SEPTEMBER 2, 1969

Gallons per acre	Droplet size micron	Percent of squares damaged by bollworm
1.0	254	13.0*bc**
	396	17.5 d
	556	15.7 dc
2.0	254	14.0 bc
	396	11.0 ab
	556	8.2 a
3.0	254	17.5 d
	396	21.0 e
	556	16.2 dc

* Average of four replicates

** Means followed by the same letter are not significantly different (P=0.05)

TABLE V

SQUARES DAMAGED BY BOLLWORMS IN DROPLET SIZE TREATMENTS 1969

Droplet size micron	July	August				September		
	24	5	12	19	26	2	9	Mean
556	0.8	40.8	30.9	9.8	4.9	13.4	15.7	16.6
396	1.2	47.4	29.2	9.3	5.9	16.5	14.8	17.8
254	0.9	45.5	36.2	9.3	6.9	14.8	15.6	18.5

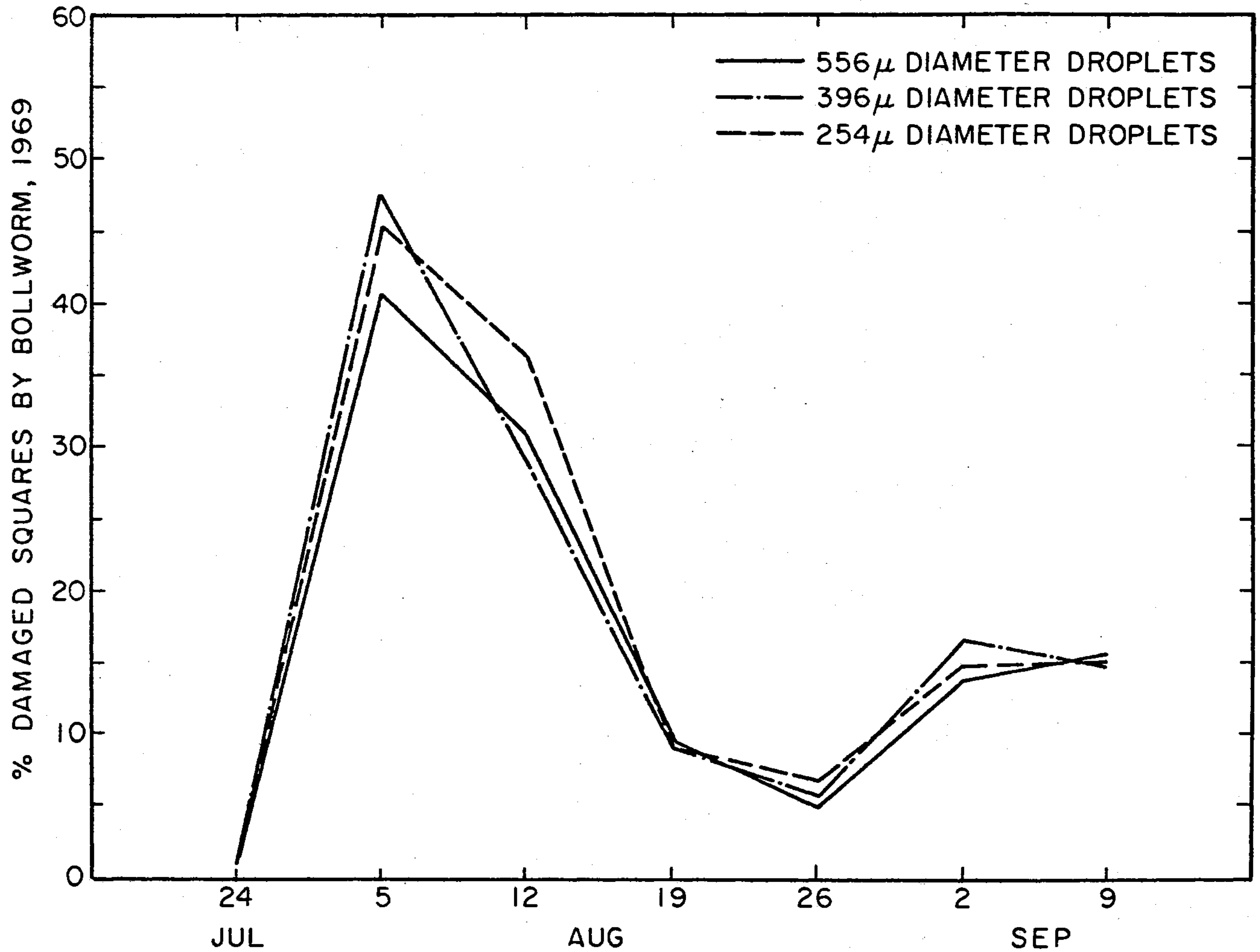


Figure 15. Percentage of squares damaged by bollworms in treatment 1969

TABLE VI

POUNDS OF SEED COTTON PER ACRE IN TREATMENTS 1969

Droplet size micron	Gallons/ acre	1st Harvest	2nd Harvest	Total
556	3.0	553.3	120.9	674.2*a**
396	1.0	516.6	125.0	641.6 ab
556	2.0	530.9	109.8	640.7 ab
396	2.0	528.8	99.6	628.5 b
396	3.0	498.2	107.2	605.4 bc
254	2.0	465.5	101.9	567.4 c
254	3.0	400.2	100.5	500.7 d
556	1.0	404.3	90.0	494.3 d
254	1.0	365.5	85.1	450.6 e

* Average of four replicates

** Means followed by the same letters are not significantly different (P=0.05)

When the 3 volume rates were averaged in each droplet size the 556- and 396- micron droplets had significantly more seed cotton than the 254- micron treatment.

The calculated pounds of lint per acre for each treatment are shown in Table VII. The data indicate that the 396- micron droplet size at 1, 2, or 3 gal. and the 556- at 2 or 3 gal. per acre yielded significantly more lint than the smaller drops 254- micron in diameter at 1, 2, or 3 gal. per acre and the 556-micron drops at 1.00 gal. per acre. The 254- micron diameter drops at 1 gal. per acre total volume had significantly less lint per acre than the same droplet size applied at 2 or 3 gal. per acre but was not significantly different for the 556-micron drops applied at 1 gal. per acre total volume. The 254-micron droplets yielded significantly more lint at 2 gal. per acre than the same droplets at 3 gal. When the three volume rates were averaged for each droplet size the 556- and 396-micron droplets yielded significantly more lint per acre than the 254-micron droplets, as was true in seed cotton yields.

The characteristics of fiber quality studied were: fineness, given in micronaire units, fiber strength with 1/8 inches Stelometer and 0 inches Stelometer given in 1000 lbs. psi, uniformity ration, and 2.5% span length measured with fibrograph in inches. Statistical analysis of the data

TABLE VII

CALCULATED POUNDS OF LINT COTTON PER ACRE IN TREATMENTS 1969

Droplet size micron	Gallons/acre	1st Harvest	2nd Harvest	Total
556	3.0	203.0	42.7	245.7*a**
396	1.0	189.2	45.6	234.8 a
556	2.0	192.6	40.1	232.7 a
396	2.0	191.5	35.8	227.2 a
396	3.0	188.5	37.5	226.0 a
254	2.0	168.6	35.1	203.7 b
254	3.0	142.9	35.5	178.5 c
556	1.0	143.8	31.8	175.5 cd
254	1.0	127.6	29.3	156.9 d

* Average of four replicates

** Means followed by the same letters are not significantly different (P=0.05)

indicated no significant differences between treatments except on the 2.5% span length data shown in Table VIII. The 254-micron diameter drops at 1, 2, or 3 gal. per acre and the 396 at 3 gal. per acre had significantly longer fiber than 396-micron drops at 1 and 2 gal. per acre total volume. Averaging the 3 rates of total volume for each droplet size applied at 254-micron drops had significantly longer fiber than the 396- and 556-micron in diameter drops. Data in psi. for the 0 inches Stelometer shown in Table IX indicated significant differences among treatments but when converted to 1000 psi. all treatments followed in the average category (from 76-85 thousand psi) given by Hoover, 1962.

<u>Total Volume of Spray</u>

Square damage data grouped in the 3 volume rates are shown in Table X and Fig. 16. The overall mean indicates a lower number of squares damaged 16.55% when two gal. of total volume was applied. The 3 gal. rate had 17.63% of squares damaged by bollworms and the 1 gal. per acre rate gave the highest with 18.70% of the squares damaged.

In the 1969 season means of the 3 volumes for percentage of squares damaged by bollworms were not significantly different except on September 2 when squares in the 2 gal. rate were significantly less damaged than in the 3 gal. rate.

TABLE VIII

SPAN LENGTH FIBROGRAPH IN INCHES 2.5%

Droplet size micron	Gallons/ acre	Span Length Inches		
		1st Harvest	2nd Harvest	Total
254	1.0	1.200	1.143	1.158*a**
254	2.0	1.192	1.138	1.154 ab
254	3.0	1.209	1.136	1.154 ab
396	3.0	1.185	1.139	1.153 ab
556	3.0	1.210	1.121	1.148 bc
556	1.0	1.189	1.125	1.143 cd
396	2.0	1.182	1.120	1.139 d
556	2.0	1.191	1.113	1.137 de
396	1.0	1.171	1.114	1.131 e

* Average of four replicates

** Means followed by the same letter are not significantly different (P=0.05)

TABLE IX

FIBER STRENGTH 0 INCHES GAUGE STELOMETER
IN TREATMENTS 1969

Droplet size micron	Gallons/acre	0" gauge stelometer 1000 psi
254	1.0	77.6
254	2.0	77.5
254	3.0	78.5
396	1.0	80.6
396	2.0	79.7
396	3.0	78.7
556	1.0	77.2
556	2.0	79.0
556	3.0	77.0

TABLE X

SQUARES DAMAGED BY BOLLWORMS IN VARIOUS SPRAY VOLUME TREATMENTS 1969

Gallons/acre	July	August				September		
	24	5	12	19	26	2	9	Mean
1.0	1.5	51.0	32.4	9.9	6.5	15.4	14.2	18.7
2.0	0.7	39.9	33.1	10.1	5.6	11.1	15.4	16.5
3.0	0.7	42.8	30.8	8.5	5.7	18.2	16.6	17.6

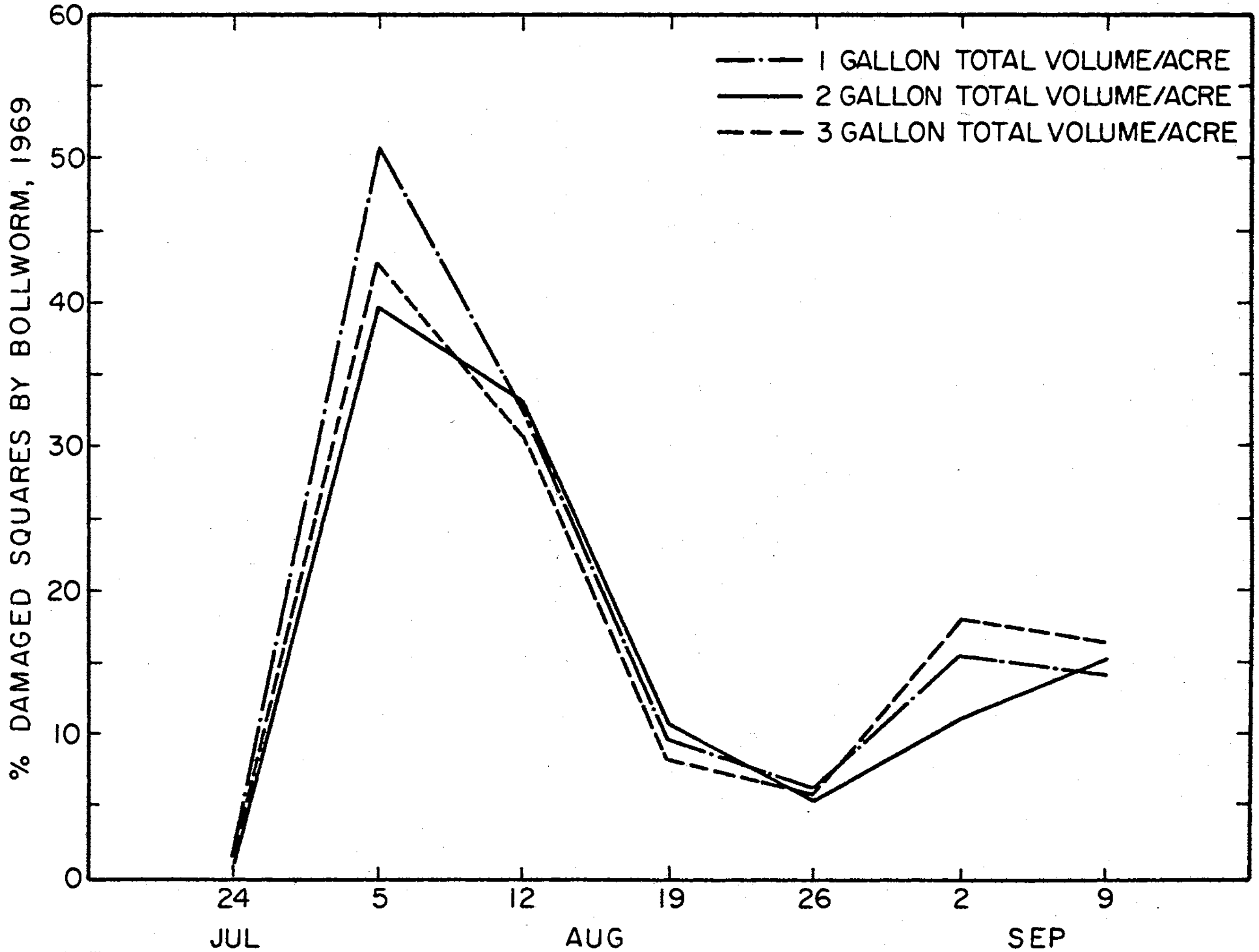


Figure 16. Percentage of squares damaged by bollworms in treatment 1969

Yields of cotton seed and of lint did not differ significantly (P=0.05) among the 3 volume rates.

1970 Test

Data for 1970 based upon percentages of squares damaged by bollworm are shown in Tables XI and XII and Fig. 17, 18, and 19. The bollworm population was low in the 1970 season, as indicated by an overall average of only 4.4% of squares damaged.

Droplet Sizes

There were no significant differences among the 3 droplet sizes through August 31. On September 7 (Table XII), the 418-micron treatments (rates of 1, 4, or 8 gal./acre) and 706-micron treatment at 1 gal./acre had significantly less squares damaged than the 706 micron treatments of 4 or 8 gal. Analysis of means for the 3 droplet sizes based on the 3 volume rates showed the 418 treatment had significantly less squares damaged than the 950-micron treatment drops. The 706-micron droplet treatments were not significantly different from either of the others.

The percentages of squares damaged for each treatment (Fig. 17, 18, and 19) show only one peak of bollworm population between the last week of August and first of September which indicates the second generation of bollworms on cotton.

TABLE XI

PERCENTAGE OF SQUARES DAMAGED BY BOLLWORMS IN SPRAY TREATMENTS 1970

Droplet size micron	Gallons/ acre	August 3	11	17	24	31	September 7	14	Mean
418	4.0	2.2	0.2	1.2	4.2	5.5	4.0	3.5	3.0*a**
418	8.0	2.2	0.2	0.7	7.2	5.5	3.7	4.2	3.5 ab
418	1.0	4.7	0.7	1.0	3.5	8.5	2.2	4.0	3.5 ab
950	8.0	1.7	0.2	1.0	7.2	8.0	5.0	3.5	3.9 b
706	1.0	4.2	3.7	2.7	6.5	4.5	3.5	4.0	4.1 b
706	4.0	3.5	2.5	1.0	7.0	2.5	10.7	4.7	4.6 b
706	8.0	1.2	1.2	2.0	5.7	7.2	10.2	4.7	4.6 b
950	4.0	1.5	1.5	1.7	5.2	7.5	13.0	7.5	5.4 c
950	1.0	5.0	2.7	0.7	10.2	8.2	11.2	7.5	6.5 d

* Average of four replicates

** Means followed by the same letter are not significantly different (P=0.05)

TABLE XII

PERCENTAGE OF SQUARES DAMAGED BY BOLLWORMS ON SEPTEMBER 7, 1970

Droplet size micron	Gallons/acre	Squares damaged
418	1.0	2.2*a**
	4.0	4.0 ab
	8.0	5.5 b
706	1.0	3.5 ab
	4.0	10.7 c
	8.0	10.2 c
950	1.0	11.2 c
	4.0	13.0 c
	8.0	5.5 b

* Average of four replicates

** Means followed by the same letter are not significantly different (P=0.05)

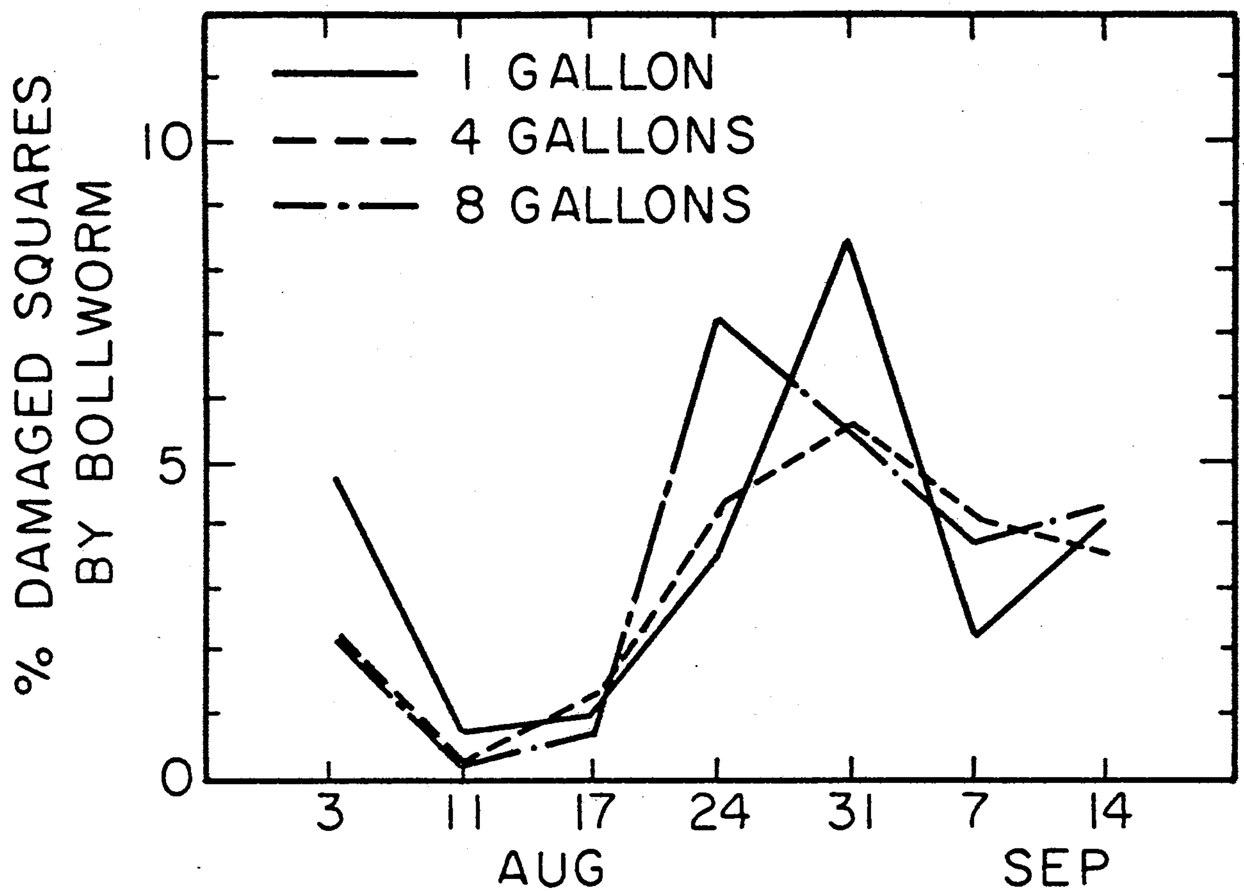


Figure 17. Percentage of squares damaged by bollworms in 418-micron droplets treatment 1970

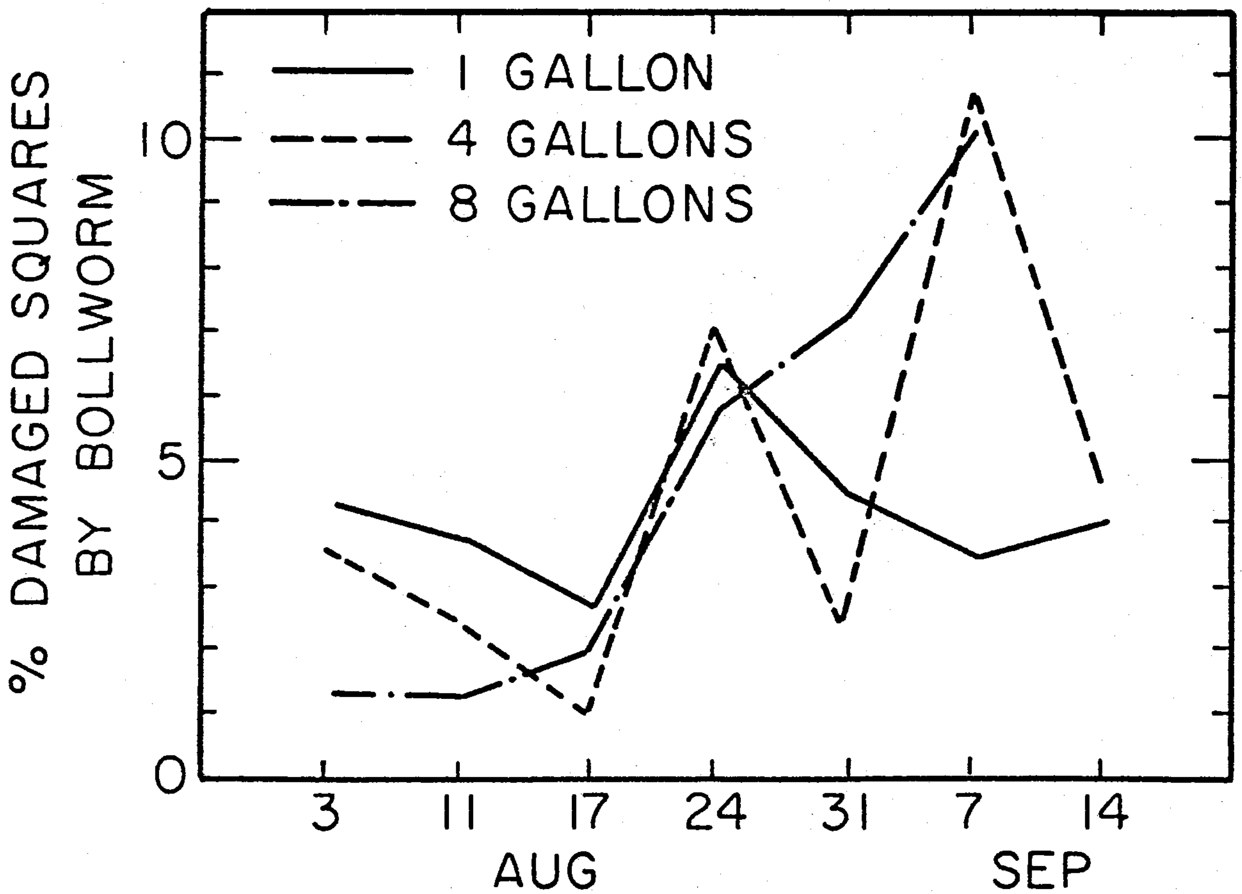


Figure 18. Percentage of squares damaged by bollworms in the 706-micron droplets treatment 1970

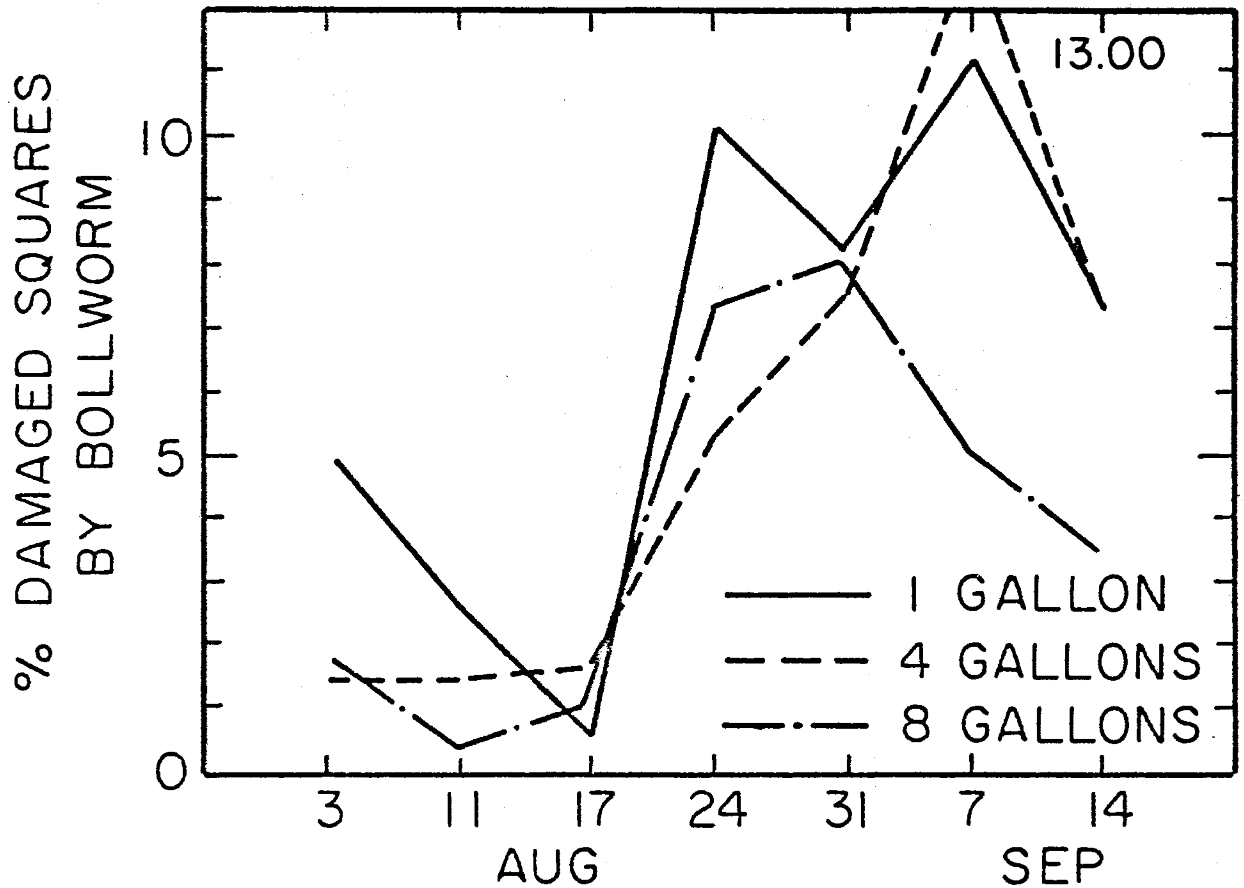


Figure 19. Percentages of squares damaged by bollworms in the 950-micron diameter droplets treatment 1970

Based upon seasonal means for percentages of squares damaged by bollworms shown in Table XI 950-micron droplets at rates of 1 and 4 gal. of total volume per acre have significantly more squares damaged by bollworms than the rest of the treatments. The 418-micron diameter droplets at 4 gal. per acre gave the best control of bollworms. This was significantly better than 706- and 950-micron drops at 1, 2, or 3 gal. per acre of total volume. No significant difference among the 1, 4, or 8 gal. total volume of the 418-micron drops was apparent. The 706-micron droplets fell in an intermediate group that was not significantly different from 950-micron drops at 8 gal. total volume per acre. Drops 950-micron in diameter at 8 gal. per acre were significantly better than the same drop size at 1 or 4 gallons per acre.

Averages of volume rates in each droplet size are shown in Table XIII and Fig. 20. They show seasonal means of 3.35, 4.46, and 5.29% squares damaged by bollworm for the 418-, 706-, and 950-micron droplets, respectively. Statistical analysis indicate that the 418 treatment had significantly less squares damaged than the 950 treatments, 706-micron droplet size treatments were not significantly different from the 418 or 950 treatments.

Total Volume of Spray

Data for the 3 volume rates applied are shown in

TABLE XIII

PERCENTAGE SQUARES DAMAGED BY BOLLWORM FOR DROPLET SIZE TREATMENTS 1970

Droplet size micron	August					Sept.		Treatment
	3	11	17	24	31	7	14	Means**
418	3.1*	0.4	1.0	5.0	6.5	3.3	3.9	3.3 a**
706	3.0	2.5	1.9	6.4	4.7	8.2	4.5	4.4 ab
950	2.7	1.5	1.2	7.6	7.9	9.7	6.2	5.3 b

* Means of four replications and three total volumes

** Means followed by the same letters are not significantly different (P=0.05)

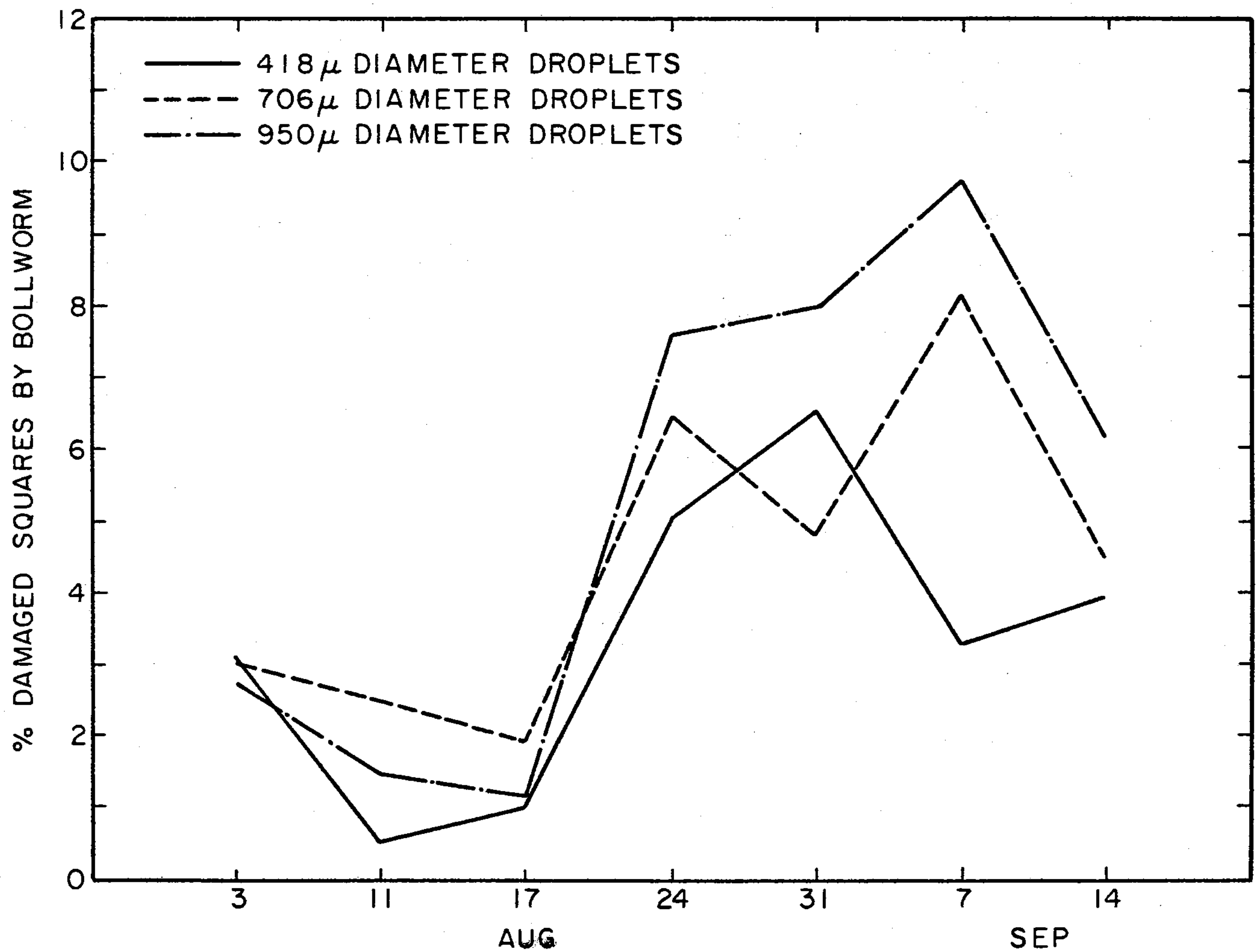


Figure 20. Percentage of squares damaged by bollworms in treatments 1970

Table XIV and Fig. 21. The highest percentage of squares damaged (9.2%) was recorded September 7 in plots receiving 4.0 gal. per acre. The seasonal means indicate similar control of bollworm population at rates of 1, 4, or 8 gal. of total volume per acre. Analysis of variance of the percentages of damaged squares by bollworm indicated no significant differences occurred among the 3 volume rates applied during the 1970 season.

Yield of seed cotton was significantly higher in the 950-micron 8 gal. treatment than in all other treatments (Table XIII).

Analysis of the seed cotton yields showed no significant difference among the 418-, 706-, or 950-micron droplet sizes.

When the data were grouped in each of the 3 rates of total volume per acre the 8.0 gal. treatments had significantly more seed cotton than the 4.0 gal. treatments. 1.0 gal. per acre was not significantly different from 8.0 or 4.0 gal. total volume per acre.

Analysis of calculated lint per acre indicated no significant difference among any of the treatment in 1970. The fiber quality characteristics studied in this test; fineness measured with micronaire, fiber strength measured with stelometer (1/8 and 0 inches gauge) fiber span length

TABLE XIV

PERCENTAGE OF SQUARES DAMAGED BY BOLLWORMS AT RATES OF 1, 4, AND 8 GALLONS SPRAY PER ACRE 1970

Gallons/acre	August					Sept.		Means
	3	11	17	24	31	7	14	
1.0	4.7	2.4	1.5	6.7	7.1	5.7	5.2	4.7
4.0	2.4	1.4	1.3	5.5	5.2	9.2	5.2	4.3
8.0	1.7	0.6	1.2	6.7	6.9	6.3	4.2	4.0

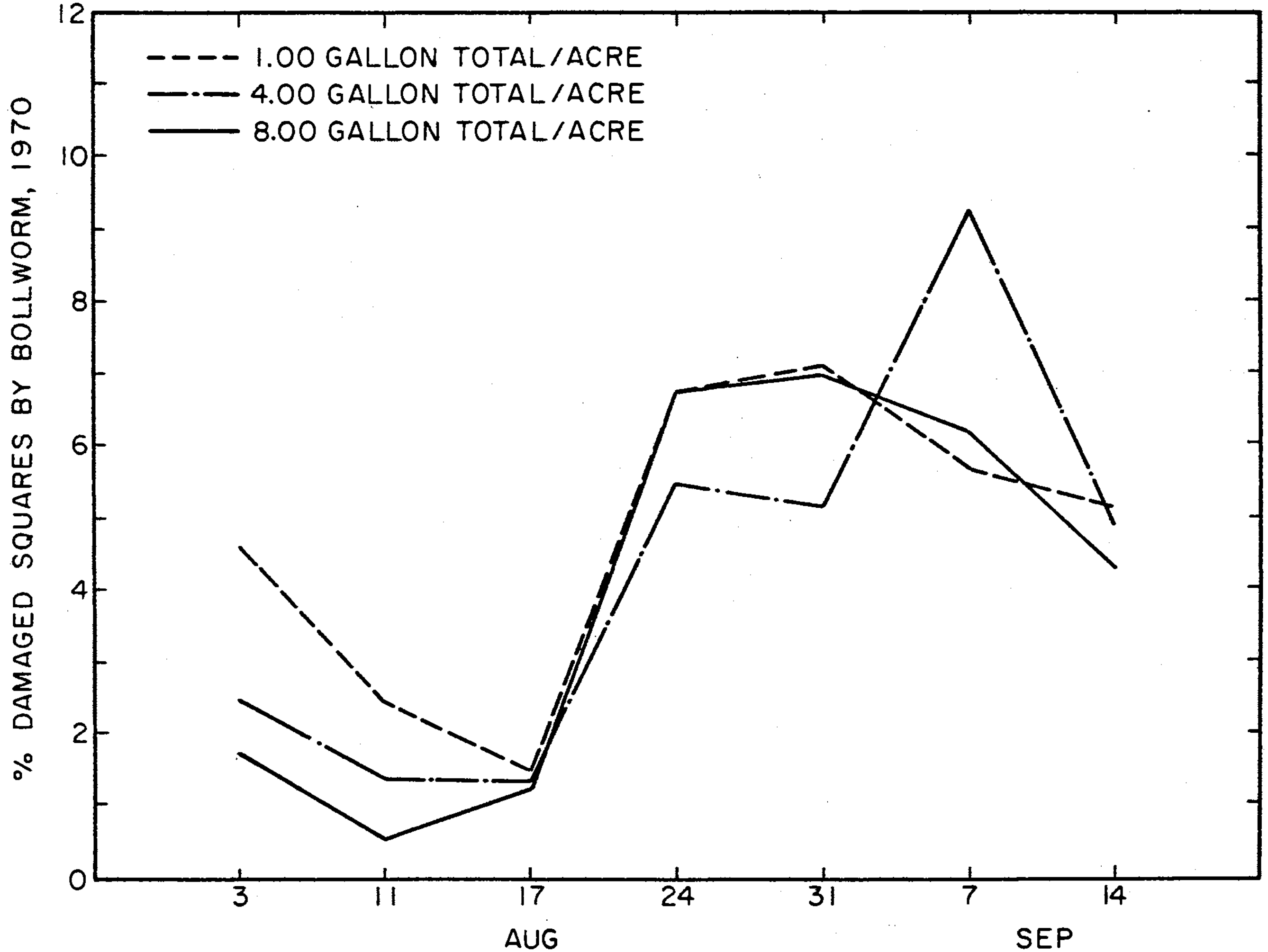


Figure 21. Percentage of squares damaged by bollworms in treatments 1970

measured with fibrograph and uniformity ratio of fiber length were not affected by the levels of bollworm infestations observed in the 9 treatments.

TABLE XV

POUNDS OF SEED COTTON PER ACRE IN TREATMENTS 1970

Droplet size micron	Gallons/ acre	Lb. of Seed Cotton		
		1st Harvest	2nd Harvest	Total
418	1.00	1406.8	243.0	1649.8*b**
	4.00	1274.1	253.2	1527.3 d
	8.00	1372.1	251.1	1623.3 bc
706	1.00	1237.4	253.2	1490.6 d
	4.00	1249.6	283.9	1533.4 d
	8.00	1372.1	249.1	1621.2 bc
950	1.00	1276.2	275.6	1551.8 cd
	4.00	1223.1	259.3	1482.4 d
	8.00	1504.9	251.1	1756.0 a

* Average of four replicates

** Numbers followed by the same letter are not significantly different (P=0.05)

CHAPTER V

SUMMARY AND CONCLUSIONS

Field experiments were conducted during 1969 and 1970 to determine the response of cotton bollworm Heliothis zea (Boddie) to various droplet sizes and volumes of spray per acre. The droplet sizes utilized in 1969 were 254, 396, and 556 average microns in diameter. Each of the droplet sizes was sprayed at 1, 2, or 3 gal. of spray per acre. To obtain better dispersion of the spray an electric charge was imposed on the droplets. Improvements of the sprayer used in 1969 were made in 1970 by providing it with magnetostrictive rod transducer nozzles, to obtain uniform droplets of 418, 706, and 950 average microns in diameter. The volumes of spray per acre used in 1970 were 1, 4, and 8 gal. A complete randomized block design with four replicates were used in both year studies.

Estimates of bollworm populations were made during both years by collecting 100 squares at random from each plot weekly throughout the fruiting seasons. Samples of 20 mature bolls were taken at random in each plot to determine the effect of bollworm damage on fiber quality. Yields sample were also taken to compare the effect of bollworm populations on cotton production.

All treatments during the 1969 season gave the same control of bollworm populations as indicated by the number of squares damaged by bollworm.

Yield data in 1969 showed no significant differences among spray volumes but the 254-micron droplets size treatment had yields significantly below the 556- and 396-micron droplet sizes.

Data obtained in 1970 for the percentages of squares damaged by bollworm indicated that 418-micron drops gave better control of bollworms than 706- or 950-micron. Volumes of 1, 4, or 8 gal./acre gave the same control of bollworm based upon percentages of damaged squares. Calculated yields per acre showed no differences in production of cotton sprayed with 418-, 706-, or 950-micron droplets. This was probably due to the low overall infestation of 4.36% damaged squares by bollworm during the 1970 season.

Studies of fiber quality characteristics indicated that fineness, fiber strength, uniformity ratio, and span length were not affected by bollworm infestations causing damage to squares from 3.00 to 19.82%.

The overall conclusion drawn from this study is that with the uniform droplet producing ground sprayer used, it is possible to obtain satisfactory bollworm control with droplets 418 microns in diameter and therefore keep drift hazards to a minimum.

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