The New Era in Insect Control[1]

By J. A. Munro[2]

The last decade has brought about a new era of improvement in insect control. It is new, largely because of the recent recognition of the valuable insect killing properties of several organic compounds and their advantages over the older insecticides. First will be considered the chlorinated hydrocarbons.

The Chlorinated Hydrocarbons

Their chief advantages include combined action as contact and stomach poisons and a lasting toxic or residual effect against insects. Most of them are incompatible with lime or other strong alkaline materials. Hence, when applied to lime (white washed) surfaces or included in mixtures containing lime, there is a marked lowering of their toxic action on insects.

They are a related group of insecticides and are now available as wettable powders, emulsifiable concentrates, dusting mixtures or as solutions. The wettable powders and emulsifiable concentrates are available in various concentrations (usually 25 per cent and 50 per cent concentrations of actual toxicant). The user must bear in mind that it takes approximately four pounds of a 25 per cent wettable powder, or two pounds of a 50 per cent wettable powder to equal one pound of the actual toxicant. The same rule also applies for emulsifiable concentrates except that liquid measure is used. The user will do well to observe the manufacturer's detailed instructions which appear on the label of each formulation.

For most kinds of spraying either the wettable powders or emulsifiable concentrates are used. When wettable powders are used the resulting suspension must be agitated or otherwise kept in motion while the spray is being applied to prevent settling of the particles. Such precautions are seldom necessary for emulsifiable concentrates because they mix readily with water, and remain in suspension. The dusting mixtures are usually obtainable in the ready prepared form for application. The solutions contain a stated amount of the toxicant in a solvent and are used mostly as sprays or as aerosols for controlling household insects.

The group includes DDT and several analogs or related compounds each of which will be introduced by its commonly accepted name and followed by chemical formula and a brief discussion of its more important uses.

DDT ($C_{14}H_9Cl_5$) has been adopted as the universal abbreviation for the chemical, dichloro-diphenyl-trichlorethane. This important organic compound was first prepared in 1874 by Othmar Zeidlar of Germany, but was not recognized as an insecticide until

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the late 1930's when Paul Muller of Switzerland demonstrated its toxicity to insects. The chemical was used extensively to control potato beetles in Switzerland in 1939, and in 1940 a patent was obtained on the preparation. In 1942 a sample was submitted to the U. S. Department of Agriculture whose entomologists confirmed it as especially useful in the control of lice, mosquitoes and other insects responsible for the transmission of human diseases. Production in the United States rapidly followed with the result that DDT came into timely and valuable use by the military in controlling insects responsible for spreading typhus, malaria and other diseases of medical importance.

Coincident with its wartime use, limited amounts of DDT were made available to federal and state experiment stations for research on its uses, with the result that at war's end in 1945 enough information on it was accumulated that agriculture and other industries absorbed the output no longer needed by the military. About 45,000,000 pounds of DDT was manufactured in the United States in 1946 with the resulting displacement of some of the old time, less effective insecticides.

DDT is highly effective in controlling mosquitoes, flies, fleas, bugs and many other species but it has its limitations. It is of little value against grasshoppers, roaches, beet webworm and a few other insects. It is considered useless against mites. Its use in orchards, greenhouses, and gardens often result in a rapid build-up of the mite populations because it fails to kill the mites, yet destroys their natural enemies.

When applied at the recommended rates, DDT is harmless to plants except for squash, melons and other cucurbits which become stunted as a result of DDT application. DDT is used to advantage in the treatment of extensive mosquito-ridden areas because it not only destroys the mosquitoes already present but its residual effect usually continues for two to three weeks to kill the mosquitoes which drift in on prevailing winds from the outer, untreated areas.

DDT has widespread use in the spraying of buildings and livestock, (except dairy buildings and milk cows) for control of flies and related pests. In addition, dairy cows should not be allowed to feed upon pastures or other fodder that has recently been sprayed because of objection to the DDT getting absorbed in the milk and its danger to public health. An investigation conducted at this station in 1948 showed that mere traces of DDT began to appear in the milk in about 60 hours after the cows had fed upon the freshly sprayed pastures.

DDT is especially useful because of its lasting action against insects. This, however, will vary with the conditions to which it is subjected. When applied to outdoor vegetation the residual toxicity seldom extends over more than two to three weeks because of new plant growth, and exposure to weathering which

causes the chemical to deteriorate, but when applied in buildings where it receives protection from the weather its effect is considerably extended.

Its long lasting action against insects in buildings was demonstrated in a fly control experiment conducted at this station in 1944. DDT spray of ¼% concentration was applied to the inner surfaces of a hog barn and several other farm buildings early in August of that year, and although its killing of flies was most spectacular in the first week or ten days, its effectiveness continued until the fly season was over in late September. The following spring there was still some evidence of its continuing insecticidal action. DDT was also tested at this station in 1944 against insects affecting potatoes and cattle lice and in both respects proved to be an outstanding insecticide.

DDD ($C_{14}H_{10}C1_4$) is also known as TDE, although the first abbreviation seems more appropriate since it stands for the three initials of its chemical name, dichloro-diphenyl-dichloroethane. It has also been referred to as Rhothane, or D-3. DDD has residual qualities which are not as long lasting, nor is the chemical as toxic to warm blooded animals as DDT.

DDD has been found to be specific on certain insects and is used extensively on apples for control of red banded leaf roller. It is also finding wide use on tomatoes and other vegetable crops.

Methoxychlor ($C_{16}H_{15}0_2C1_3$) is also known as DMDT or Marlate. Methoxychlor is however the accepted name. It is an excellent insecticide in many respects, being nearly as effective as DDT against flies and most other insects and yet less toxic to man and animals. It has been used to advantage to replace DDT for the spraying of dairy barns, dairy cattle and other purposes where DDT is objectionable. Methoxychlor is effective against a wide range of crop, livestock, household and industrial insects.

Benzene hexachloride ($C_6H_6C1_6$) is known as BHC, was discovered by Michael Faraday in 1825 but not recognized as an insecticide until 1943. Most of its early development and production was done in England during World War II. Large quantities of BHC were then used in Africa and the British Isles in the control of grasshoppers, and various other agricultural pests.

In its crude state BHC contains five isomers of which only one, the gamma isomer, is of value as an insecticide. One of the serious objections to BHC has been its disagreeable odor, which has limited its use in the control of insects affecting stored foods.

Recently, however, much progress has been made in refining BHC with the result that a product known as lindane containing about 99% gamma isomer is now available. Coincident with increasing the gamma isomer content its insecticidal value has been increased and its objectionable odor has been diminished. Lindane

is now a highly recommended insecticide for spraying livestock for control of mange mites and is a recommended seed treatment for destruction of wireworms in the soil.

Chlordane ($C_{10}H_6Cl_8$) is an effective insecticide and is used with outstanding success in the control of grasshoppers, crickets, roaches, houseflies and ants. It is an effective control of chiggers, sheep tick, ticks, mange mites and box elder bugs. It may be used in bait, sprays, or as dusts against grasshoppers and black field crickets. For control of ants it may be applied as a spray or dust with excellent results. For the control of roaches and box elder bugs good results are had by applying the emulsion spray or a ready prepared household solution containing 2 per cent chlordane.

The residual or lasting effect of chlordane, like most other organic insecticides, varies somewhat upon weathering. In field use against grasshoppers at 1 lb. per acre its effectiveness continues for about three weeks, which is long enough to extend over the hatching period of these insects. Most satisfactory protection of crop land is obtained by spraying the hatching areas soon after hatching begins, and before the young have dispersed and become widespread. The recommended rate of application ranges from ½ to 1½ pound per acre of actual chlordane. The lower amount is used when applied as a spray to control the young 'hoppers.

Where chlordane is used in buildings and other protected places the period of protection appears more lasting. This was demonstrated here in an experimental application of a 2 per cent chlordane emulsifiable spray to the floors and baseboards of a local building overrun with roaches, May 7, 1947. It not only gave quick control of the insects in the building but its lasting effects were observed to continue up to 16 weeks following the application. Although frequent inspection was made, no roaches were observed again in this building until the first week in September—and then only a few. Black field crickets (young and adults) were frequently observed to enter this building in late summer but were usually killed within one or two hours after they had entered by the continuing lethal effect of chlordane.

Toxaphene ($C_{10}H_{10}Cl_8$) is an effective insecticide in the control of grasshoppers, field crickets, armyworms, sugar beet webworms, lice, horn fly, sheep tick and insect pests of cotton. It is used at a higher rate than chlordane but, being lower in price, represents about the same cost on the per acre basis. From 1 to 2½ pounds of toxaphene per acre is recommended for control of grasshoppers. Our experience has indicated that toxaphene, as well as others in this group, tend to lose their toxicity faster when applied during periods of hot weather.

In tests conducted at this station in 1947, using both chlordane and toxaphene, excellent control was obtained when applications were made during periods when daily temperatures ranged from 70°F. to 80°F., but as temperatures increased above 90°F. the control became noticeably poorer.

Aldrin ($C_{12}H_8C1_6$) formerly known as Compound 118 and **Dieldrin** ($C_{12}H_80C1_6$) until recently known as Compound 497, are new preparations which show valuable possibilities in the control of various pests. They may be used alone or combined with certain other insecticides such as DDT to advantage. They are effective at low dosages and are compatible when mixed with most other materials. Further evaluation of these insecticides is desirable. They are not as yet readily available. These are the only alkali stable compounds in this group of chlorinated hydrocarbon insecticides. They are not adversely affected by lime or high soil pH.

The Organic Phosphates

Three organic phosphate compounds have come into extensive use during the past few years. They are **TEPP** (tetra-ethyl-pyrophosphate), **HETP** (hexa-ethyl-tetra-phosphate) and **parathion.** They are more effective in the control of aphids, red spider mites and some greenhouse pests than other chemicals in common use. They are, however, more dangerous to handle, and so, greater care must be exercised in their use. **IT IS DANGEROUS TO INHALE THE FUMES OR ALLOW THE SKIN OR CLOTHING TO GET SATURATED WITH THESE INSECTICIDES.** Such spray upon getting on the skin should be promptly washed off with water. Contaminated clothing should be replaced with fresh clothes. The operator should observe the additional precaution of wearing a respirator while using these insecticides and avoid any prolonged exposure to them.

During 1949 approximately 40,000 acres were sprayed in North Dakota with TEPP or parathion by airplane to control infestations of greenbug (grain aphid) in fields of late-seeded wheat and barley. This resulted in 90 to 95% control of the pests within a few hours following application. More lasting protection against these insects results from the use of parathion.

The Piperonyls

The piperonyls include two compounds of somewhat recent introduction. They are **piperonyl cyclonene** and **piperonyl butoxide.** Their main advantages are those of being non-toxic to warm blooded animals, but possessing valuable insecticidal properties. They are particularly useful as synergists to "step up" or increase the insecticidal value of pyrethrum and rotenone. They are recommended especially for control of insects in food processing places, and for treatment of such crops as spinach, lettuce, beans and ripening fruits, since their use represents no danger to human health.

ANNOTATED REFERENCES ON INSECT CONTROL[1]

By Dr. Richard Lewis Post[2]

I. Experimental Use of the Newer Organic Insecticides by the NDAC Experiment Station.

1944 Munro, J. A. New Insecticides. N. D. Bimon. Bull. 6 (5):14. (DDT is mentioned as a residual insecticide and its probable widespread use when available for domestic use.)

1945 Munro, J. A. and Redman, K. Effectiveness of DDT Against Potato Insects. N. D. Bimon. Bull. 7 (4):11. (Tests conducted in 1944 indicated that a 5% DDT-Copper dust was superior to other treatments including an arsenical, copper-lime, DN, and other dusts).

..... Munro, J. A. DDT Points the Way to Control of Insects. The Dakota Farmer. April 7, 1945. (A popular discussion about the outstanding results of DDT in 1944 on livestock, barns and potatoes in N. Dak.).

..... Munro, J. A., Redman, K., and Longwell, J. H. Effectiveness of DDT Against Flies in Livestock Barns. N.D. Bimon. Bull. 7 (5) :21-23. (Residual effects of DDT were recorded from application on August 10th until September 15, when the fly season was nearly over).

1946 Munro, J. A. and Hoyman, W. G. Evaluation of Various Spray and Dust Materials in the Control of Insects and of the Fungus Causing Early Blight of Potatoes. N.D. Bimon. Bull. 8 (3):23-30. (32 Spray and Dust treatments were applied at Grand Forks and Park River which included combinations of DDT and DDD. The treatments which contained DDT averaged the highest degree of insect control).

1947 Munro, J. A., Post, R. L. and Hoyman, W. G. Effect of Insecticides on Tuber Yield and Control Recommendations for 1947. N.D. Bimon. Bull. 9 (4):109-110. (Sixteen spray and dust treatments including DDT, DDD, BHC, and Chlordane were applied at Grafton. DDT dusts and sprays were among the highest yielding plots).

..... Knapp, R. B. and Aanestad, A. Summer Fly Spraying with DDT Controls Cattle Lice. N.D. Bimon. Bull. 9 (4):119. (From a survey conducted in February 1947 it was found that buildings and animals which had been treated the previous summer had a marked decrease in cattle lice).

..... Munro, J. A., Post, R. L. and Colberg, W. J. The New Insecticides in Fly Control. N.D. Bimon. Bull. 9 (5):123-128. (Six buildings and their livestock were treated with emulsions and wettable powders of DDT, DDD, and BHC. All insecticides gave satisfactory fly control at .5% concentrations. BHC—pure gamma isomer now called LINDANE—gave outstanding results in the hog barn).

..... Post, R. L., Munro, J. A. and Knapp, R. B. Chemical Control of Wireworms. N.D. Bimon. 10 (1):26-31. (DDT, Chlordane and BHC dusts were applied as soil treatments in wireworm infested fields at Minot and Southam. BHC 10% [1% gamma] dust was outstanding when applied at 20 lbs. per acre. At that time attention was called to possible taste contamination with the use of the crude material. This work is now very significant as the highly refined gamma isomer for seed treatment LINDANE—has recently become available).

..... Post, R. L., Munro, J. A. and Somsen, H. W. Control of Mosquitoes in Recreational Areas. N.D. Bimon. 10 (2):61-66. (Seven parks were sprayed with DDD, DDT, BHC and Chlordane emulsions or wettable powders. Excellent results were obtained with a .25% concentrations for one week and the mosquitoes reduced in numbers from 10 to 14 days).

1948 Post, R. L., Colberg, W. J., and Munro, J. A. Results of Spraying and Dusting Potatoes in North Dakota for 1946 and 1947. The American Potato Journal 25 (9):334-339. (A summarization of the results of two years of application of the newer residual insecticides. Practically all of the newer residuals, including the organic phosphates, were used with the exception of the newly developed ALDRIN and DIELDRIN).

..... Post, R. L., Colberg, W. J., and Munro, J. A. Effect of Insecticides on Tuber Yields. N.D. Bimon. Bull. 10 (3):98-100. (Sixteen spray and dust treatments were applied at Grand Forks. Two treatments, DDD, and DDT, showed significantly higher yields, Parathion, Toxaphene, HETP, Piperonyl butoxide and piperonyl cyclohexanone were among those tested. This was the first use of organic phosphates for aphid control in North Dakota).

..... Post, R. L. Potato Aphids and Their Control. N.D. Seed Journal 17 (2):2-3. (Aphid counts were made at weekly intervals on 16 insecticide plots at Grand Forks. The three plots showing lowest aphid populations were HETP, Toxaphene and Parathion respectively. Although no damage by Toxaphene was observed attention was called to its reported damage to potatoes in other states).

..... Munro, J. A. Spraying Alfalfa with DDT for Control of Lygus Bugs. N.D. Bimon. Bull. 10 (3):114-115. (A spray of 4 lbs. 50% DDT wettable powder to 100 gals. of water per acre gave 140 lbs. of alfalfa seed as compared to 18 lbs. per acre from the untreated area).

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[1]Supplement to a discussion on, "Use of the Newer Insecticides" at the Third Annual Statewide Conference on Use of Chemical in Agriculture at Devils Lake, North Dakota, March 31, 1950, and presented at the Second Annual Conference on Aerial Crop Dusting and Spraying at NDAC, Fargo, April 11, 1910.

[2]Associate Entomologist.

..... Munro, J. A., Nostdahl, W. D., and Engel, K. S. Baits and Dusts Against Grasshoppers and Crickets. N.D. Bimon. Bull. 11 (1):11. (Five insecticides were applied as a dust mixture in bran bait. Chlordane was superior over BHC, Sodium fluosilicate, Parathion and Toxaphene).

1949 Munro, J. A., Nostdahl, W. D. and Post, R. L. Wheat Stem Sawfly. N.D. Bimon. Bull. 11 (3):85-91. (The application of insecticides were ineffective in the control of the wheat stem sawfly. Chlordane, DDT, Toxaphene, Parathion, BHC and DDD dusts were applied).

..... Post, R. L., Colberg, W. J. and Munro, J. A. Effect of Insecticides on Tuber Yield and Insect Populations. N.D. Bimon. Bull. 11 (3):92-95. (Two plots, Parathion spray and Toxaphene dust, showed significantly higher yields as compared to the check plot. All of the 15 insecticides kept the major potato pests in check and the lowest aphid population was on the Parathion spray plot).

..... Post, R. L. and Munro, J. A. Mosquitoes of North Dakota. N.D. Bimon. Bull. 11 (5):173-183. (DDT content of milk samples following grazing of cows on pastures treated with DDT is reported at .1 to .7 ppm 60 hours following consumption).

..... Munro, J. A. and Davis, E. G. Greenbug Outbreak in 1949. N.D. Bimon. Bull. 12 (1):3-8. (The successful use of TEPP and Parathion in the control of the Greenbug [Grain Aphid] during the 1949 outbreak is reported. Nicotine sulphate, Toxaphene, BHC, Aldrin, Dieldrin and other organic insecticides were applied experimentally in the Gwinner area).

..... Post, R. L., McCalley, R. W. and Munro, J. A. Insecticidal Applications and Tuber Yields in North Dakota for 1949. N.D. Bimon. Bull. 12 (2):42-46. (Five treatments showed highly significant yields as follows: DDT 5% dust with CP-5 sticker, Parathion spray, Lethane-DDT spray, DDT-Sulphur dust and Parathion 1% dust. Parathion sprays had the lowest aphid population and among the highest yields both in 1948 and 1949. Due to the role of aphids in the transmission of virus diseases special emphasis was placed on aphid control. For the fourth consecutive year DDT 3% dust outyielded DDT 5% dust with an average difference of 15 bu. per acre for the four years).

..... Munro, J. A., Leraas, M. A. and Nostdahl, W. D. Biology and Control of the Sweet Clover Weevil. Jour. Ec. Ent. 42 (2):318-321. (Of the several insecticides tested during the past three years DDT, Chlordane, and Toxaphene were the most effective. Other insecticides including BHC, Barium fluosilicate, DDD, Calcium arsenate, Paris green and Parathion 1% dusts were less effective in the order named).

..... Munro, J. A. and Post, R. L. Control of Boxelder Bugs. Jour. Ec. Ent. 42 (6):994. (Excellent control of boxelder bugs was obtained by 2% Chlordane, Lindane and Toxaphene sprays followed by CS-645A, DDD 2% and DDT 1% sprays in that order).

II. NDAC Extension Service.

1950 Colberg, W. J. Kill Those Hoppers with Chlordane and Toxaphene. NDAC Ext. Ser. Circ. No. A-144. (An excellent six page circular of information covering all phases of grasshopper control).

III. Selected Sources for Information on Insect and Insect Control.

1939 Metcalf, C. L. and Flint, W. P. Destructive and Useful Insects. (Second Edition) 981 pp. This is the standard and best reference work on the life history, habits and recognition of insect pests. Unfortunately it does not cover the new area of residual organic insecticides. McGraw-Hill. $8.50.

1948 Metcalf, R. L. The Mode of Action of Organic Insecticides. Review No. 1. National Research Council. Washington, D. C. An academic discussion of the organic insecticides. This is a technical publication not intended for the layman as it is highly technical and has structural formulas for the various isomers and analogs. $1.50.

1949 McClintock, J. A. and Fisher, W. B. Spray Chemicals and Application Equipment. This book is excellent for equipment and is well illustrated. Also recommended for fungicides. However, only if interested in insecticides and their action would recommend ENTOMA for this information. Available from City & Farm Home Supply, LaGrange, Ind. $6.25.

1950 ENTOMA Eighth 1949-50 Edition. A Directory of insect and plant pest control with information on the newer insecticides, supplies and equipment together with tables of information and lists of entomological services and Insecticide and fungicide mgs. Postpaid for $1.50 from Geo. S. Langford, Chm. of the Editorial Comm. of the Eastern Branch of the Am. Ass'n. of Ec. Ent., Univ. of Md., College Park, Md. This is a must for every pest control operator and dealer of insecticides.

..... Frear, D.E.H. and Hilborn, M.T. Pest control Materials, 1950. The first list published in 1949 by Frear, Hilborn and Prince contained a list of more than 3,000 trade names. The new edition lists 4022 trade names of fungicides, herbicides, insecticides, and rodenticides. In addition it has both active ingredients and alphabetical list of companies cross referenced to the numbered list of trade names.