THE CONTROL OF THE CORN EARWORM AND CORN LEAF APHID ON BAGGED SORGHUM HEADS

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By

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PREFACE

In February of 1950, Dr. Reynold G. Dahms suggested this problem to the writer. Mr. John B. Sieglinger, of the United States Department of Agriculture, offered the funds by which the research work could be carried out.

The writer wishes to express his appreciation to Dr. Dahms under whose direction this research was conducted. Dr. Dahms offered many helpful suggestions and criticisms in the writing of this thesis. Indebtedness is also acknowledged to Dr. Charles H. Brett for his constructive suggestions and excellent advice; to Mr. John B. Sieglinger, who gave valuable suggestions; and to the Department of Agronomy for the use of their sorghum field.

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INTRODUCTION

The expressed hope of the sorghum breeder, particularly of Mr. John B. Sieglinger, of the United States Department of Agriculture, has been that a method would be produced to control the corn earworm, Heliothis armigera (Hbn.) and the corn leaf aphid, Aphis maidis Fitch, attacking bagged sorghum heads. The objective of this thesis has been to find a satisfactory chemical control of these two species when found on bagged heads.

Plant crops are divided roughly into four groups, depending on their method of reproduction:

1. Naturally self-pollinated, 2. Naturally cross-pollinated, 3. Dioecious, 4. Often cross-pollinated.

Sorghum is an often cross-pollinated crop (usually 94-95 per cent selfed and 5-6 per cent crossed); therefore, in any sorghum breeding program it is necessary to bag all heads that are to be used for seed, in order to prevent cross-pollination and to insure pure seed stock. Cross-pollination is prevented by the use of paper sacks. The humidity and temperature are raised within the sacks which make ideal conditions for development of the corn earworm and the corn leaf aphid.

The corn earworm attacks sorghum in the soft dough stage and completely devours the whole grain. It is not uncommon for this pest to damage, and in many cases to

destroy completely the grain in the sorghum head as shown in figure 4. Quinby and Gaines (12)[1] demonstrated, at substation number 12, Chillicothe, Texas, that the corn earworm destroys approximately 75 per cent of the grain in bagged sorghum heads.

Upon hasty examination one may be led to believe that the corn leaf aphid causes little damage to sorghum heads. These tiny greenish or greenish-blue plant lice often attack the head during its soft dough stage, where they sap juices from the developing grain. In heavy infestations heads become a mass of stickiness, covered thoroughly with honeydew. Later fungi develop which give the sorghum heads an unsightly appearance.

Hayes (7) reported that in heavily infested heads the grain is badly shriveled and its germinative power is affected. He found from several thousand germination tests that the percentage of germination was very low in check plots. McColloch (11) reported in 1921 that

> The reddish discoloration on sorghum, due to bacterial infections, is usually associated with A. maidis, and often becomes serious enough to cause the rotting of the whole stalk. In 1920 the stalks from 7 to 10 per cent of the plants in a kafir field were heavily infested with A. maidis and bacterial blight. The infestation resulted in shrinking the head, causing a loss of about 33 per cent in weight and 50 per cent in volume.

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[1]Numbers in parantheses refer to Literature Cited, Page 43.

The corn leaf aphid may also cause some damage indirectly. A thick coverage of honey-dew probably prevents, to some extent, proper pollination of the head. The corn earworm moth (2) is apparently attracted to honey-dew (especially in the case of uncovered heads), and corn leaf aphids serve as food for predators which otherwise would consume corn earworm eggs.

Fungi are also a serious problem on bagged sorghum heads, but since this is a pathological problem it was studied only slightly in this experiment.

MATERIALS USED

1947-49 Tests

Tests conducted by Dr. Reynold G. Dahms[1] in 1947-49 indicated that several insecticides, formulated as an emulsion, were of considerable value for corn earworm and corn leaf aphid control. Since he obtained more favorable results with the emulsion forms than with suspensions and dusts, only the emulsion forms of insecticides were used in this experiment.

The 1949 tests indicated that a 2.0 per cent toxaphene emulsion was of some value for both corn earworm and corn leaf aphid control. A 1.0 per cent DDT emulsion gave 100 per cent control of the corn earworm but the corn leaf aphid population was greatly increased. Aldrin emulsion gave excellent control of both the corn leaf aphid and the corn earworm. Benzene hexachloride emulsion at a concentration of 0.025 per cent gamma isomer was not effective against either corn leaf aphids or corn earworms; at 0.1 per cent gamma it gave fair control of the corn leaf aphid and poor control of the corn earworm, but a 0.5 per cent gamma emulsion impregnated into sacks gave excellent control of the corn leaf aphid and fair control of the corn

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[1]Unpublished data from experiments made during the summer of 1947-49 by Dr. Reynold G. Dahms.

earworm. Sacks impregnated with 0.5 per cent parathion gave fair control of corn earworms but poor control of corn leaf aphids.

Since aldrin emulsion gave the best results in 1949, it was tested more intensively than the other insecticides in this experiment. Some insecticides used in the 1949 tests gave good results against the corn earworm, but only fair or poor results against the corn leaf aphid and vice versa. In this case the two insecticides were mixed to give control of both insects.

Lindane, a pure gamma form of benzene hexachloride, was used in this experiment. Insecticides tested in 1950, other than the ones tested in 1949, include: dieldrin, "Metacide," "dilan," heptachlor, "Systox," and "20/58." The fungicides tested were basic copper sulphate, sulfur, "Dithane Z78," and "Orthocide 406," all used as wettable powders.

Stock Materials, Concentrations, and Properties of Insecticides and Fungicides Used

1. Aldrin - A 24 per cent emulsifiable concentrate formulated by Julius Hyman and Company was used at a concentration of 0.5 per cent, 0.25 per cent, and 0.1 per cent. This insecticide was also mixed with the four fungicide treatments. Aldrin is a generic name for an insecticide formerly known as compound "118," which was

developed in the Research Laboratories of Julius Hyman and Company, Denver, Colorado. It has an empirical formula of $C_{10} H_5 Cl_7$ and contains not less than 95 per cent of the chemical: 1, 2, 3, 4, 10, 10-hexachloro - 1, 4, 4a, 5, 8, 8a - hexahydro - 1, 4,5,8- dimethanonaphthalene, and not more than 5 per cent of insecticidally active related chlorinated hydrocarbons. This compound appears to be slightly more volatile[2] than chlordane and exhibits a very marked vapor activity. It is stable in the presence of strong alkali and appears to be so in the presence of metallic chlorides. It also appears to be stable in sunlight and air.

2. DDT - A 25 per cent emulsion obtained from the Michigan Chemical Corporation was used at two different concentrations, a 1.0 per cent and a 0.5 per cent. Dichloro-diphenyl-trichloroethane or DDT (6) is a compound known as 2, 2- bis (p-chlorophenyl)-1, 1, 1-trichloroethane. It was first synthesized and described by Zedler in Germany in 1874. Re-synthesized and tested by Swiss workers in 1939, this insecticide rapidly became popular. The toxic ingredient in DDT is the para, para-isomer. The setting point is approximately 80° C and the melting point about

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[2]Emphasis is placed on the volatility of each insecticide, as this is probably the mode of kill within the sacks.

109° C. The residual action of DDT is excellent, but the permanence of residual deposits is affected by temperature and sunlight.

3. Lindane - A 25 per cent lindane emulsion obtained from the Ethyl Corporation was used at a 0.5 per cent and a 0.25 per cent concentration. This insecticide was also mixed with toxaphene and DDT at various concentrations. Lindane (C6 H6 Cl6) is the coined name for the gamma isomer of the chemical 1,2,3,4,5,6-hexachlorocyclohexane (benzene hexachloride), of a purity not less than 99 per cent. It is somewhat volatile which gives it a fumigating effect, but its residual action is less than DDT. The gamma isomer is considered to be the active toxicant in benzene hexachloride. Alpha, beta, delta, and epsilon are non-active and impart an objectionable flavor to some crops.

4. Toxaphene - Three different concentrations, a 2.0 per cent, a 1.5 per cent, and a 1.0 per cent were made from a 50 per cent toxaphene emulsion which was formulated by the California Spray Chemical Corporation. Toxaphene or chlorinated camphene (C_{10} H_{10} Cl_8) is a chlorinated plant product. The amount of chlorine present is the index to its purity. Toxaphene is one of the few American products. It was discovered by the Hercules Powder Company. This compound is not highly volatile, is insoluble in water, but is soluble when mixed with organic solvents.

5. Parathion - A 25 per cent emulsion obtained from the Planetary Chemical Company was used at a 1.0 per cent and a 0.5 per cent concentration. Parathion (C_{10} H_{14} O_5 NPS), an organic phosphate (o-O-diethyl - O-p nitrophenyl thiosphosphate) has approximately the same residual action as DDT, when the two insecticides are applied in equal amounts. This chemical, however, is generally used at a much lower concentration than is DDT. It is soluble up to 20 p.p.m. in water, soluble in organic solvents, and is not affected by basic or acidic materials. Its volatility probably gives it some fumigative effect but shortens the residual action.

6. Dieldrin - A 24 per cent emulsifiable concentrate was used at three different concentrations, a 0.5 per cent, a 0.25 per cent, and a 0.1 per cent. Dieldrin, formerly known as compound "497," is an oxygenated derivative of aldrin. This insecticide, as is the case with aldrin, was also developed by and obtained from Julius Hyman and Company. Its chemical name is 1,2,3,4,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonapthalene with an emperical formula of C_{12} H_8 O Cl_6. This compound exhibits excellent residual properties, comparable in this respect with DDT. Because of its remarkable residual effectiveness dieldrin has a very low vapor pressure.

7. "Metacide" - This material containing 30 per cent organic phosphates was obtained from the Geary Chemical

Corporation, and was used at a 1.0 per cent, a 0.5 per cent, and a 0.25 per cent concentration. A 0.5 per cent concentration of "Metacide" was also mixed with a 0.5 per cent concentration of DDT in one treatment. In another treatment a 0.5 per cent concentration was mixed with a 0.25 per cent concentration of toxaphene. "Metacide" or "Gearphos" is a dimethyl analog of parathion. Like parathion, this insecticide was discovered by Dr. Gerhard Schrader working in the I. G. Farben Research Laboratory at Elberfeld, Germany. The dimethyl ester is significantly less toxic than is parathion.

8. "Dilan" - A 25 per cent emulsion, manufactured by Commercial Solvents Corporation but obtained through Grisham's Seed Store, Oklahoma City, Oklahoma, was used at a 1.0 per cent and a 0.5 per cent concentration. "Dilan" is a Commercial Solvent's trade name for an insecticide containing active ingredients consisting of 2-Nitro -1, 1-bis (p-chlorophenyl) propane, one part and 2-Nitro -1, 1-bis (p-chlorophenyl) butane, two parts. These are nitroparaffin derivatives developed by research under the code numbers CS-645A (propane) and CS-674A (butane). "Dilan" is about one-half as toxic to warm-blooded animals as DDT.

9. Heptachlor (C_{10} H_5 Cl_7) - A 42 per cent emulsion, manufactured by the Velsicol Corporation was used at a 1.0 per cent and a 0.5 per cent concentration. This

chloronated hydrocarbon was discovered in the laboratories of the Velsicol Corporation. It is a white crystalline solid with a chemical name of 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene. Heptachlor has a very low vapor pressure at ordinary temperatures, and consequently its residual toxicity is quite good. It is resistant to the effect of heat, and does not break down at temperatures as high as 150 or 160° C. It is stable upon long exposure to light, moisture, and air. Its solutions are stable even under conditions of elevated temperatures and prolonged contact with strong acids, strong bases, and strong oxidizing agents.

10. "Systox" and "20/58" - Each of these two insecticides contained 33 per cent of organic phosphates and were obtained through the Geary Chemical Corporation. They were used at a 0.5 per cent concentration. Both are systemically active organic phosphates. Developed in the same laboratory as parathion and "Metacide," they have shown remarkable ability to penetrate plants by absorption, entering into seeds, roots or leaves. These two chemicals in preliminary tests have particularly shown remarkable results against aphids, mites, and other sucking insects.

11. A 1.0 per cent concentration of basic copper sulphate, sulfur, "Dithane Z78," and "Orthocide 406" were combined with a 0.5 per cent concentration of aldrin in

four different treatments. Basic copper sulphate - A 52 per cent wettable powder was manufactured by Phelps Dodge Refining Corporation. Sulfur - A 100 per cent wettable powder was obtained from Grisham's Seed Store, Oklahoma City, Oklahoma. "Dithane Z78" (Zinc ethylenebisdithiocarbamate) - A 65 per cent wettable powder was manufactured by Rohm & Haas. "Orthocide 406" (N-thrichlormethylthis tetrahydrophthalimide) - A 50 per cent wettable powder was manufactured by California Spray Chemical Corporation.

PROCEDURE

Good grade 50 weight liquor sacks sixteen inches long and seven inches in diameter were used for all tests.

It was desired to determine the residual activity of the insecticides in order to see how long the materials would remain effective in impregnated bags. Bags were treated at three different times, February 20, May 26, and July 22. In February and May the bags were impregnated, for the most part, with only the high concentration of each insecticide. Lindane and toxaphene, however, were used at two concentrations at this time. "Dilan," heptachlor, "Systox," and "20/58" were not available in February and May; consequently, bags were impregnated with these insecticides and with the 0.5 per cent aldrin plus four different fungicides only in July. In July each insecticide was used at two or more different concentrations with the exception of "Systox" and "20/58," which were used at a 0.5 per cent concentration. All insecticides used were formulated as emulsions. The four fungicides were used as wettable powders.

Thirty sacks were included in each treatment except in the July 0.5 per cent concentration of aldrin, the aldrin plus fungicide treatments, and the "Systox" and "20/58" treatments. Three hundred sacks were treated with a 0.5 per cent concentration of aldrin July 22. Fifteen

sacks were used for each of the aldrin plus fungicide treatments and 13 sacks for each "Systox" and "20/58" treatment. Two hundred-five untreated check sacks were used in the experiment.

There were 63 different treatments in the experiment. In each case the desired concentration of insecticide was mixed into one gallon of water with the exception of the July 0.5 per cent aldrin treatment and the "Systox" and "20/58" treatments. For the July 0.5 per cent aldrin treatment the desired concentration of aldrin was mixed with water to make a total volume of ten gallons. The systemic insecticides, "Systox" and "20/58," were tested by two different methods: 1. The material was mixed with water to make the desired concentration, and each sack was given five shots from a small hand spray gun. To determine the amount of liquid used per sack, equal shots of water were sprayed into a jar and measured. 2. Six shots of the proper concentration were sprayed on the head and vegetative portion of each sorghum plant. The amount of material used per plant was again determined by measuring equal shots of water.

Sacks to be treated were placed in the liquid (only one treatment at a time) and allowed to absorb the material for approximately ten minutes or until each sack was thoroughly soaked. The 300 July 0.5 per cent aldrin treated sacks, however, were placed in a large galvanized can and

ten gallons of material poured over them. These 300 sacks were allowed to absorb the material for 22 hours.

The amount of liquid and actual toxicant absorbed per sack was determined in each case (tables 1, 2, 3). The sacks were placed in a screened insectory to dry. All sacks were completely dry before being used.

The following twenty nine varieties and strains of sorghum were used in the experiment:

The Milo types: Martin, Redbine-60, (Club X Day) x338-4, Club X Day-16, Westland, Resistant-Wheatland, Midland, Plainsman, 51X-5, 51X338-1, 51X811-2, Caprock, Texas milo.

The Kafir types: Combine kafir-60, Sunrise kafir, Sharon kafir, Dwarf kafir 44-14, Redlan, Kaferita CI. 811.

The Darso types: Dwarf darso X Darso-7, Darso #1.

The Hegari types: Bonita, Hegari.

The Sorgo types: Honey Chinch Bug-resistant, Sumac, Atlas, African millet, Sugar Drip, Honey.

Sorghum heads were bagged just before the first anthers began to open.

The varieties were planted side by side and the experimental field was small. Generally one bag of each treatment was used for each variety. The 63 treatments were randomized for each variety by shuffling the various treated sacks to prevent the same treatment from occupying the same place

throughout the field. The July bags were not treated when varieties 51x-5, 51x338-1, and 51x811-2 were ready to bag, consequently, these varieties were bagged only with the February and May treated bags. All varieties except the above three were bagged with eleven July 0.5 per cent aldrin treated bags. Varieties Kaferita CI.811 and Darso #11 contained only a few plants, therefore, each of these two varieties were bagged with only eleven 0.5 per cent July treated aldrin bags. Three bags and two bags each of all July treatments with the exception of 0.5 per cent aldrin were put on Texas milo and Combine kafir-60, respectively. The check sacks were distributed over the 29 varieties.

Since each sorghum variety began to head at a different time there was a wide range in number of days from the time the sacks were treated to the time they were placed on sorghum heads. The February treated bags were put on from 150-175 days after being treated; the May treated bags from 56-71 days; and the July treated bags from 2-24 days.

In the test 2,237 bags were used. Each bag was placed over the sorghum head, the bottom of each sack wrapped around the stock and secured with a paper clip. Each sorghum head was carefully examined for corn earworm and corn leaf aphid damage 12-14 days after being bagged. When the grain matured (46-50 days after the heads were bagged), the heads were cut off and examined again for corn earworm and corn leaf aphid damage. At this time each head was

weighed and records made for fungi and sterility. Five different ratings or grades were made for each factor as indicated in (tables 1, 2, 3).

The rating or grade for the 12-14 day examination of the corn earworm was determined by the number of live corn earworms present. At the end of the test, the grade was determined for this insect by the amount of frass present and the amount of grain consumed. The grade for the corn leaf aphid was determined for each examination by the amount of honey-dew and corn leaf aphids present. At the end of the test, however, honey-dew was dry and only exuviae of corn leaf aphids were present.

In another test (table 4) 30 sorghum heads were bagged with untreated sacks, and an infestation of corn earworms was allowed to build up. The untreated bags were then removed and the corn earworms on each head counted. These heads were then bagged with sacks that had been impregnated three days previous with a 0.5 per cent concentration of aldrin. Care was taken to avoid loss of larvae during the exchange. The 0.5 per cent aldrin treated bags were removed at the end of 48 hours and the corn earworm count on each head was again made. The corn earworms were of all sizes ranging from approximately one-fourth to two inches in length.

A similar test was made with the corn leaf aphid, in which 12 heads were used instead of 30. Each head was

given a grade (table 5) before and after the exchange of untreated bags for 0.5 per cent aldrin bags.

RESULTS

Insecticides and Fungicides Tested

The concentration of each insecticide, number of heads, amount of liquid absorbed per sack, actual amount of toxicant absorbed per sack, and results of these tests are shown in (tables 1, 2, 3, 4, 5).

Results from the two examinations indicated the corn leaf aphid infestation increased as the season progressed. The two corn earworm examinations corresponded rather closely, although there were some differences.

There may have been some discrepancy in the determination of the corn earworm grade at the end of the test, as the grade was based on amount of frass present and amount of grain consumed. A few very slightly infested heads may have passed undetected; on the other hand, a few heads which should have been given a grade of zero may have been given a grade of one. The writer believes the grade assigned to the 12-14 day corn earworm examination is correct. Live corn earworms were present at this time and easily counted.

The terms "good, fair and poor" will appear throughout the remainder of this thesis and will have the following meaning:

Per Cent of Heads Infested

	Corn Earworm	Corn Leaf Aphid
Good	1- 6	1-25
Fair	7-15	26-50
Poor	16-	51-

The above terms were based primarily on the per cent of heads infested rather than the rating or grade. Each treatment was compared with the other treatments in making this determination.

Aldrin. All 0.5 per cent treatments gave 100 per cent control of the corn earworm. The February treatment and the average of the July 0.5 per cent concentration of aldrin and the 0.5 per cent aldrin plus fungicides treatments gave good control of the corn leaf aphid. The May 0.5 per cent treatment gave fair control of this pest. The results indicate that a 0.5 per cent is as low a concentration as should be used. The 0.25 per cent and 0.1 per cent treatments gave good control of the corn earworm but only fair and poor control of the corn leaf aphid, respectively. Bacon (3) applied a 0.25 per cent concentration of aldrin plus an emulsifier to the ears of sweet corn for corn earworm control and obtained 51.5 per cent clean ears as compared to 32.5 per cent clean ears for the check. The rate of application was 2.04 pounds of actual toxicant

per acre. This was considered unsatisfactory control.

DDT. A great amount of research has been done with DDT on the control of the corn earworm on corn. Anderson and Hashe (1) obtained approximately 88 per cent control with a 1.0 per cent concentration in mineral oil applied either by high-pressure aerosol or by injecting 0.5 - 0.6 cubic centimeters of insecticide to the silk channel of each ear. According to Hervey (8), the United States Department of Agriculture obtained 80-90 per cent control of the corn earworm in badly infested corn fields by using three quarts of 25 per cent emulsifiable DDT, two and one-half gallons of oil, with enough water to make 25 gallons; two or three sprayings (25 gallons of the above material per acre per application), should be made for good control.

All 1.0 per cent and 0.5 per cent DDT treatments gave 100 per cent control of the corn earworm but no control of the corn leaf aphid.

Lindane. All 0.5 per cent treatments with one exception, gave 100 per cent control of the corn earworm. The May treatment gave good control of this pest. Good control of the corn leaf aphid was obtained with all 0.5 per cent treatments. This high a concentration, however, consistently caused some sterility and in a few cases severe sterility. Lindane used at a 0.25 per cent concentration gave practically as good control as did the 0.5 per cent material and

caused less sterility. Bacon (3) used approximately 0.125 per cent concentration of lindane plus an emulsifier for corn earworm attacking corn and obtained 38.5 per cent clean ears over the checks; the insecticide was applied with a knapsack hand sprayer at 1.08 pounds of actual toxicant per acre.

Toxaphene. Sacks were impregnated with a 2.0 per cent concentration in February, May and July. The 1.5 per cent and 1.0 per cent concentrations were used only in July. All treatments gave poor control of the corn leaf aphid. The July 1.5 per cent and 1.0 per cent concentrations gave good corn earworm control. The February, May and July 2.0 per cent treatments gave fair control of this insect. Kulash (10) reported 69.2 per cent ears free of corn earworms as compared to 54.5 per cent clean ears of untreated checks by using approximately one or two pounds of actual toxaphene per acre. He applied a 0.25 per cent concentration of toxaphene emulsion as a solid stream for two or three seconds to the silk channel of the ear. Anderson and Hashe(1) obtained 74.5 per cent control above the untreated checks with a 1.0 per cent toxaphene concentration in mineral oil; 0.5 - 0.6 cubic centimeters of mineral oil insecticide was applied to the tips of each ear with a 1-pint force - oil can.

Parathion. Sacks impregnated with a 1.0 per cent parathion emulsion in July, gave 100 per cent control of

the corn earworm. The February 1.0 per cent and the July 0.5 per cent treatments gave good control. However, the 1.0 per cent May treatment gave only fair control of this pest. All treatments gave fair control of the corn leaf aphid. Kulash (9) found that a 0.25 per cent concentration of a parathion spray gave some control of the corn earworm on corn; each ear received about five cc of the spray material, which was applied to the tip of the corn husk, with each one of three applications.

Toxaphene plus Lindane. The February and July treatments of 2.0 per cent toxaphene plus 0.25 per cent lindane gave good control of the corn earworm, while the February, May and July treatments of 3.0 per cent toxaphene plus 0.25 per cent lindane and the July treatments of 2.0 per cent toxaphene plus 0.5 per cent lindane, 1.5 per cent toxaphene plus 0.5 per cent lindane, and 1.5 per cent toxaphene plus 0.25 per cent lindane gave 100 per cent control of the corn earworm. All toxaphene plus lindane treatments gave good control of corn leaf aphids.

DDT plus Lindane. The February, May, and July treatments of 1.0 per cent DDT plus 0.25 per cent lindane and the July treatments of 1.0 per cent DDT plus 0.5 per cent lindane, 0.5 per cent DDT plus 0.25 per cent lindane, and 0.5 per cent DDT plus 0.5 per cent lindane gave 100 per cent control of the corn earworm. All DDT plus lindane treatments gave good control of corn leaf aphids.

Dieldrin. All treatments except one gave 100 per cent control of the corn earworm. The 1.0 per cent July treatment had 5.6 per cent of heads infested with corn earworms. The February, May and July 0.5 per cent treatments and the 0.25 per cent treatment gave fair control of the corn leaf aphid. The 0.1 per cent treatment gave poor control of this insect. Bacon (3) used a 0.125 per cent concentration of dieldrin emulsion plus an emulsifier on sweet corn for corn earworm control and obtained 32 per cent clean ears above the untreated checks. The rate of application was 1.07 pounds of actual toxicant per acre.

"Metacide." The February 1.0 per cent treatment gave good control and the July 0.5 per cent treatment gave 100 per cent control of the corn earworm. The July 1.0 per cent and 0.25 per cent concentrations gave fair control while the 1.0 per cent May treatment gave poor control of this insect. The February 1.0 per cent concentration gave poor results against the corn leaf aphid. The 1.0 per cent May treatment and the July 1.0 per cent and 0.25 per cent treatments, however, gave fair control.

"Metacide" plus DDT and "Metacide" plus Toxaphene. Both treatments were used only in July. The 0.5 per cent "Metacide" plus 0.5 per cent DDT gave 100 per cent control of the corn earworm but only fair control of the corn leaf aphid. The 0.5 per cent "Metacide" plus 1.5 per cent toxaphene treatment gave good results against both of these insect pests.

"Dilan." This insecticide, used at a 1.0 per cent and a 0.5 per cent concentration, gave poor control of the corn earworm and no control of the corn leaf aphid.

Heptachlor. Both the 1.0 per cent and 0.5 per cent treatments gave 100 per cent control of the corn earworm and good control of the corn leaf aphid.

"Systox" and "20/58." "Systox," at a 0.5 per cent concentration, gave no control of the corn earworm, but 100 per cent control of the corn leaf aphid by both methods used. No corn earworm control was obtained with "20/58." One method, where 0.5 per cent "20/58" was sprayed into the sack, gave good control of the corn leaf aphid. The other method, however, where "20/58" was sprayed on heads and vegetative portion of sorghum plants gave only fair corn leaf aphid control.

Basic Copper Sulphate, Sulfur, "Dithane Z78," and "Orthocide 406." A 1.0 per cent concentration of each fungicide was combined in four different treatments with a 0.5 per cent concentration of Aldrin. All these treatments and all other insecticide treatments gave no control of the fungi. Practically all treatments had 100 per cent of the heads infected. Nineteen of the 63 treatments, however, showed 86.7 per cent to 98.6 per cent of heads infected with fungi.

Effect of Insecticides on the Germination of Sorghum Grain.

This test was conducted to determine if sacks impregnated with the insecticides had any effect on germination of sorghum grain. In the first test the sorghum variety Texas milo was used. Seed from the high concentration of each treatment planted in sand germinated as good or better than seed from the check except in one case. Seeds from the 0.5 per cent dieldrin treatment had a very low germination count. However, in another test conducted with seed from a 0.5 per cent dieldrin treatment the germination count was equally as high as the checks. Varieties Redlan, Westland, and Plainsman were used for the later test.

Sterility

All twenty two February and May treatments except one had a higher rating of sterility than the untreated check. However, approximately one-half had fewer per cent of heads showing some sterility. The above results may be explained by the fact that variety 51x811-2 was extremely male sterile, and varieties 51x-5 and 51x338-1 showed some male sterility.

Lindane was used alone or in combination with other insecticides in 11 of the July treatments. In all cases the 0.5 per cent concentration caused marked sterility over the untreated checks and in a few cases severe sterility. In

all cases except two the 0.25 per cent concentration of lindane caused marked sterility. None of the other insecticides when impregnated into sacks caused an increase in sterility over the checks.

Sixty out of 63 treatments produced more grain than the untreated checks. Three of the 0.5 per cent lindane treatments which showed severe sterility yielded less grain.

Effect of Aldrin on Small and Large Corn Earworms and on Corn Leaf Aphids

In the test where the corn earworm infestation had increased under untreated sacks (table 4) and these sacks then exchanged for 0.5 per cent aldrin treated sacks, all small corn earworms were killed within 48 hours. The large corn earworms were not killed. However, a few large ones were sluggish. Eighty two per cent of the corn earworm infestation was killed by this treatment. The above method also decreased the corn leaf aphid infestation by 62.5 per cent.

TABLE 1

The effectiveness of insecticides, impregnated in sacks 2-24 days prior to use, against insects attacking bagged sorghum heads. Agronomy Farm. Stillwater, Oklahoma. 1950.

July Treatment	Concentration	No. heads	Liquid per sack	Actual toxicant per sack	Corn Leaf Aphid: Per cent Heads infested 12-14 days after bagged	Corn Leaf Aphid: Per cent Heads infested 46-50 days after bagged	Corn Leaf Aphid: Infestation Rating 12-14 days after bagged	Corn Leaf Aphid: Infestation Rating 46-50 days after bagged	Corn Earworm: Per cent Heads infested 12-14 days after bagged	Corn Earworm: Per cent Heads infested 46-50 days after bagged	Corn Earworm: Infestation Rating 12-14 days after bagged	Corn Earworm: Infestation Rating 46-50 days after bagged	Sterility: Per cent heads showing some 46-50 days after bagged	Sterility: Rating 46-50 days after bagged	Weight oz. 46-50 days after bagged
	%		cc	mg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg
Check	none	205	none	none	39.5	88.9	1.12*	3.31	94.5	88.3	3.63	2.6	30.3	.38	2.4
Aldrin	0.5	281	35.6	178.0	2.2	26.7	.04	.37	0	0	0	0	11.7	.14	3.3
Aldrin	0.25	28	29.4	73.5	7.4	46.4	.07	1.20	0	3.6	0	.04	7.1	.07	3.0
Aldrin	0.1	29	28.7	28.7	3.4	75.9	.07	1.41	3.4	0	.03	0	10.3	.10	2.9
Aldrin + Basic Copper Sulphate	0.5 / 1.0	15	25.4	127.0 / 254.0	7.1	20.0	.07	.4	0	0	0	0	26.7	.33	2.9
Aldrin + Sulfur	0.5 / 1.0	15	21	105.0 / 210.0	0	13.3	0	.3	0	0	0	0	13.3	.13	3.3
Aldrin + Dithane Z78	0.5 / 1.0	15	21	105.0 / 210.0	0	26.7	0	.26	0	0	0	0	6.7	.07	3.0
Aldrin + Orthocide 406	0.5 / 1.0	15	21.8	109.0 / 218.0	0	13.3	0	.13	0	0	0	0	0	0	3.3
Average of the five treatments containing 0.5% aldrin					1.9	20.0	.02	.29	0	0	0	0	11.7	.13	3.2
D D T	1.0	27	28.0	280.0	73.0	100.0	1.69	3.45	0	0	0	0	3.7	.03	3.0
D D T	0.5	28	28.4	142.0	48.1	82.1	1.93	2.74	0	0	0	0	7.1	.07	2.9
Lindane	0.5	29	29.5	147.5	0	10.0	0	.45	0	0	0	0	51.7	.79	2.7
Lindane	0.25	30	27.5	68.7	0	14.8	0	.15	0	0	0	0	46.7	.68	2.8
Toxaphene	2.0	28	32.2	644.0	39.9	60.7	.96	1.11	10.7	10.7	.14	.11	10.7	.11	3.0
Toxaphene	1.5	28	28.8	432.0	42.9	53.6	1.00	1.42	3.6	3.6	.04	.07	17.8	.18	2.7
Toxaphene	1.0	27	29.0	290.0	55.6	70.4	1.40	1.63	3.7	3.7	.07	.04	7.4	.07	2.6
Parathion	1.0	26	31.7	317.0	4.0	34.6	.08	.50	0	0	0	0	19.2	.19	3.2
Parathion	0.5	27	29.1	145.0	7.4	33.3	.11	.50	0	3.7	0	.04	11.1	.11	3.8
Toxaphene + Lindane	2.0 / 0.25	30	33.5	670.0 / 83.7	0	16.7	0	.17	0	3.3	0	.03	40.0	.67	2.8
Toxaphene + Lindane	2.0 / 0.5	30	35.2	704.0 / 176.0	0	10.0	0	.10	0	0	0	0	86.7	2.33	2.0
Toxaphene + Lindane	1.5 / 0.5	29	33.7	505.5 / 168.5	0	20.7	0	.24	0	0	0	0	89.6	2.27	2.0
Toxaphene + Lindane	1.5 / 0.25	27	29.5	442.5 / 63.7	0	3.7	0	.11	0	0	0	0	50.0	.96	2.6

TABLE 1 (Continued)

July Treatment	Concentration	No. heads	Liquid per sack	Actual toxicant per sack	Corn Leaf Aphid: Per cent Heads infested 12-14 days after bagged	Corn Leaf Aphid: Per cent Heads infested 46-50 days after bagged	Corn Leaf Aphid: Infestation rating 12-14 days after bagged	Corn Leaf Aphid: Infestation rating 46-50 days after bagged	Corn Earworm: Per cent Heads infested 12-14 days after bagged	Corn Earworm: Per cent Heads infested 46-50 days after bagged	Corn Earworm: Infestation rating 12-14 days after bagged	Corn Earworm: Infestation rating 46-50 days after bagged	Sterility: Per cent heads showing some 46-50 days after bagged	Sterility: Rating 46-50 days after bagged	Weight oz. 46-50 days after bagged
	%		cc	mg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg
Toxaphene ≠ Lindane	3.0 0.25	28	33.1	993.0 827.0	0	17.8	0	.18	0	0	0	0	32.1	.39	2.6
D D T ≠ Lindane	1.0 0.25	29	29.0	290.0 62.5	0	6.8	0	.68	0	0	0	0	17.2	.14	3.0
D D T ≠ Lindane	1.0 0.5	29	31.5	315.0 157.5	3.6	3.4	.07	.07	0	0	0	0	41.4	.65	2.3
D D T ≠ Lindane	0.5 0.25	30	29.2	146.0 73.0	3.8	20.0	.08	.33	0	0	0	0	13.3	.17	2.9
D D T ≠ Lindane	0.5 0.5	29	29.5	147.5 147.5	3.7	17.2	.07	.17	0	0	0	0	37.0	.65	2.8
Dieldrin	0.5	28	28.8	144.0	10.7	28.5	.19	.39	0	5.6	0	.04	7.1	.19	2.8
Dieldrin	0.25	27	27.1	67.7	16.0	48.1	.36	.81	0	0	0	0	3.7	.03	2.9
Dieldrin	0.1	27	25.0	25.0	38.5	70.4	.96	1.44	0	0	0	0	3.7	.04	2.9
Metacide	1.0	29	34.5	345.0	26.7	41.4	.47	.86	0	13.8	0	.24	27.6	.27	2.8
Metacide	0.5	28	33.0	165.0	21.7	39.2	.52	1.14	0	0	0	0	32.1	.46	2.8
Metacide	0.25	30	32.4	81.0	24.1	50.0	.55	1.20	0	10.0	0	.20	16.7	.30	2.7
Metacide ≠ D D T	0.5 0.5	29	34.4	172.0 172.0	22.2	44.8	.48	1.28	0	0	0	0	17.2	.17	2.8
Metacide ≠ Toxaphene	0.5 1.5	29	35.6	178.0 534.0	11.5	24.1	.23	.45	0	3.4	0	.03	6.9	.07	2.6
Dilan	1.0	29	31.6	316.0	82.3	89.3	2.10	4.10	17.2	10.7	.38	.18	10.7	.10	2.8
Dilan	0.5	30	31.1	155.5	64.3	96.7	2.11	3.77	17.8	23.3	.54	.33	3.3	.67	3.2
Heptachlor	1.0	26	30.1	301.0	0	11.6	0	.11	0	0	0	0	11.6	.11	2.9
Heptachlor	0.5	22	30.4	152.5	0	4.6	0	.04	0	0	0	0	4.5	.04	3.0
Systox (in sack)	0.5	13	18.	90.0	0	0	0	0	100.0	100.0	3.32	2.61	23.1	.11	2.6
Systox (on plant)	0.5	13	21	105.0	0	0	0	0	100.0	100.0	2.61	2.23	23.1	.23	3.0
20/58 (in sack)	0.5	12	18	90.0	0	8.3	0	.17	100.0	100.0	3.00	2.5	25.0	.33	2.6
20/58 (on plant)	0.5	13	21	105.0	0	38.5	0	.54	92.3	92.3	1.85	2.00	23.1	.38	3.0

* Rating system used: 0 - none, 1 - very slight, 2 - slight, 3 - moderate, 4 - heavy, 5 - very heavy.

TABLE 2

The effectiveness of insecticides, impregnated in sacks 56-71 days prior to use, against insects attacking bagged sorghum heads. Agronomy Farm. Stillwater, Oklahoma. 1950

May Treatments	Concentration	No. heads	Liquid per sack	Actual toxicants per sack	Corn Leaf Aphid: Per cent Heads infested 12-14 days after bagged	Corn Leaf Aphid: Per cent Heads infested 46-50 days after bagged	Corn Leaf Aphid: Infestation Rating 12-14 days after bagged	Corn Leaf Aphid: Infestation Rating 46-50 days after bagged	Corn Earworm: Per cent Heads infested 12-14 days after bagged	Corn Earworm: Per cent Heads infested 46-50 days after bagged	Corn Earworm: Infestation Rating 12-14 days after bagged	Corn Earworm: Infestation Rating 46-50 days after bagged	Sterility: Percent heads showing some 46-50 days after bagged	Sterility: Rating 46-50 days after bagged	Weight oz. 46-50 days after bagged
	%		cc	mg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg
Check	none	205	none	none	39.5	88.9	1.12*	3.31	94.5	88.3	3.83	2.6	30.3	.38	2.4
Aldrin	0.5	30	25.7	128.5	0	33.3	0	.40	0	0	0	0	26.7	.70	2.9
D D T	1.0	29	27.2	272.0	50.0	79.3	1.58	2.41	0	0	0	0	24.1	.65	3.0
Lindane	0.5	29	25.0	125.0	0	13.8	0	.14	0	3.4	0	.17	51.7	1.24	3.0
Toxaphene	2.0	29	29.6	592.0	46.4	72.4	1.31	2.20	10.7	10.3	.11	.21	24.1	.76	2.8
Parathion	1.0	29	32.6	326.0	15.4	27.6	.20	.28	0	10.3	0	.10	41.4	.79	3.2
Toxaphene +	2.0			372.0											
Lindane	0.25	26	28.6	71.5	0	23.1	0	.21	0	3.8	0	.08	50.0	1.04	2.8
Toxaphene +	3.0			986.0											
Lindane	0.25	29	32.2	80.5	0	17.2	0	.37	0	0	0	0	27.6	.59	2.9
D D T +	1.0			273.0											
Lindane	0.25	29	27.3	68.2	0	24.1	0	.24	0	0	0	0	27.6	.72	2.8
Dieldrin	0.5	27	26.4	132.0	15.4	50.0	.31	.88	0	0	0	0	33.3	.74	2.8
Metacide	1.0	29	31.8	318.0	15.4	41.3	.35	1.03	0	17.2	0	.21	27.6	.79	2.8

* Rating system used: 0 - none, 1 - very slight, 2 - slight, 3 - moderate, 4 - heavy, 5 - very heavy.

TABLE 3

The effectiveness of insecticides, impregnated in sacks 150-175 days prior to use, against insects attacking bagged sorghum heads. Agronomy Farm. Stillwater, Oklahoma. 1950.

February Treatment	Concentration	No. heads	Liquid per sack	Actual toxicant per sack	Corn Leaf Aphid: Per cent Heads infested 12-14 days after bagged	Corn Leaf Aphid: Per cent Heads infested 46-50 days after bagged	Corn Leaf Aphid: Infestation Rating 12-14 days after bagged	Corn Leaf Aphid: Infestation Rating 46-50 days after bagged	Corn Earworm: Per cent Heads infested 12-14 days after bagged	Corn Earworm: Per cent Heads infested 46-50 days after bagged	Corn Earworm: Infestation Rating 12-14 days after bagged	Corn Earworm: Infestation Rating 46-50 days after bagged	Sterility: Per cent heads showing some 46-50 days after bagged	Sterility: Rating 46-50 days after bagged	Weight oz. 46-50 days after bagged
	%		cc	mg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg
Check	none	205	none	none	39.5	88.9	1.12*	3.31	94.5	88.3	3.83	2.6	30.3	.38	2.4
Aldrin	0.5	30	27.9	139.5	3.6	16.5	.04	.20	0	0	0	0	29.7	.50	2.9
D D T	1.0	27	22.2	222.0	61.5	81.4	2.0	.31	0	0	0	0	22.2	.67	3.0
Lindane	0.5	28	27.4	137.0	0	10.7	0	.14	0	0	0	0	75.0	1.73	2.5
Lindane	0.25	30	19.4	48.5	3.4	13.3	.10	.13	3.4	3.3	.03	.07	20.1	.23	3.2
Toxaphene	2.0	27	29.7	594.0	34.6	27.7	.85	.66	3.8	7.4	.04	.07	29.6	.63	2.8
Parathion	1.0	29	26.2	262.0	3.5	31.0	.07	.38	0	3.4	0	.07	20.6	.36	2.6
Toxaphene +	2.0			508.0											
Lindane	0.25	30	25.4	63.5	0	10.0	0	.11	3.4	10.0	.03	.10	40.2	.46	3.0
Toxaphene +	3.0			954.0											
Lindane	0.25	27	31.8	79.5	0	15.4	0	.15	0	0	0	0	42.2	.73	2.6
D D T +	1.0			273.0											
Lindane	0.25	28	27.3	68.2	0	0	0	0	0	0	0	0	17.9	.40	3.1
Dieldrin	0.5	29	27.2	136.0	10.3	41.3	.21	.34	0	0	0	0	24.1	.62	2.5
Metacide	1.0	27	32.5	325.0	30.8	62.9	.23	1.85	0	3.7	0	.04	40.7	.79	2.9

* Rating system used: 0 - none, 1 - very slight, 2 - slight, 3 - moderate, 4 - heavy, 5 - very heavy.

TABLE 4

The effectiveness of a 0.5 per cent concentration of Aldrin, impregnated in sacks, against large and small corn earworms attacking bagged sorghum heads. Perkins Farm. Perkins, Oklahoma, 1950.

Head Number	Number of corn earworms present before exchange of untreated bags for treated bags	Number of corn earworms present 48 hrs. after exchange of untreated bags for treated bags
1	4	0
2	4	0
3	2	0
4	3	1
5	2	0
6	4	1
7	5	1
8	3	1
9	1	0
10	2	1
11	6	1
12	1	1
13	2	0
14	1	0
15	1	0
16	2	0
17	3	1
18	2	0
19	2	1
20	3	0
21	2	0
22	2	0
23	3	1
24	2	0
25	4	0
26	1	1
27	6	1
28	5	1
29	3	2
30	2	0

TABLE 5

The effectiveness of a 0.5 per cent concentration of Aldrin, impregnated in sacks, against an infestation of corn leaf aphids on bagged sorghum heads. Perkins Farm. Perkins, Oklahoma, 1950.

Head Number	Rating of corn leaf aphid infestation before exchange of untreated bags for treated bags.	Rating of corn leaf aphid infestation 48 hrs. after exchange of untreated bags for treated bags.
1	3 *	1
2	4	2
3	3	1
4	3	1
5	3	1
6	4	1
7	3	1
8	3	1
9	3	1
10	3	1

* Rating system used for determining corn leaf aphid infestation:

0 - none, 1 - very slight, 2 - slight, 3 - moderate, 4 - heavy, 5 - very heavy.

Figure 1

Sorghum plants with bagged heads.

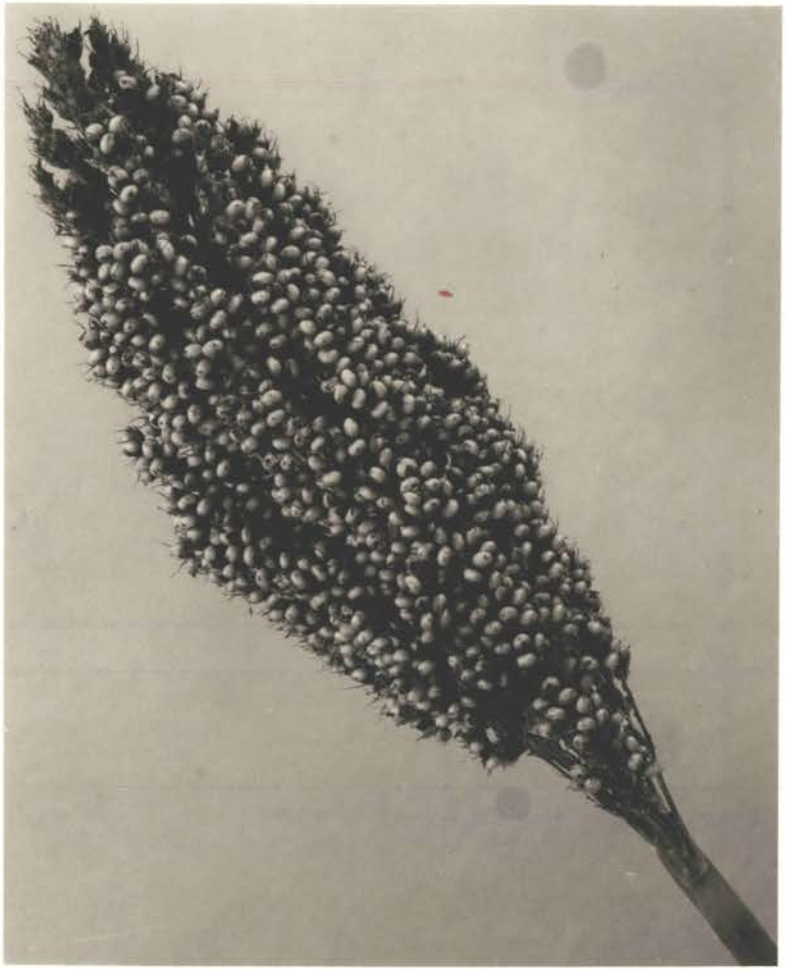
Figure 2

Figure 3

Texas milo: Head in Figure 2 was bagged with an untreated sack. Head in Figure 3 was bagged at the same time with a sack which had been impregnated with a 0.5 per cent concentration of aldrin.

Figure 4

Figure 5



Redbine-60 milo; Head in Figure 4 was bagged with an untreated sack. Head in Figure 5 was bagged at the same time with a sack which had been impregnated with a 1.0 per cent concentration of DDT plus a 0.25 per cent concentration of lindane.

DISCUSSION

A review of the literature up to the present time revealed that nothing has been published concerning the control of the corn earworm and the corn leaf aphid on bagged sorghum heads. However, intensive work has been done on control of the corn earworm on corn and the cottom bollworm[1] under natural field conditions. No recent work has been done on control of the corn leaf aphid.

From close observation the writer has concluded that eggs of the corn earworm moth must be present on florets of sorghum heads when the heads are bagged. The bags were clipped on heads fairly tight, but it would not be impossible for the corn earworm moth to gain entrance to bagged heads by crawling between the bag and sorghum stock. However, with unbagged heads[2] in the area it would seem logical for a large percentage of corn earworm moths to deposit eggs to these exposed florets rather than the concealed ones.

The insecticides probably kill the corn earworm soon after it emerges from the egg, as it is very tiny at this time and least resistant to adverse conditions.

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[1]Corn earworm and cotton bollworm are synonymous names for the same insect.

[2]Sorghum breeders do not bag all heads in a sorghum field.

Some corn leaf aphids may be present when heads are bagged, but these small ovoviviparously[3] reproduced insects tend to become more numerous as the growing season advances.

Fumigation is probably the mode of kill within the sacks, although tests need to be conducted to prove or disprove this theory.

The control of these pests on bagged sorghum heads is very valuable to the sorghum breeder. The Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma, and the Southern Great Plains Experiment Station, Woodward, Oklahoma, use approximately 30,000 bags annually for sorghum breeding purposes. Texas uses approximately one-half million bags per year. With good control the sorghum breeder could bag less than one-half as many heads and obtain as much or more seed, thus saving much time and labor.

Preliminary tests made by Dr. Reynold G. Dahms in 1947-48, indicated that fair control could be obtained by spraying and dusting the heads with certain insecticides just before the heads are bagged. However, since one sorghum breeder may bag as many as 30,000 heads in one season, the labor and time involved in treating each head would be almost prohibitive. The most practical method

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[3]Type of reproduction associated with aphids. The young are born alive because of the hatching of the eggs in the body of the female.

would be to treat the sacks during the "off season" or even at the factory where the sacks are made. The sacks are sold in lots of 25,000 and cost approximately one-half cent per sack. Most sorghum breeders would probably be willing to pay from two to four cents for treated sacks.

Although no work has been done on this particular phase of research, Dr. Richard T. Cotton and co-workers have done some interesting work on insect-proofing paper and cotton bags. Cotton, Balzer, and Young (4) reported that soft towel paper and kraft paper impregnated with a 10 per cent solution of DDT in acetane gave excellent results against the cadelle, Tenebroides mauritanicus (L); the lesser grain borer, Rhyzopertha dominica (F); and certain other insects. Cotton and Frankenfeld (5) found that pyrethrins used alone or in combination with piperonyl butoxide gave satisfactory protection against the confused flour beetle, Tribolium confusum Duv.; the cadelle, Tenebroides mauritanicus (L); and the Mediterranean flour moth, Ephestia kuehniella Zell for a period of seven months.

SUMMARY

In any sorghum breeding program, it is necessary to bag all heads that are to be used for seed in order to prevent cross-pollination. Conditions within these bags are ideal for insect and fungi development. The corn earworm, Heliothis armigera (Hbn.) and the corn leaf aphid, Aphis maidis Fitch, often become serious problems. Heads are often completely destroyed by the corn earworm, and honeydew which is secreted by corn leaf aphids make heads unsightly in appearance.

Tests conducted by Dr. Reynold G. Dahms in 1949 indicated that control could be obtained by treating sacks with certain insecticides formulated as emulsions.

All insecticides used in this experiment were formulated as emulsions. The four fungicides were used as wettable powders. Sacks were impregnated with 7 of the 11 insecticides in February, May and July. The other four insecticides were impregnated in sacks in July only. The February and May sacks were treated with only the high concentration of each insecticide except lindane and toxaphene which were used at two concentrations each. All insecticides in the July treatments were used at two or more different concentrations except "Systox," "20/58," and the aldrin plus fungicide treatments. In each case sacks to be treated were placed in the liquid and allowed to absorb the material

until each sack was thoroughly soaked. The amount of liquid and actual toxicant absorbed per sack was determined. The February treated bags were placed on sorghum heads 150-175 days after being treated; the May treated bags from 56-71 days; and the July bags from 2-24 days.

One examination of corn earworms and corn leaf aphids was made 12-14 days after the heads were bagged. When the grain matured, 46-50 days after the heads were bagged, another examination was made of the corn earworm, corn leaf aphid, fungi, sterility, and each head was weighed.

Best control of the corn earworm and corn leaf aphid was obtained from a 0.5 per cent aldrin treatment, a 0.25 per cent lindane treatment, and either a 1.0 per cent or 0.5 per cent heptachlor treatment, each of the four treatments giving excellent control of the corn earworm and good control of the corn leaf aphid. The toxaphene plus lindane and DDT plus lindane treatments except one gave equally as good control of both insects as the above four treatments. Sacks impregnated with a 0.5 per cent lindane gave slightly better control of both insects than did the 0.25 per cent concentration, but it caused severe sterility in a few cases. The 0.25 per cent lindane treatment caused some sterility. Both the 1.0 per cent and 0.5 per cent concentration of DDT gave excellent results against the corn earworm but no control of the corn leaf aphid. Dieldrin,

at a concentration as low as 0.1 per cent, gave excellent control of the corn earworm; all treatments gave fair to poor control of the corn leaf aphid. The 1.5 per cent and 1.0 per cent toxaphene treatments gave good control of the corn earworm, but all treatments gave poor control of the corn leaf aphid. The July 1.0 per cent parathion treatment gave excellent control of the corn earworm but only fair control of corn leaf aphids. The 1.0 per cent, 0.5 per cent, and 0.25 per cent concentrations of "Metacide" gave less favorable results against both insect pests than did the majority of the insecticides, however, the 0.5 per cent concentration plus 0.5 per cent concentration of DDT gave 100 per cent control of corn earworms and fair control of the corn leaf aphid, while the 0.5 per cent concentration of "Metacide" plus 1.5 per cent toxaphene gave good control of both insects. The 1.0 per cent and 0.5 per cent concentrations of "dilan" was not effective against either insect. The 0.5 per cent concentration of "Systox" gave the best control of the corn leaf aphid but no control of the corn earworm. The 0.5 per cent concentration of "20/58" gave no control of the corn earworm but good control of the corn leaf aphid in the treatment where the material was sprayed into the sack. However, only fair control of the corn leaf aphid and no control of the corn earworm was obtained where a 0.5 per cent

concentration of "20/58" was sprayed on heads and vegetative portion of sorghum plants.

None of the insecticides tested except the February 1.0 per cent DDT plus 0.25 per cent lindane and the "Systox" treatments gave 100 per cent control of the corn leaf aphid. The other five DDT plus lindane treatments gave less than 100 per cent control of the corn leaf aphid. Several of the treatments gave 100 per cent control of corn earworms. None of the fungicides, basic copper sulphate, sulfur, "Dithane Z78," and "Orthocide 406," or insecticides were effective against fungi.

The results of these tests indicate that the majority of the insecticides used will remain effective in impregnated sacks for at least 150-175 days prior to use.

None of the insecticide or fungicide treatments were harmful to the germinative power of the sorghum grain.

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THESIS TITLE: THE CONTROL OF THE CORN EARWORM AND CORN LEAF APHID ON BAGGED SORGHUM HEADS

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