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THE EFFECT OF
BENZENE-HEXACHLORIDE
ON CROPS GROWN ON
VARIOUS SOIL TYPES

Thesis for the Degree of M. S.

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The Effect of Benzene-Hexachloride
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THE EFFECT OF BENZENE-HEXACHLORIDE ON CROPS
GROWN ON VARIOUS SOIL TYPES

by
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TABLE OF CONTENTS

PART ONE

	Page
EFFECT OF BENZENE-HEXACHLORIDE ON VARIOUS CROPS	
INTRODUCTION	1
NOMENCLATURE	1
REVIEW OF LITERATURE	1
EXPERIMENTAL WORK	3
RESULTS AND DISCUSSION	5
A. SWEET CORN	5
B. WAX BEANS	13
C. CUCUMBERS	18
D. RADISHES	23
STIMULATION	29
CONCLUSIONS AND SUMMARY	30

PART TWO

RESIDUAL EFFECT OF BENZENE-HEXACHLORIDE IN THE SOIL

RESULTS AND DISCUSSION	34
A. OATS	34
B. BARLEY	40
C. RYE	44
D. WHEAT	50
SUMMARY AND CONCLUSIONS	52
REFERENCES CITED	55

PART 1

**EFFECT OF BENZENE-HEXACHLORIDE
ON VARIOUS CROPS**

INTRODUCTION

Investigations have shown that benzene-hexachloride is a promising insecticide for control of wireworms, the larve of Japanese beetles and other insects living in the soil. However, it is not too well established what effect this insecticide may have on seed germination and growth of various vegetable and grain crops. It was the purpose of this study to determine what effect different rates of application of benzene-hexachloride has on various crops when grown on soils of different texture and pH.

NOMENCLATURE

The product referred to as benzene-hexachloride is technically 1,2,3,4,5,6- hexachlorocyclohexane composed of the alpha, beta, gamma and delta isomers. It has the empirical formula of $C_6H_6Cl_6$. For this reason it is often referred to and sold as "666". In addition to the above trade name, this compound is known as: "BHC", "HCCH", "Gammexane", "Gamtex" and others. However, it is more commonly known as benzene-hexachloride and it will be referred to as such throughout this report.

REVIEW OF LITERATURE

Benzene-hexachloride was first prepared by Michael Faraday in 1825 but it was not until 1912 that van der Linden established the fact that the product was a mixture of at least four isomers, the alpha, beta, gamma and delta iso-

mers (14). Its insecticidal properties were discovered in France in 1941 and independently by the British in 1942 (7,3). Late in 1942, pure specimens of the alpha and beta isomers were prepared and their toxicity to insects was investigated by Thomas of England (6,14). He found that both these isomers were relatively harmless to weevils. In 1943, the gamma isomer was isolated and it was then established that this specific isomer caused the toxic effect (6,14).

American attention was first focused on this product after the English made their discovery known. Since 1943, a considerable amount of experimental work has been progressing in this country.

Brooks and Anderson (4) found that 0.3 per cent gamma benzene-hexachloride, applied to the soil at a rate of 175#/A* at planting time caused a considerable reduction in germination of sweet corn and Lima bean seeds. However, when snap beans were subjected to a similar treatment, germination was slightly higher than the untreated. These workers also reported that germination was considerably reduced for bantam sweet corn, Bountiful snap beans, Henderson and Fordhawk lima beans when benzene-hexachloride was applied directly to the seed prior to planting.

Grayson and Poos (9) reported that corn planted on a fine sandy loam immediately after an application of 100#/A of 30 per cent concentrate of benzene-hexachloride suffered almost complete kill soon after germination. A similar re-

* #/A denotes pounds per acre

sult was obtained when corn was planted ten to twelve days following a like treatment.

The effects of this insecticide was tested under greenhouse conditions by Culliman (8) on a clay loam soil, sandy soil and muck. He found that practically all vegetable crops were adversely effected and plant growth was depressed without causing any obvious toxic symptoms.

As benzene-hexachloride has a characteristic odor, much concern is expressed that it may cause an "off taste" on products. Peaches and pears (10,15) are susceptible to this undesirable property caused from a spray or dust residue. It is believed that potatoes have the ability to adsorbe this material from the soil, thus fostering an "off taste".

EXPERIMENTAL WORK

Crops were grown in the summer of 1947 in thourghly cleaned seven inch flower pots under a wire enclosure. Optimum soil moisture was maintained by keeping pots to weight with distilled water. There was very little shading to retard the growth of plants.

Four vegetable crops were used in this work, namely: Golden cross hybrid sweet corn, Pencil Pod wax (snap) beans, Boston pickling cucumbers and Early Scarlet Globe radishes.

Five different soil materials were used, three light textured and two heavy textured soils. All soils were in storage at the college soils barn since 1940 or 1941. However, the Wauseon sandy loam used for cucumbers and radishes

was collected just prior to planting. At the time of collection, this soil was not in cultivation and had been idle for the year previous.

The organic content of the soil was determined by the "loss on ignition" method.

pH values of the soils were measured by means of a direct reading from a pH meter.

Table 1. Properties of Soils Used and Fertilizer Application

Soil Series	Texture	Organic content	pH	Fertilizer used	Rate/A lbs.
Fox	Sandy loam	3.5%	5.4	3-12-12	1000
Isabella	" "	2.1	5.9	"	"
Wauseon	" "	5.4	7.5	"	"
Miami	Clay loam	3.8	5.9	4-12-8	"
Wisner	" "	11.9	7.6	"	"

Four different rates of application of benzene-hexachloride were used, using untreated pots as control or checks. Four replications of each treatment were used, thus making a total of twenty pots for each crop on one specific soil type.

Benzene-hexachloride, sold by the trade name of "Gamtox" was supplied by the California Chemical Company. This was a 5 per cent wettable compound containing 10 to 12 per cent of the gamma isomer. Applications were made at the rate of 800, 400, 200, and 100 pounds per acre which is equi-

valent to 40, 20, 10 and 5 pounds per acre of the technical grade of benzene-hexachloride. The insecticide and fertilizer were mixed and in turn the mixture was thoroughly incorporated with the top three inches of the soil.

Crops were planted immediately after the treatment or within the following three days.

Plants and soil were tested at various intervals for nutrient content by the Spurway quick test method. Appropriate amounts of nutrients were added whenever the tests indicated such applications were necessary.

RESULTS AND DISCUSSION

A. SWEET CORN

The hybrid variety of Golden Cross sweet corn was used. Corn was planted on June 30 at the rate of seven seeds per pot and was later thinned to two stalks per pot. Approximately fifty days after germination, the plants were harvested, dried and weighed.

1. Toxicity Symptoms: Sweet corn showed definite symptoms of toxicity from the use of this insecticide.

Although for the first ten days after germination, corn on treated pots appeared to be superior to that on untreated pots.

Approximately seventeen days after emergence, plants on treated pots began to show symptoms of injury. The tips of the lower leaves began to turn yellow and in about two days, the entire lower leaf had turned brown and dry. These signs of

disorder continued in severity and twenty to twenty-two days after germination, there was a decided injury to the plants. At this time many of the lower leaves had died. As the lower leaves were drying, the upper leaves began to assume the same characteristics but to a lesser degree. The severity of the injury appeared to be in direct relationship with the rate of application of the insecticide for injury was most severe on the 800#/A treatment. No injury was apparent at the lowest rate of application.

These signs of injury appeared to be similar to those symptoms usually associated with potassium deficiencies on corn. However, tissue and soil tests revealed that a sufficient amount of plant nutrients were available for normal growth.

Approximately four weeks after germination, injury of the plant appeared to have alleviated itself. Color had improved, yellowing and browning of the leaves had subsided and the entire plant assumed a more vigorous condition. Those plants that were not as severely affected made rapid growth after recovery while plants at the heaviest rate of application remained in a somewhat stunted condition.

2. Sweet Corn on Light Textured Soils: Germination was not adversely effected by the use of benzene-hexachloride. On the contrary, germination was benefited from all rates of application. See Figure 1b.

Examination of seed that failed to germinate indicated

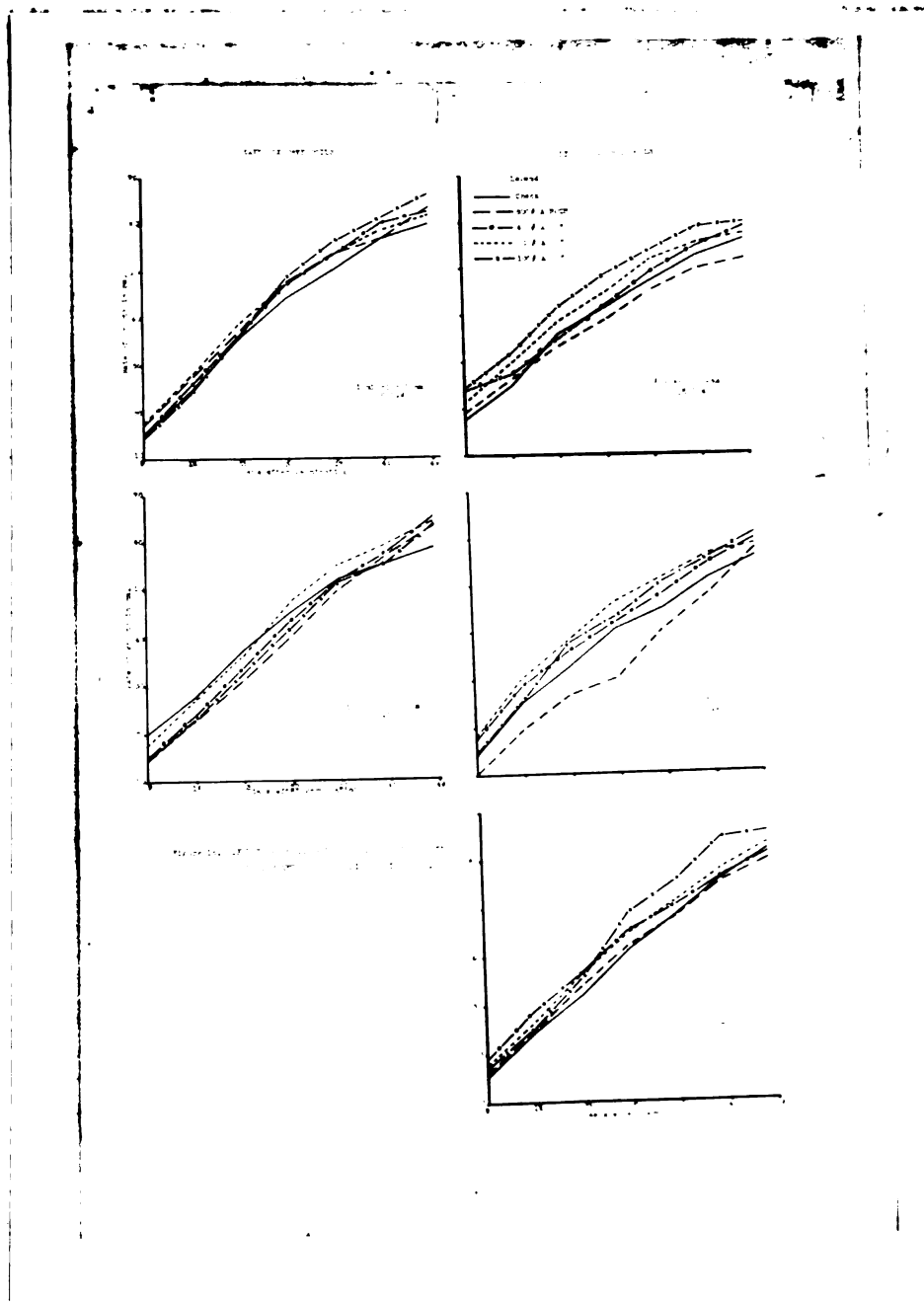


Figure 1a. Effect of benzene-hexachloride on the growth rate of sweet corn on various soil types.

Note: Rates of applications in hundreds of pounds for each bar.

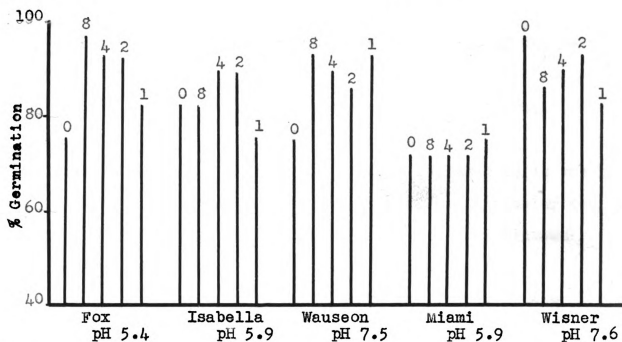


Figure 1b. EFFECT OF BENZENE-HEXACHLORIDE ON GERMINATION OF SWEET CORN IN VARIOUS SOIL MATERIALS.

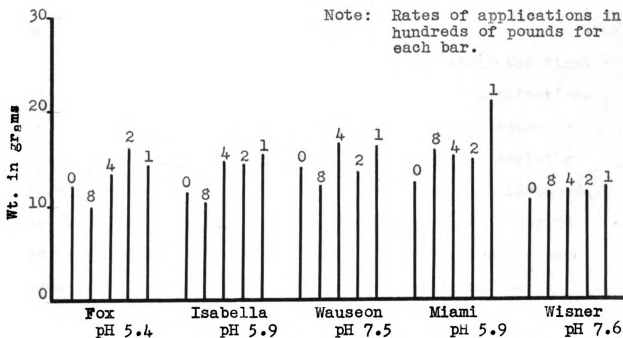


Figure 1c. EFFECT OF BENZENE-HEXACHLORIDE ON TOTAL DRY WEIGHT OF SWEET CORN GROWN ON VARIOUS SOIL TYPES.

no correlation between non-germinated seed on treated or untreated pots indicating that the insecticide had no harmful effect on seed germination. Apparently, viability of the seed was not too high.

No difference in time required for germination was noted.

Early growth of sweet corn on light textured soils was for the most part improved by the use of benzene-hexachloride. However, it is apparent from Figure 1a that on Isabella sandy loam, early growth was depressed by the 800/A application.

Improvement in growth was characterized by a greater height and a slightly greener color. This was true for all rates of application with the exception noted above. Early stimulation was more noticeable on the two sandy soils low in organic matter and less noticeable on the sand high in organic material.

This stimulation persisted for approximately the first seventeen days of growth at the heavier rates of application. After this time, plants began to show symptoms of injury as discussed previously. Symptoms of toxicity were especially severe on sandy soils low in organic matter and considerably less on the sand high in organic material. It was observed that symptoms of toxicity were especially severe on the two heavier rates of application of the insecticide and not noticeable at the lowest rate. Generally speaking, symptoms of toxicity decreased as rates of application decreased.

Symptoms of toxicity are not too distinguishable from

Figure 1a. Growth continues while plants were suffering injury but generally speaking, at a somewhat suppressed rate.

Approximately four weeks after germination, plants had resumed a normal condition except on the 800#/A application. At harvest time, plants in pots with the three lower rates of application were superior to the untreated.

Dry weight yields of plant tissue produced were somewhat variable but for the most part yields varied indirectly with the rate of application. By referring to Figure 1c, it can be seen that the least amount of dry plant tissue was produced when 800#/A of benzene-hexachloride was applied. Yields on the remaining three rates of application were erratic but a greater quantity of dry plant tissue was produced from the treated than from the untreated soil.

3. Sweet Corn on Heavy Textured Soils: Germination was slightly depressed by the use of benzene-hexachloride on Wisner clay loam. However, from Figure 1b, it is indicated that germination was very poor on all pots on the Miami clay loam. Why this lower rate of germination was experienced on Miami clay loam cannot be explained.

Early stimulation of growth was not as marked with sweet corn on heavy textured soils as on the light textured soils.

Symptoms of toxicity were considerably less noticeable on Miami clay loam than on the sandy soils. Plants treated with 800#/A of the insecticide showed some signs of injury

but not so severe as to impede growth. Pots with 400#/A of benzene-hexachloride showed some signs of injury while no depressing effect was observed on the 200#/A treatment.

Sweet corn behaved differently on Wisner clay loam. This can be readily seen from Figure 1a where all rates of application had a depressing effect for approximately the first thirty-five days of growth with no external symptoms of toxicity. After this period, all plants resumed normal growth and at harvest time, plants from treated pots were slightly larger than from the control pots.

Sweet corn plants from treated pots on the Miami soil produced more dry plant tissue than from untreated pots. Where soils were treated at the rate of 100#/A of the insecticide, considerably more plant tissue was obtained than with any other treatment (Fig. 1c).

The weight of dry plant tissue of sweet corn grown on Wisner clay loam was lower than from the Miami soil. Treated and untreated pots were very nearly equal, indicating that the insecticide had no influence on this one crop on this specific soil (Fig. 1c).

4. Texture vs Treatment: A definite relationship exists between texture of the soil, rate of application of the insecticide and plant growth. Signs of toxicity were considerably more severe on light textured soils than on the heavy textured soils with similar treatments. Toxicity was also related to the amount of soil organic matter. For soils of

the same texture, those with a greater organic matter content, as Wauseon sandy loam, presented fewer toxicity symptoms. It was also observed that at the lower rates of application, plants were more vigorous on the lighter textured soils when compared with the heavier textured soils. This can readily be seen from Figure 1a, by comparing rate of growth on the Fox and Miami soil types.

5. pH vs Treatment: No relationship is apparent between pH of the soil and the behavior of sweet corn grown on soil treated with benzene-hexachloride. Differences in symptoms of toxicity and apparent stimulation are attributed to the texture of the soil rather than pH.

6. Recommendations for Sweet Corn: (On Light Textured Soils) One-Hundred pound applications of benzene-hexachloride will cause no harmful effects to sweet corn. Applications above this concentration may cause symptoms of toxicity with 800#/A being definitely toxic.

Sandy soils high in organic matter may be able to withstand heavier rates of application with no symptoms of toxicity.

(On Heavy Textured Soils) Two-hundred pound applications of benzene-hexachloride will cause no harmful effects to sweet corn. Applications of 400#/A may or may not cause damage.

B. WAX BEANS

The variety of pencil pod wax beans were used. Seeds were planted at the rate of seven seeds per pot on June 27. Weekly average measurements were taken. On August 27, the beans were harvested. Green weight of pods was recorded and the plants were air dried and weighed.

1. Wax Beans on Light Textured Soils: Germination on sandy soils was erratic but it appeared as though wax beans were not effected by the use of benzene-hexachloride.

Bean plants showed no toxic signs from the use of this insecticide. Conversely, a stimulation effect was noted in the early stages of growth. This effect was more noticeable on the sandy soils low in organic matter.

After the plants had become established, no external symptoms of toxicity were noted as in the case of sweet corn. On Fox sandy loam, plants on the treated soils appeared to be normal throughout the growing season. However, on Isabella sandy loam, growth appeared to be slightly depressed with all treatments by twenty days after germination. (Fig. 2a) On the sandy soil high in organic matter, plant growth on the treated soils were equal to the check except for a depressing effect from the 100#/A application. The depressing effect at this one application was believed to be caused from a shaded area in which these pots were placed rather than from the insecticide.

No difference in blossoming time was observed between treated and untreated plants. The number of blossoms produced and the length of time the flowers were in bloom appeared to be the same for treated and untreated soils.

The green weight of bean pods produced from the various treatments was variable but it appears that the sandy soils treated with the insecticide gave a lower yield of pods than plants from untreated pots. See Figure 2d.

The quantity of dry plant tissue produced was erratic. On the Isabella sandy loam, the treated pots produced a slightly smaller quantity of plant tissue than the untreated pots. With the other two sandy soils, the treated pots produced a greater quantity of plant tissue than the untreated. See Figure 2c.

2. Wax Beans on Heavy Textured Soils: Germination of wax beans on heavy textured soils was slightly improved from the use of benzene-hexachloride. See Figure 2b.

On Miami clay loam, plant growth on the 200#/A application appeared to be superior to all other plants. Plant growth on all other applications, including checks was very nearly equal.

Wax beans grown on treated Wisner clay loam soils were definitely ahead of those grown on untreated pots and this condition persisted throughout the growing period. It is difficult to determine which treatment was ideal, for all treated pots grew with equality. See Figure 2a.

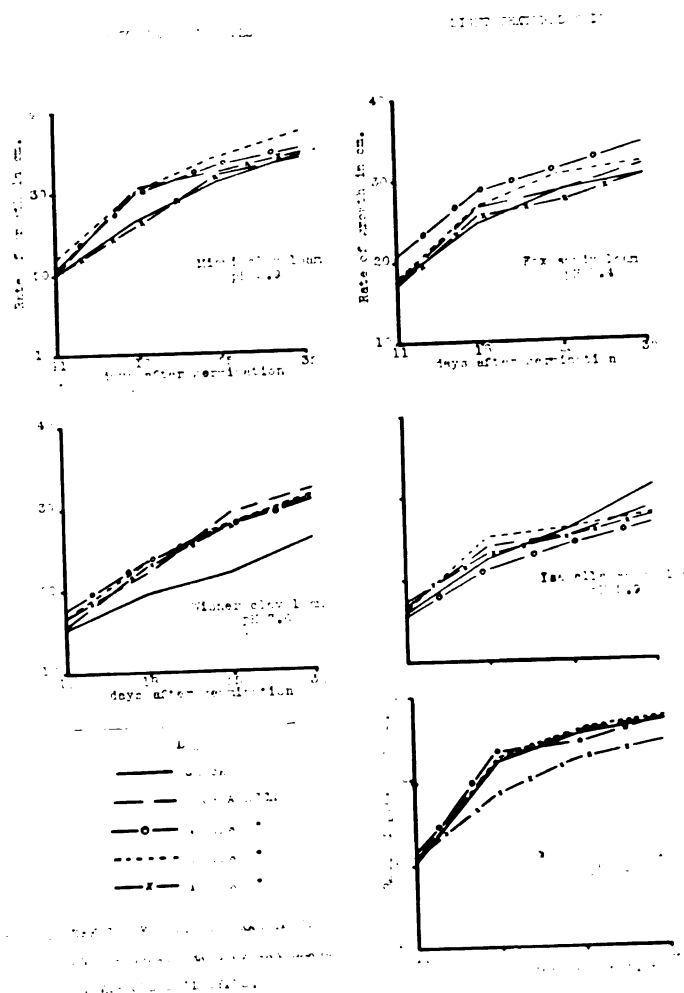


Figure 2a. Effect of benzene-hexachloride on the growth rate of wax beans on various soil types.

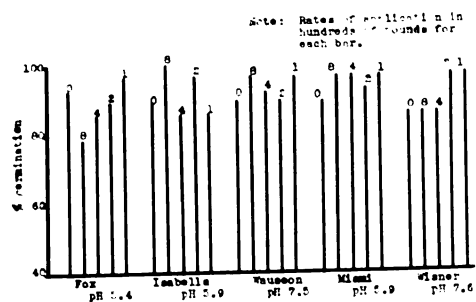


Figure 2b. EFFECT OF DDT-HEXACHLORIDE ON GERMINATION OF WAX BEANS ON VARIOUS SOIL TYPES.

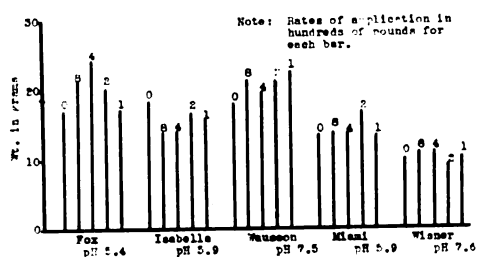


Figure 2c. EFFECT OF DDT-HEXACHLORIDE ON TOTAL DRY WEIGHT OF WAX BEAN GROWN ON VARIOUS SOIL TYPES.

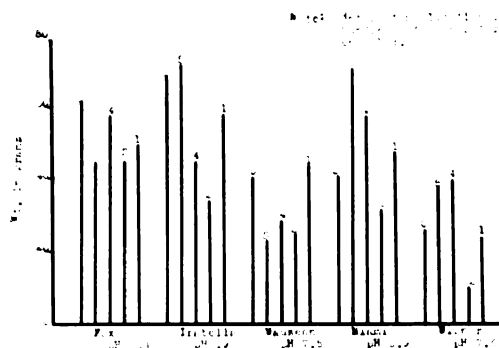


Figure 2d. EFFECT OF DDT-HEXACHLORIDE ON THE NUMBER OF WAX BEAN PLANTS GROWN ON VARIOUS SOIL TYPES.

Blossoming time was equal between the various treatments.

The weight of bean pods produced from plants on treated soil was greater than on the check soil. This is not in conformity with the data from sandy soils where the untreated pots produced the greatest amount of bean pods (Fig. 2d).

3. Taste Quality of Wax Beans: Much concern is expressed regarding possibilities of an "off taste" on products treated with benzene-hexachloride. Samples of wax beans were analyzed for taste scoring by the Home Economics Department of Michigan State College. Only beans from the heaviest rate of application from each soil were scored. It was assumed that if an undesirable taste would be present, it would be detected first at the heavier rate of application.

The beans were boiled and scored, using a scoring range from one to seven, with seven being the most desirable. Scores are listed below.

Table 2. Taste Score of Wax Beans. Score of Seven Is the Most Desirable.

	Fox check	Fox 800#	Isabella 800#	Wauseon 800#	Miami 800#	Wisner 800#
Odor	4.3	4.3	4.3	3.5	4.5	1.8
Flavor	3.5	3.5	3.3	3.0	3.8	2.3
General Conclusion	3.0	3.0	3.0	2.0	3.5	1.0

This data should be interpreted with considerable caution, since the beans were not in very good condition for scoring. The number of beans in each sample was small and too mature to permit proper cooking and sampling. However,

it gives an indication that this particular variety of wax beans may not assimilate benzene-hexachloride in sufficient quantities to impair its edible qualities.

4. Texture vs Treatment: Bean plants grown on the lighter textured soils appeared to be slightly more vigorous than plants grown on heavy soils with corresponding treatments. This stimulation appeared to be indirectly related to the colloidal content of the soils.

5. pH vs Treatment: No relationship was observed in terms of growth factors between pH of the soil and insecticide treatment.

6. Recommendations: The maximum amount of benzene-hexachloride can be used in the soil for the control of insects with no deleterious effect to pencil pod wax beans.

C. CUCUMBERS

Boston pickling variety of cucumbers were used. Seeds were planted on June 29 at the rate of nine seeds per pot. However, cucumbers on Wauseon sandy loam were planted some three weeks later (July 6). The supply of soil was exhausted at this time and the above mentioned time was necessary to obtain the additional soil sample. All plants were harvested on August 29 and air dry weights were taken.

1. Cucumbers on Light Textured Soils: Germination of cucumber seeds on sandy soils low in organic matter was not

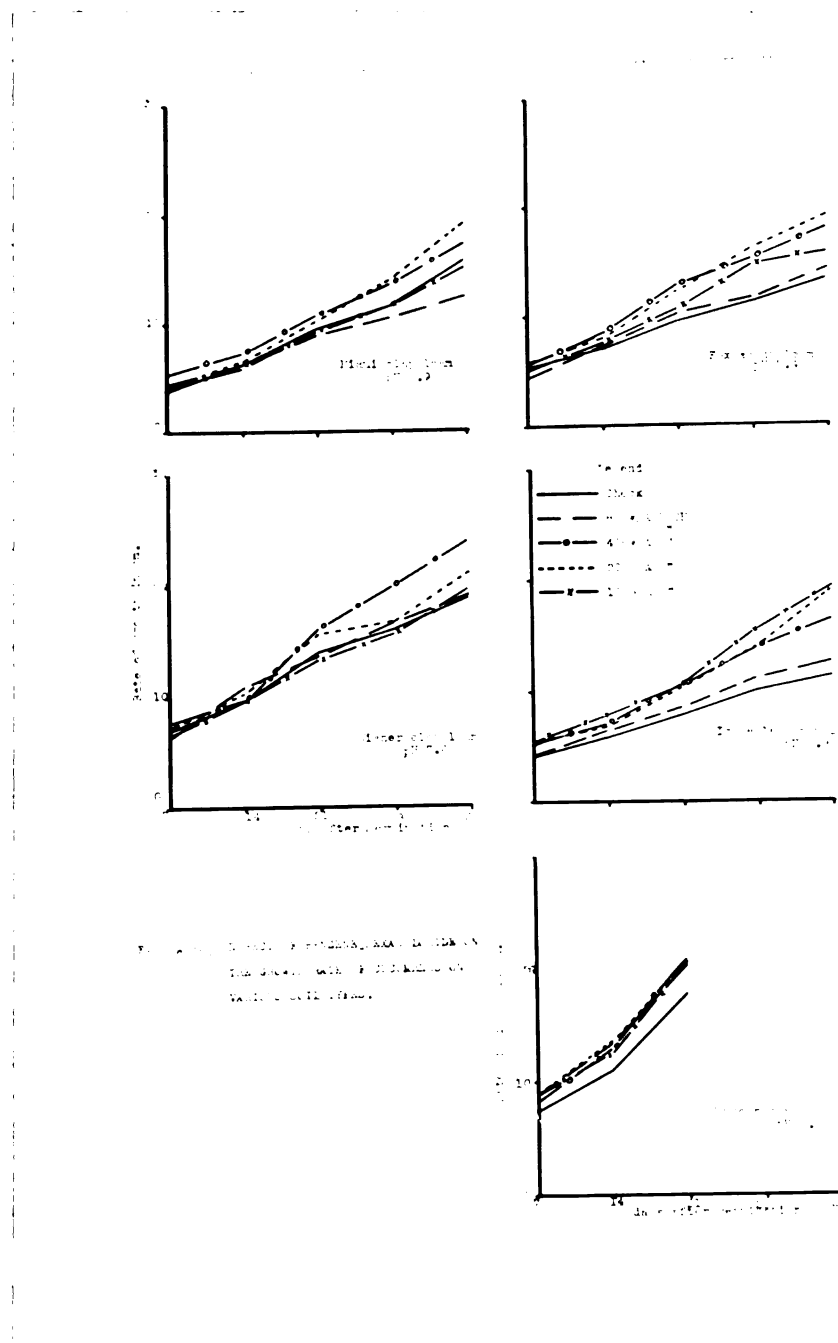


Figure 3a. Effect of benzene-hexachloride on the growth rate of cucumbers on various soil types.

Note: Rates of application in hundreds of pounds for each bar.

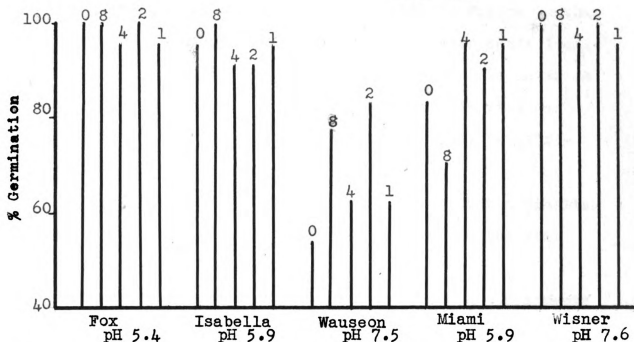


Figure 3b. EFFECT OF BENZENE-HEXACHLORIDE ON GERMINATION OF CUCUMBERS ON VARIOUS SOIL TYPES.

Note: Rates of application in hundreds of pounds for each bar.

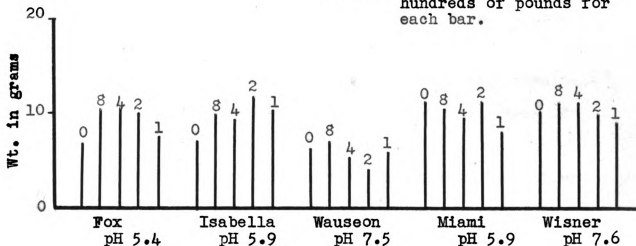


Figure 3c. EFFECT OF BENZENE-HEXACHLORIDE ON TOTAL DRY PLANT WEIGHT OF CUCUMBERS GROWN ON VARIOUS SOIL TYPES.

adversely affected by the use of benzene-hexachloride in the soil. However, it is apparent from the data in Figure 3b that germination was considerably lower on the Wauseon sandy loam. Cucumbers on this soil were planted some three weeks later as previously mentioned. As the temperature at this time was between 85° to 90°F, the low germination value may be attributed to this factor.

No symptoms of toxicity were visible on Boston pickling cucumbers from the use of benzene-hexachloride in the soil. This chemical actually improved growth and color.

This stimulation was not consistent between treatments on sands low in organic matter. On the Fox sandy loam, the 200#/A treatment produced the greatest growth followed closely by the 400#/A application (Fig. 3a). On the Isabella sandy loam, the degree of stimulation was inversely proportional to the rate of application. The degree of stimulation was equal between all treatments on Wauseon sandy loam and all treatments were superior to the checks.

All pots of cucumbers blossomed approximately simultaneously. No relationship was observed between the number of blossoms and treatments.

The quantity of plant tissue produced was somewhat erratic, ie, it was not proportional to the rate of growth. This can be seen by comparing Figure 3a and 3c. However, to generalize, the amount of plant tissue produced was greater on soils treated with benzene-hexachloride than without.

2. Cucumbers on Heavy Textured Soils: Germination was not deleteriously effected by the use of benzene-hexachloride. On heavy soils, germination was very nearly equal between all treatments and better than on the untreated pots. However, germination on the Miami soil receiving the 800#/A application was considerably lower than in the check soil (Fig. 3b). Considering that germination on other soils treated similarly did not act in a like manner, this should not be taken as conclusive evidence of damage.

Growth of cucumbers on heavy soils appeared to be slightly retarded by heavy applications of benzene-hexachloride. Also, a slight depression was noted on the Wisner soil with an 100#/A application. Why this erratic result occurred on this soil and at this low rate of application cannot be explained.

For the most part, the use of this insecticide at the lower concentrations improved growth and color of plants.

No difference in blossoming was noted.

The quantity of plant tissue produced on the Miami soil that received benzene-hexachloride was slightly less than on the untreated soil. On Wisner clay loam, plant tissue produced was very nearly equal between treated and untreated pots. See Figure 3c.

3. Texture vs Treatment: Cucumbers showed a greater stimulation when grown on light textured soils than on the heavy textured soils. A high organic content of sandy soil

reduced the stimulating effect of this insecticide. No such coorelation was noted on the heavy soils.

4. pH vs Treatment: No relationship was noted between behavior of plants, the pH value of the soil and the rate of application of the soil insecticide.

5. Recommendations for Cucumbers: (On Light Textured Soils) Applications of 400#/A of benzene-hexachloride may produce detrimental effects and the treatments should be kept at or below this maximum limit.

Sandy soils high in organic matter may be able to withstand greater applications of the insecticide than sandy soil low in organic material.

(On Heavy Textured Soils) Applications of 400#/A may be safely made with no harmful effects.

D. RADISHES

The variety of Early Scarlet Globe radishes were used. Radishes were planted on July 10, at the rate of nine seeds per pot. Plantings on the Wauseon sandy loam were not made until some three weeks later (July 29), due to a lack of soil.

1. Radishes On Light Textured Soils: No deleterious effect on germination of radish seed was caused by benzene-hexachloride. Although results were very erratic, it appears from Figure 4b that germination may have been somewhat benefited by the use of this chemical.

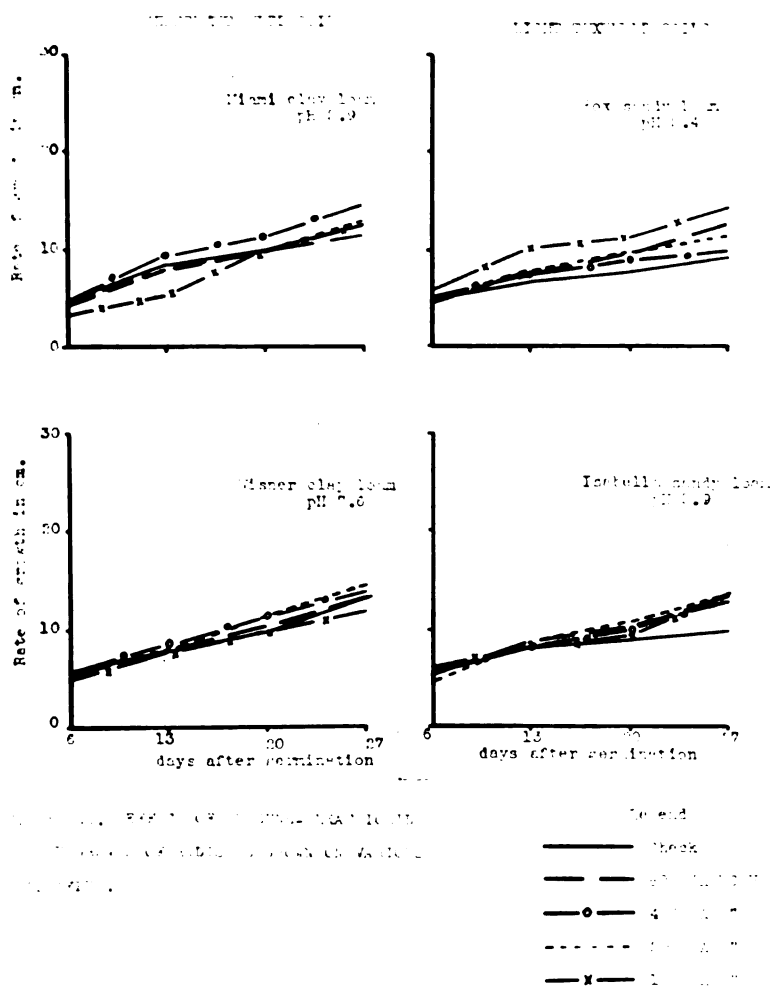


Figure 4a. Effect of benzene-hexachloride on the growth of radishes grown on various types.

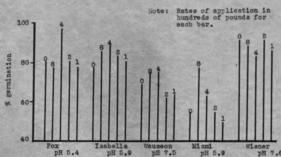


Figure 43. EFFECT OF BENZENESULPHACHLORIDE ON GERMINATION OF RADISH ON VARIOUS SOIL TYPES.

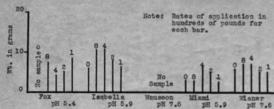


Figure 43. EFFECT OF BENZENESULPHACHLORIDE ON TOTAL DRY PLANT WEIGHT (TOPS ONLY) OF RADISHES GROWN ON VARIOUS SOIL TYPES.

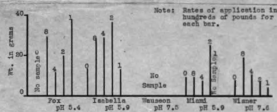


Figure 44. EFFECT OF BENZENESULPHACHLORIDE ON ROOT GROWTH OF RADISHES GROWN ON VARIOUS SOIL TYPES.

Plant growth was very poor due to the hot weather. Therefore, the results obtained must not be regarded as conclusive.

Growth appeared to be slightly increased by the use of this chemical. From the start of growth, plants in treated soils were slightly superior to those in untreated soils and remained so throughout the growing season. It is apparent from Figure 4a, that growth on Fox sandy loam was better on the 100#/A treatment while on Isabella sandy loam. Growth on all treated pots was very nearly equal and slightly better than on the untreated soil.

Radishes on Wauseon sandy loam grew so poorly that no accurate observations or measurements could be taken and the crop was not harvested.

The quantity of tops and bottoms of radishes produced was very erratic (Fig. 4c, 4d) but results indicate that benzene-hexachloride is not toxic to the growth of radishes.

2. Radishes On Heavy Textured Soils: Germination of radish seed on Miami clay loam was very poor, probably due to the surface crusting of this soil. In general, germination did not appear to be effected by the use of benzene-hexachloride (Fig. 4b).

Growth of radishes was very poor and erratic on the heavy textured soils. Growth on treated and untreated pots was very nearly equal with only slight indications that a beneficial effect was exerted by benzene-hexachloride

(Fig. 4a). It is also apparent from Figure 4a that the 100#/A treatment on both soils caused a depressing effect with no outward symptoms of toxicity being observed. No explanation can be advanced as to why this depressing effect is present at the lowest rate of application.

As the growth of radishes was very poor, no definite coorelation can be established between a specific treatment and quantity of plant tissue produced.

3. Taste Quality of Radishes: Radishes were tasted by the writer for possibilities of an "off taste" caused by the use of this chemical. Results are given in Table three.

Table 3. Results of taste test of radishes grown on soil treated with benzene-hexachloride.

Traits	Soil Type	Rates of soil insecticide /A				
		800	400	200	100	Check
Off taste	Fox	xxx	xx	x	No	No
" smell	"	xxx	x	x	No	No
Off taste	Isabella	xxx	xx	No	No	No
" smell	"	xxx	xx	No	No	No
Off taste	Miami	No	No	--	No	No
" smell	"	No	No	--	No	No
Off taste	Wisner	No	No	No	No	No
" smell	"	x	No	No	No	No

xxx Strong off taste or smell.

xx Noticeable off taste or smell.

x Slight off taste or smell.

-- No sample.

Radishes grown on light textured soils receiving 800 and 400#/A of benzene-hexachloride were so strongly tainted with this insecticide that the radishes would have been unfit for market. Plants from the 200#/A application had a slight "off taste" and smell while radishes from the 100#/A application appeared to be normal in taste and smell. Radishes from the untreated pots were used as taste standards.

Radishes grown on heavy textured soils had no "off taste" or smell, regardless of rate of application.

4. Texture vs Treatment: Radishes on light textured soils showed slightly greater stimulation of plant growth than did those on heavy textured soils. However, as noted above, radishes grown on treated light textured soils had a characteristic "off taste" but this condition was not observed on the heavy textured soils. This latter condition is probably due to the buffering or absorptive capacity of the colloidal material of the heavy soils.

5. pH vs Treatment: No differences were noted in plant behavior that could be attributed to pH of the soil and the various rates of application of benzene-hexachloride.

6. Recommendations for Radishes: Rate of application on light textured soils should not exceed 100#/A. Applications above this rate will give radishes a characteristic off taste and smell.

On heavy textured soils, benzene-hexachloride may be applied to the soil at the rate of 800#/A, causing no off taste or smell.

STIMULATION

It has been observed throughout this work that a definite improvement in growth, vigor and color was noted on each crop in varying degrees when the soil was treated with benzene-hexachloride. The degree of stimulation varied with the crops and the soils used.

A similar condition was reported by Lange (12). This worker offered the hypothesis that the physical or chemical properties of the soil might be changed or that an increase in population of the more beneficial bacteria accounted for these benefits. It seems doubtful that the first hypothesis offered is the answer to this problem. However, it is thought that the chemical properties may be altered and that the bacteria population of the soil could be advantageously changed.

Workers in Scotland (2) reported that when turnips were planted with a mixture of benzene-hexachloride and fertilizer, growth was more vigorous and color was improved. Similar results were observed on oats. It was concluded that perhaps the insecticide exerted this stimulation by reducing the number of harmful bacteria in the soil.

Annand (1) reports that this insecticide may act as a hormone on some varieties of plants.

It is suggested by the writer of this paper that stimulation is probably caused by the chemical breakdown of this compound in the soil. In the presence of a weak alkali, such as the soil calcium, this compound breaks down to form the isomers

of trichlorobenzene. Perhaps it is this chemical (13) together with a greater population of beneficial bacteria in the soil that exerts the stimulating effect.

The degree of stimulation varies somewhat with the texture of the soil. Increases in growth and improvement in color are not as marked on the heavy textured soils (clay) as on the lighter textured soils (sand). It appears that stimulation is inversely proportional to the amount of colloidal material in the soil. This colloidal material may be either the organic or inorganic colloidal fraction of the soil. Therefore, it is concluded that the organic or inorganic colloids acts as a buffering agent and the greater the amount of colloidal material in the soil, the stimulation exerted by this insecticide will be less.

CONCLUSIONS AND SUMMARY

Five crops were grown on light and heavy textured soils treated with varying amounts of a 4 per cent compound of benzene-hexachloride to determine what effect this insecticide may have on germination and growth.

It is important to keep in mind that results contained herein should be regarded as indications only and not as conclusive data. More research is necessary before definite and accurate recommendations can be made.

SWEET CORN

Germination and the early stage of growth of sweet corn on light textured soils appeared to be benefited by the use of this chemical. However, approximately twenty days after germination, symptoms of toxicity appeared, closely resembling those symptoms associated with potassium deficiency. The severity of toxicity appeared to be directly proportional to the rate of application with no symptoms observed on the 100#/A treatment. Toxicity signs were but temporary and thirty days after germination, plants had fully recovered and resumed normal growth. At harvest time, treated pots were superior to the untreated with the exception of the 800#/A treatment.

Benzene-hexachloride in the light textured soils exerted a definite stimulation on sweet corn at the lower rates of application.

Sweet corn grown on sandy soils high in organic matter did not show symptoms of toxicity as severely as plants grown on sandy soils low in organic matter. However, stimulation was not as great.

Germination of sweet corn on heavy textured soils was slightly depressed on Wisner clay loam but was not effected on Miami clay loam. Early growth was slightly stimulated on the Miami clay loam but appeared to be slightly depressed on the Wisner clay loam for approximately the first thirty-five days after germination. After this period of time, corn on the Wisner soil resumed normal growth and at harvest time, all plants on the treated pots were superior to the checks.

Symptoms of toxicity were not as severe on corn grown on heavy textured as on light textured soils. Applications of 800 and 400#/A of benzene-hexachloride showed some signs of temporary injury on the heavy soils but no symptoms were observed at the two lower rates of application.

WAX BEANS

Germination of wax beans on light textured soils did not appear to be effected in any way by the addition of benzene-hexachloride in the soil. However, on heavy textured soils, this insecticide appeared to improve germination.

Bean plants were slightly stimulated by the insecticide except on the Isabella sandy loam. On this soil, plants were depressed for about the first twenty days after germination although no outward symptoms of toxicity were observed.

In no case was there any indications of an "off taste" when the beans were cooked and scored.

Data from this one experiment show that plants from the treated sandy soils produced a smaller quantity of bean pods than those on the untreated pots. This condition was reversed on the heavy textured soils.

CUCUMBERS

Germination of cucumber seed was not influenced in any way by the use of benzene-hexachloride.

Generally speaking, plant growth was stimulated where the insecticide was applied. However, there appeared to be a

slight depressing affect on the sandy soils treated with 800#/A of benzene-hexachloride. The 400#/A treatment appeared to be on the border line of safety while on heavy soils this application was safe. No outward symptoms of toxicity were observed and the data at harvest time indicated that plants from the treated pots were superior to those from the untreated soils.

The quantity of plant tissue produced from the treated sandy soils was greater than from those soils receiving no insecticide, while plant tissue produced on the heavy textured soils was equal on the treated and untreated pots.

RADISHES

Radishes grew very poorly due to unfavorable growing conditions. Therefore, the following conclusions must be regarded as indications only.

Germination of radish seed did not appear to be lowered by the use of this chemical.

The growth of radishes on treated sandy soils appeared to be slightly greater but on the heavy textured soils few such indications were noted.

The data suggest that the treated soil will produce more root growth than the untreated soil regardless of the texture.

Radishes grown on sandy soils treated with more than 100#/A of benzene-hexachloride had a characteristic "off taste". However, radishes grown on the heavy textured soils had no indications of such a taste, regardless of rate of application.

PART 2

RESIDUAL EFFECT OF BENZENE-HEXACHLORIDE
IN THE SOIL

RESIDUAL EFFECT

Approximately four weeks after the previously mentioned crops were harvested the pots were moved into a green house and various cover crops were planted to determine if benzene-hexachloride has any residual effect on subsequent crops that may be grown in the rotation.

The soil was thoroughly reworked and a complete fertilizer was applied at the rate of 1000#/A.* Approximately seven weeks after the summer crops were harvested, the cover crops were planted.

RESULTS AND DISCUSSION

A. OATS

The Eaton variety of oats was used. Seeds were planted on Oct. 8, at the rate of eight per pot and plants were later thinned to three plants per pot. Plants were harvested on Dec. 29, dried and weighed.

1. Oats on Light Textured Soils: Germination was very nearly 100 per cent in all cases. See Figure 5a.

Symptoms of toxicity were not observed at any period of growth. Conversely, growth was stimulated by the use of this insecticide. Stimulation here was characterized by a taller growth and a deeper green color. From Plate 1, 2, it is

* Pounds per acre

Note: Rates of application in hundreds of pounds for each bar.

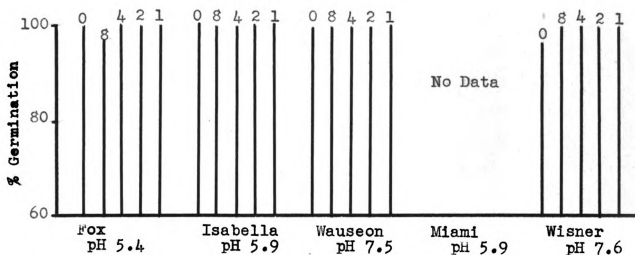


Figure 5a. EFFECT OF BENZENE-HEXACHLORIDE ON GERMINATION OF OATS ON VARIOUS SOIL TYPES.

Note: Rates of application in hundreds of pounds for each bar.

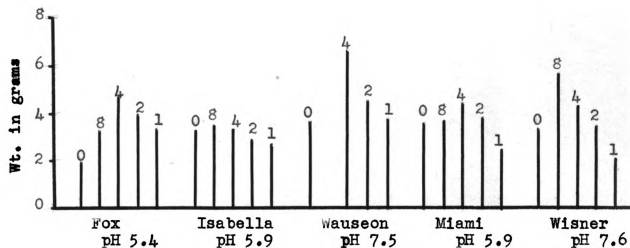


Figure 5b. EFFECT OF BENZENE-HEXACHLORIDE ON TOTAL DRY PLANT WEIGHT OF OATS GROWN ON VARIOUS SOIL TYPES.

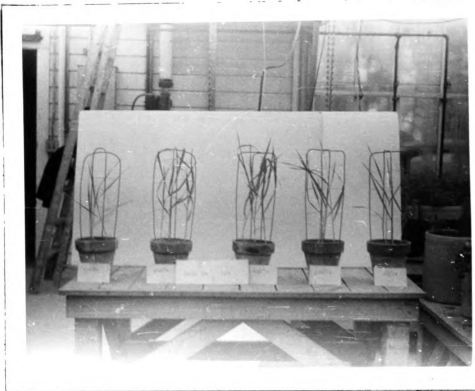
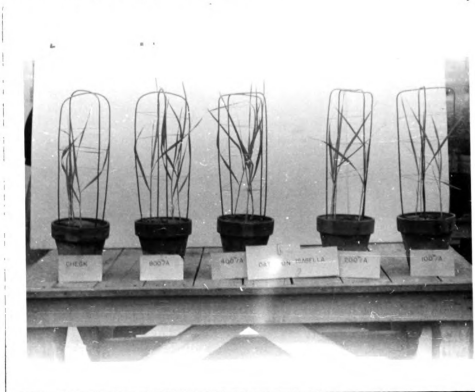


Plate 1. The effect of benzene-hexachloride on oats grown on Fox sandy loam (above) and Isabella sandy loam (below). Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.



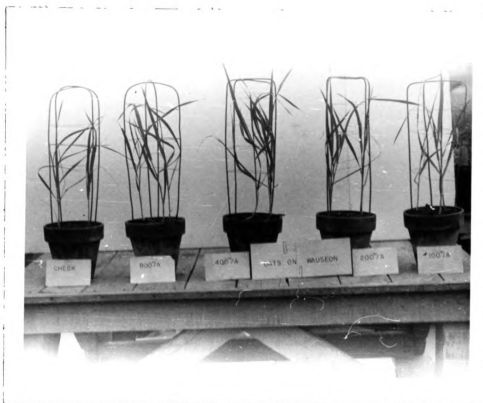


Plate 2. Effect of benzene-hexachloride on oats grown on Wauseon sandy loam. Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.

apparent that a stimulation occurred in a varying degree at all rates of application. It also appears that the 400#/A application produced the greatest stimulation on the Fox and Wauseon soils while the 800#/A application gave the greatest growth on the Isabella. The degree of stimulation between treatments is closely related with the amount of dry plant tissue produced (Fig. 5b).

2. Oats on Heavy Texture Soils: No germination data were obtained from the Miami soil but germination on Wisner was very nearly equal between all treatments (Fig. 5a).

Oat plants grown on soils where benzene-hexachloride had been applied showed a slight increase in growth instead of symptoms of toxicity. Oats on Miami were very nearly equal between treated and untreated pots. On the Wisner, a greater degree of stimulation was observed on the 800#/A and 400#/A application and a smaller growth on the 200#/A treatment. On the 100#/A application, a depressing effect took place (Plate 3). Why this depressing effect occurred at this rate of application cannot be explained.

The quantity of plant tissue produced follows very closely the size of plants as indicated in Figure 5b. However, the small quantity of plant tissue produced on the 100#/A application on the Miami soil cannot be explained, especially when this condition is not apparent from Plate 3.

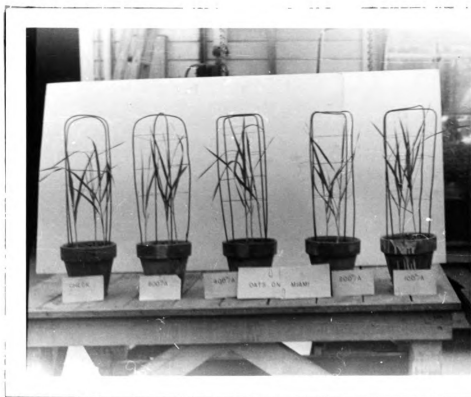
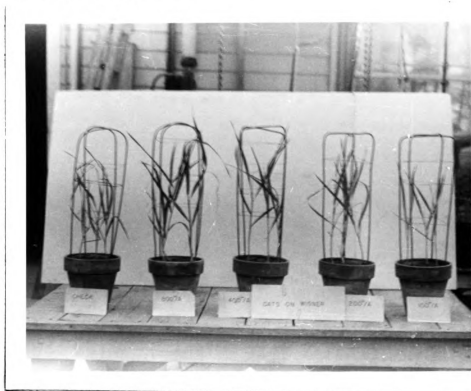


Plate 3. Effect of benzene-hexachloride on oats grown on Miami clay loam (above) and Wisner clay loam (below). Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.



B. BARLEY

The Bay variety of barley was used. Seven seeds per pot was planted on Oct. 9. Later the plants were thinned to three per pot. Plants were harvested on Dec. 29, air dried and weighed.

1. Barley on Light Textured Soils: Germination of barley seed on Fox and Wauseon sandy loam was not affected by the use of this insecticide, but it appeared to be slightly depressing on Isabella sandy loam. See Figure 6a.

Growth was not depressed by the use of this insecticide. Conversely, it appeared to be slightly stimulated. The 800#/A and 400#/A treatment on the Fox and Isabella, produced a slightly greater growth than other treatments. On the Wauseon sandy loam, the 800, 400 and 200#/A treatments produced an equal but considerable increased plant growth over the checks. An unexplainable depressing effect occurred on the 100#/A treatment. See Plates 4, 5.

The yield of dry plant tissue produced follows very closely the plant growth on Fox and Isabella sandy loam, but does not conform with plant growth on Wauseon sandy loam (Fig. 6b). It is apparent from Figure 6b that the untreated soil produced more dry plant tissue than the pots with the 400 and 200#/A application. Apparently an error was made in the harvesting or weighing of barley on this one soil for it was observed that the treated soils produced a heavier, more luxuriant vegetative growth that was definitely superior to

Note: Rates of applications in hundreds of pounds for each bar.

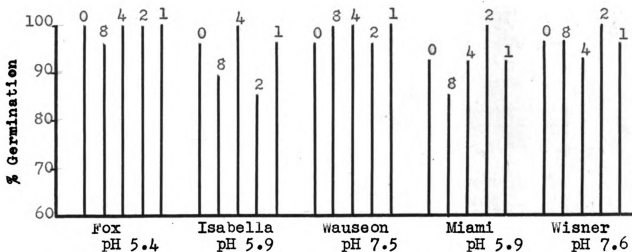


Figure 6a. EFFECT OF BENZENE-HEXACHLORIDE ON GERMINATION OF BARLEY ON VARIOUS SOIL TYPES.

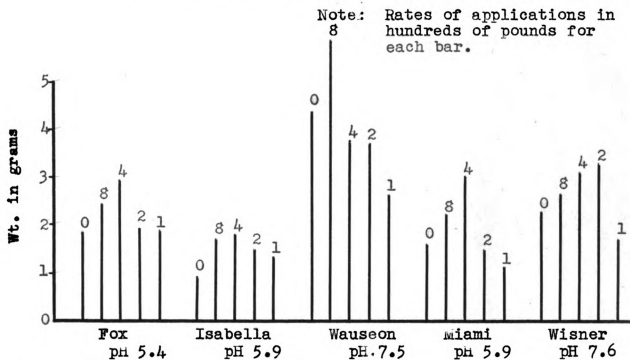


Figure 6b. EFFECT OF BENZENE-HEXACHLORIDE ON TOTAL DRY PLANT WEIGHT OF BARLEY GROWN ON VARIOUS SOIL TYPES.

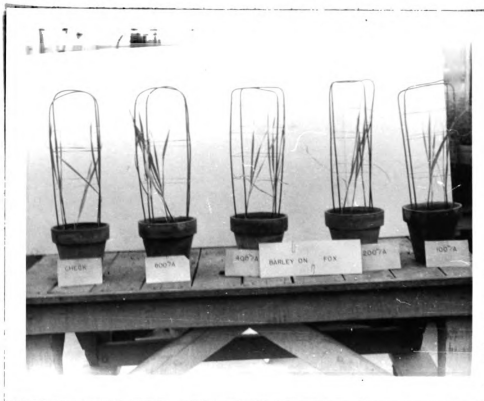
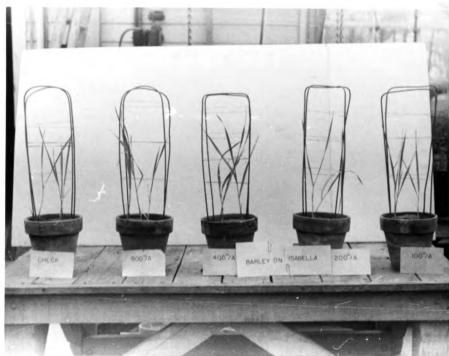


Plate 4. Effect of benzene-hexachloride on barley grown on Fox sandy loam (above) and Isabella sandy loam (below). Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.



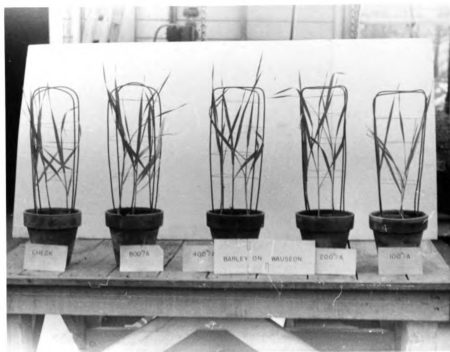


Plate 5. Effect of benzene-hexachloride on barley grown on Wauseon sandy loam. Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.

the checks.

2. Barley on Heavy Textured Soils: Germination of barley was very nearly equal between all pots on the heavy textured soils (Fig. 6a).

No symptoms of toxicity were observed on the barley throughout the growing season. On the other hand, a more vigorous growth was noted. Plants appeared to benefit most from the 400#/A application on the heavy soils. This superiority was very marked on Miami clay loam and less marked on the Wisner. Once again a depressing effect was noted on soils treated with 100#/A of benzene-hexachloride. No explanation can be advanced for this strange behavior. See Plate 6.

The quantity of dry plant tissue follows very closely the plant growth, with the depressing effect on the 100#/A treated pots being reflected in the weight of dry plant tissue produced. See Figure 6b.

C. RYE

Rosen rye was planted on Oct. 8, at the rate of seven seeds per pot. Later the stand was thinned to three plants per pot. For approximately the first two weeks of growth, all the plants were in a thrifty condition. After this time, the plants began to assume a drooping condition. This is thought to be caused from the constant warm temperature of the greenhouse which was not conducive to the growth of rye. Plants were harvested on Dec. 29, dried and weighed.

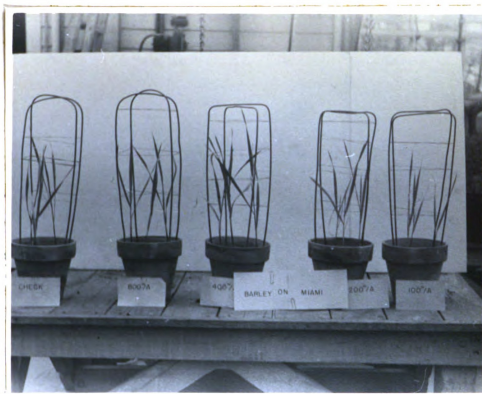
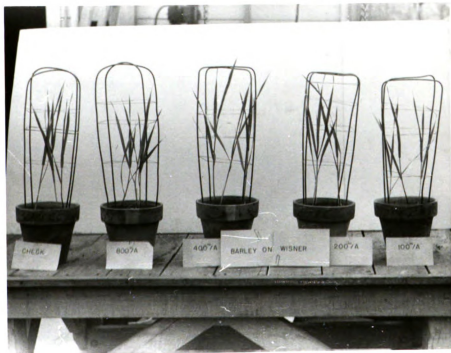


Plate 6. Effect of Benzene-hexachloride on barley grown on Miami clay loam (above) and Wisner clay loam (below). Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.



1. Rye on Light Textured Soils: Germination of rye seed was very erratic and no conclusive results could be obtained. See Figure 7a.

No symptoms of toxicity were noted on rye grown on soil treated with this insecticide. Increase in growth was observed but it was not as evident as with oats or barley. For soil treated with 400#/A of benzene-hexachloride produced a greater amount of plant growth than did soil receiving lower concentrations of this insecticide. On the Isabella sandy loam, the 200 #/A applications produced the greatest stimulation. On the Wauseon sandy loam, plants were benefited more from the 400#/A rate than from the other treatments. See Plates 7, 8.

The quantity of dry plant tissue produced follows quite closely the growth of the plants (Fig. 7b).

2. Rye on Heavy Textured Soils: Germination of rye seed on Miami clay loam was very poor and erratic. Germination on Wisner was slightly better on the treated than on the untreated soils (Fig. 7a).

No symptoms of toxicity were observed on rye. In fact, a slight stimulation was observed, with increased vigor being more prominent on the Wisner than on the Miami soil type. On Miami clay loam, all treatments were very nearly equal except on the 100#/A treatment where growth appeared to be depressed. On Wisner clay loam, the pots treated with 200#/A of the insecticide were superior to other treatments. See Plate 9.

The quantity of dry plant tissue produced was greatest

Note: Rates of applications in hundreds of pounds for each bar.

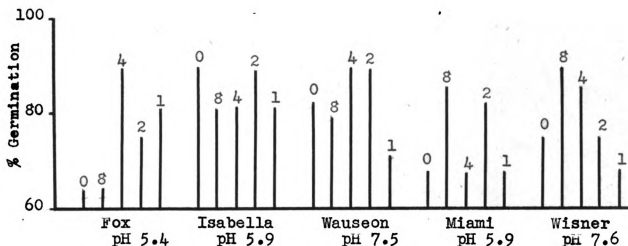


Figure 7a. EFFECT OF BENZENE-HEXACHLORIDE ON GERMINATION OF RYE ON VARIOUS SOIL TYPES.

Note: Rates of applications in hundreds of pounds for each bar.

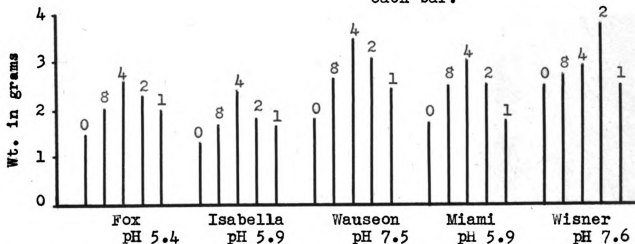


Figure 7b. EFFECT OF BENZENE-HEXACHLORIDE ON TOTAL DRY PLANT WEIGHT OF RYE GROWN ON VARIOUS SOIL TYPES.

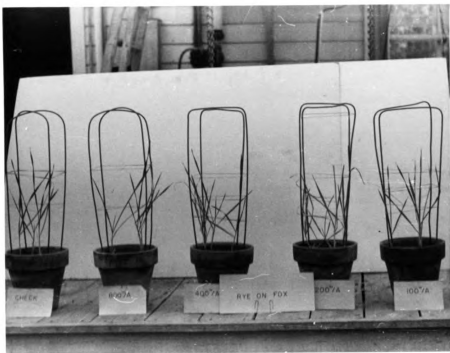
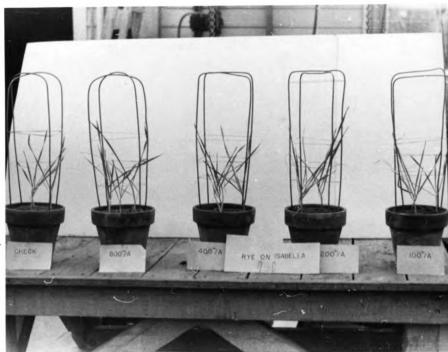


Plate 7. Effect of benzene-hexachloride on rye grown on Fox sandy loam (above) and Isabella sandy loam (below). Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.



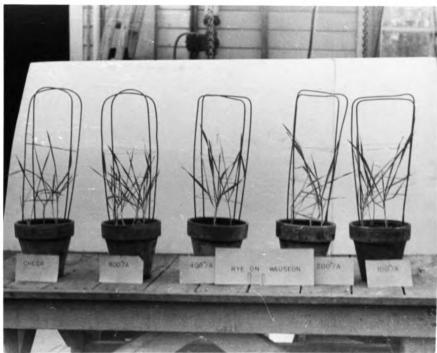


Plate 8. Effect of benzene-hexachloride on rye grown on Wauseon sandy loam. Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.

on treated soils. The weight of dry tissue produced can be correlated with the degree of stimulation (Fig. 7b).

D. Wheat

The Yorkwin variety of wheat was used. Seven seeds per pot were planted on Oct. 9. Later the plants were thinned to three per pot. On Dec. 29, the plants were harvested, dried and weighed.

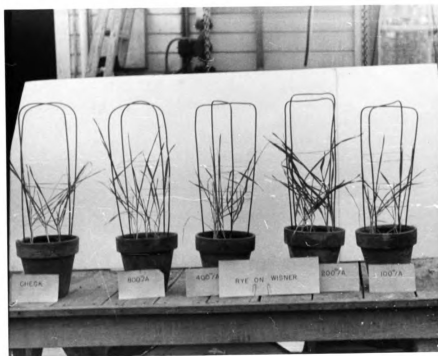
This study made on the residual effect of benzene-hexachloride on wheat must not be taken as conclusive. Approximately three weeks after germination, the wheat plants became seriously affected with powdery mildew. Various sulphur dusts and sprays were used with little success and it is thought that this fungus infection may have altered the results. Therefore, the following results must be considered as indications only and not as conclusive.

1. Wheat on Light Textured Soils: Germination of wheat was variable between the various treatment of benzene-hexachloride. However, it does appear that germination was not adversely affected by the use of this chemical (Fig. 8a).

In the early stages of growth, the wheat plants appeared to be slightly stimulated on soil treated with benzene-hexachloride and no toxicity symptoms were observed at any time. It appeared that plants grown on soil treated with the greater amounts of this insecticide were more vigorous than plants on soils receiving the lower rates of application. However, in



Plate 9. Effect of benzene-hexachloride on rye grown on Miami clay loam (above) and Wisner clay loam (below). Treatments from right to left in pounds per acre of benzene-hexachloride: none, 800, 400, 200, 100.



some cases the difference was very slight. Figure 8b somewhat substantiates these observations.

2. On Heavy Textured Soils: Germination was not effected by the use of benzene-hexachloride as a soil insecticide.

Plant growth appeared to be slightly greater on the treated pots of Wisner clay loam even when all pots were infected with powdery mildew. Stimulation in growth was more noticeable on this soil than on the Miami clay loam. On the latter soil type, the amount of plant growth appeared to be nearly equal on treated and untreated pots (Fig. 8b).

3. Infection by Powdery Mildew: From observations it appeared that the untreated pots of wheat were not infected with powdery mildew as seriously as the treated pots. No explanation can be advanced to account for this behavior.

Regardless of this serious infection of powdery mildew, the treated soil produced on the average greater plant growth than the untreated soil. This indicates that benzene-hexachloride does produce increases in growth which more than compensates for the yield depressions caused by this fungus infection.

SUMMARY AND CONCLUSIONS

This investigation shows that there is a residual effect of benzene-hexachloride on following crops in the rotation. This residual effect is not deleterious. Conversely, it appears to have a stimulating effect.

Note: Rates of applications in hundreds of pounds for each bar.

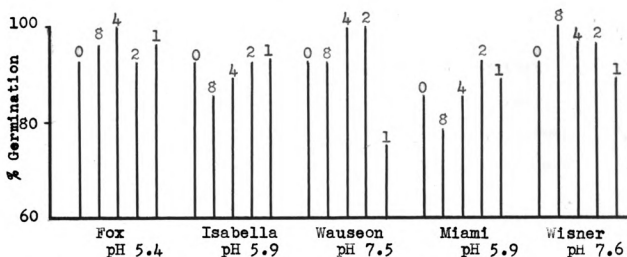


Figure 8a. EFFECT OF BENZENE-HEXACHLORIDE ON GERMINATION OF WHEAT ON VARIOUS SOIL TYPES.

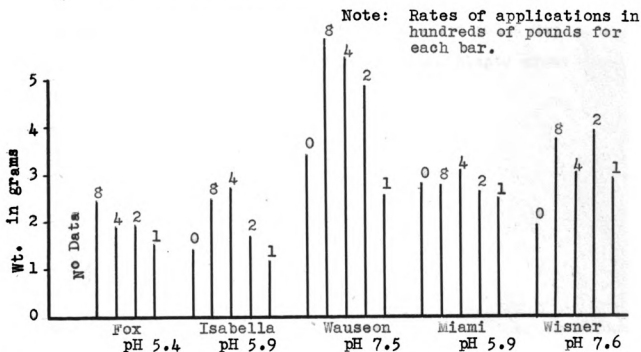


Figure 8b. EFFECT OF BENZENE-HEXACHLORIDE ON TOTAL DRY PLANT WEIGHT OF WHEAT GROWN ON VARIOUS SOIL TYPES.

A stimulation in plant growth in varying amounts was observed on all of the treated soils for all crops. Oats showed the greatest stimulation being followed very closely by barley. Rye probably showed the least.

As a rule, the heavier rates of application of this insecticide gave the greatest increase in growth and vigor.

Oats and barley appeared to be somewhat depressed when the soil was treated with 100#/A of this insecticide. No explanation can be advanced for this strange behavior.

Wheat grown on treated soils produced more dry plant tissue than wheat grown on untreated soils. This shows that benzene-hexachloride exerts a stimulation that is greater than the deleterious effects of the powdery mildew.

It was observed that wheat grown on treated soils was more seriously infected with powdery mildew than plants grown on untreated soils.

REFERENCES CITED

- (1) Annand, P.N.
1947 Insecticides. Agricultural Chemicals
2:34-39 No. 10.
- (2) Anonymous
1946 Hexachlorocyclohexane - A Promising New In-
secticide. Ag. News Letter 14:49 No. 3.
- (3)

1947 Benzene-hexachloride. Chem. Ind. 60:418-422.
- (4) Brooks, J.W., Anderson, L.D.
1947 Toxicity tests of some new insecticides.
J. Ec. Ent. 40:220-228.
- (5) Carpenter, S. J.
1947 Control of stored food insects with benzene-
hexachloride. J. Ec. Ent. 40:136.
- (6) Chamlin, G.R.
1946 The chemistry of benzene-hexachloride and
its insecticidal properties.
J. Chem. Ed. 23:283-284.
- (7) Cox, A. J.
1947 Comments. Agricultural Chemicals 2:47-49
No. 4.
- (8) Cullinan, F.P.
1947 Effect of some of the newer organic chemicals
on plant life. Agricultural Chemicals.
2:18-20 No. 5.
- (9) Grayson, J.M., Poos, F.W.
1947 Southern corn rootworm as a pest of peanuts.
J. Ec. Ent. 40:251-256.
- (10) Hamilton, D.W.
1947 New insecticides for control of pear psylla.
J. Ec. Ent. 40:234-236.
- (11) Hill, R.E., Hixson, E.
1947 Hexachlorocyclohexane dusts and fogs to
control grasshoppers. J. Ec. Ent. 40:137-138.
- (12) Lange, W.H.
1947 New developments in soil insecticides.
Agricultural Chemicals. 2:20-23 No. 9.

- (13) Mitchell, J.
1943-47 Plant growth regulators. Yearbook of
Agriculture, U.S.D.A. p 257.
- (14) Slade, R.E.
1945 The gamma-isomer of hexachlorocyclohexane.
Chem. and Ind. 40:314-319.
- (15) Snapp, O.J.
1947 Benzene-hexachloride for control of plum
curculio on peaches. J. Ec. Ent. 40:382-385.
- (16) Wilson, N.F., et all
1947 A comparison of rotone, DDT, and benzene-
hexachloride for pea aphid control.
J. Ec. Ent. 40:101-103.

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