

## THE POSSIBILITIES OF THE UTILIZATION OF DDT AND GAMMEXANE FOR PLANT PROTECTION IN CEYLON

B. A. BAPTIST, Ph.D. (Cantab.), B.Sc. (Lond.),  
 ENTOMOLOGIST, DEPARTMENT OF AGRICULTURE

**D**URING the past five years two important new insecticides have come into prominence as being the most effective insect poisons so far discovered for dealing with insect pests. These are "DDT" and "Gammexane (666)", two synthetic organic chemicals. They have much resemblance to each other in their properties as far as methods of application and toxicity to insects are concerned. The general principles of the utilization will thus be largely controlled by the same factors.

"DDT" or 2, 2-bis (parachlorophenyl), 1, 1, 1-trichloroethane or dichlorodiphenyltrichloroethane, was first prepared in 1874 by Ziedler. The chemically pure substance is a crystalline solid, practically colourless and almost odourless. It is relatively stable and has low volatility. It is insoluble in water but soluble in most organic solvents. In 1936, J. R. Geigy of Basle, Switzerland, discovered that it possessed insecticidal properties. It has been very extensively used during the war for the control of mosquitoes, flies and household pests. Since 1943 it has been widely tested as an insecticide for use against insects attacking plants and domestic animals, and its insecticidal effectiveness contrasted with the commonly used insecticides like the Arsenic, Pyrethrum, Derris and Nicotine products. Comprehensive large scale field trials have, however, been relatively few on account of supplies not being available during the war for general or civilian use.

Gammexane or 666, the Gamma isomer of Benzene hexachloride or 1, 2, 3, 4, 5, 6-hexachlorocyclohexane, is a substance rather similar in appearance and general physical properties to DDT. It is rapidly decomposed in the presence of alkalies but it is stable in the presence of ground limestone or chalk either dry or in water at ordinary temperatures. Its insecticidal usefulness was discovered by Raucort in 1941 in connexion with the control of the clothes moth when it was found to be superior to Napthalene and Paradichlorobenzene, and by Thomas and others in 1942 in connexion with the control of the Turnip flea beetle in England. Subsequently, it has been tested against various agricultural pests on the majority of which it has shown a high toxic effect, comparable with the results achieved with DDT and far superior to the common insecticides.

Both DDT and Gammexane can be used as dispersible powders diluted with selected materials or in solution in an organic solvent, these solutions being diluted for use with kerosene and other suitable oils. Against mosquitoes and household pests, where water sprays are not necessary, relatively high concentrations of the active ingredient can be used and from 5-10 per cent.

of the insecticides have been applied. A 5 per cent. DDT in kerosene has been generally found to be the most economical method of spray application in these cases. For agricultural use, however, where water sprays are required only much lower concentrations have been available for use as sprays. As dusts higher concentrations have been available.

The insecticidal properties of both these substances and their manner of action appear to be somewhat similar. Their toxicity to almost all insects against which they can be applied is definitely greater than that of the well known insecticides generally used for the control of agricultural pests. In their mode of action they appear to act as nerve poisons and are effective both when ingested with food or when absorbed through the outer body wall. The first symptoms are the twitching of movable organs. This is followed by paralysis of the legs and eventually collapse and death. The speed of knock-down especially with Gammexane is not so great as that given by Pyrethrum. It is largely dependent on the size or body weight of the insect, as well the general habits and activity of the insect in cases where the spray or dust is not directly applied on them. Death occurs with few exceptions only several minutes or hours after the actual exposure to the insecticide. Apart from the direct effect obtained by application of the insecticide on the body or food of the insect, both insecticides have a very potent residual action, being effectively absorbed from surfaces to which the insecticide has been applied through the tarsi of the legs. This residue is able to withstand atmospheric conditions and is thus effective for several days after application, thus contributing a cumulative effect and greatly increasing mortality. There is of course individual variation depending on the particular insect and insecticide used and the nature of the application on the plant surface.

From trials already carried out in various countries, DDT has been found to be more effective than other standard insecticides for insects of such widely different habit as surface feeding beetles and caterpillars, sucking insects and even certain boring insects. It has also been successfully used against stored grain-infesting insects and soil insects. Gammexane has not been so extensively tested but has given more or less similar results, showing a toxicity value equal to or greater than DDT in the majority of cases. It has also been clearly shown in actual tests both on a laboratory and field scale that the insecticidal effectiveness of these two substances against practically all the insects tested is not less and is usually far superior to other insecticides which can be used. Amongst insects which are extremely sensitive to DDT are the Diptera including the flies and mosquitoes, and it has been very successfully used on a large scale in controlling these pests. Many tests have also been carried out against important agricultural pests with DDT. In America DDT has been found to be far superior to Derris, Pyrethrum and Nicotine against Cabbage caterpillars. It has been found to be superior to arsenates for the control of the cotton boll weevils, bollworm and cotton bugs. As an orchard spray against Codling moth and other pests it has been found to be superior to arsenate sprays. It has also been found to be very effective on sucking bugs such as, Capsids and leaf hopper pests against which it has been difficult to utilize other insecticides economically in order to effect a satisfactory control. On the other hand it is very toxic to bees and other pollinating insects, as well as to parasitic and predatory insects which effect in many cases a natural control of pests. It is also toxic to fish and crustacea but fortunately rather less so to birds and mammals.

As far as man and domestic animals are concerned the concentration of these insecticides in applications to plants is too small to cause any harm or produce any toxic symptoms. They are, however, very much more toxic to all animals as an emulsion than as an oil or suspension and particular care should be exercised if an emulsion is used. Sprays have better residual effects than dusts, the deposit being more stable and not affected by the mechanical effects of rain.

#### DESCRIPTION OF TRIALS

In Ceylon these insecticides have only been available in sufficient quantity for tests on a laboratory scale and trials have been directed chiefly towards ascertaining the relative degree of toxicity for individual pests with a view to working out effective dosage strength and the most suitable manner of application in the field. In addition to the descriptive account given, the final observations on mortality are recorded in comparative tables.

*Stored grain insects.*—In carrying out the trials a sample size of 125 oz. of grain was used and storage done in jute hessian bags placed on a cement floor. Green gram, cowpea, and wheat were used, the two former being infested with *Bruchus chinensis* L., and the wheat with *Calandra oryzae* L., and *Rhizopertha dominica* F. Insecticidal dusts were the proprietary products D025 (666) and Gesarol (DDT). Preliminary tests showed that dosages of less than .025 per cent. Gammexane and .012 per cent. DDT became progressively infested after 4–6 weeks of storage. Dosages of .025 per cent. (666) and .012 per cent. DDT were the most suitable and were found to destroy all insects in the grain and to keep grain free from attack for a period of 6 months and over. The use of higher dosages did not make an appreciable difference to the effectiveness of the treatment. No detrimental effect on germination was experienced and no ill effects were produced on poultry fed with the treated grain for a continuous period of 2 weeks.

*Leptocorisa varicornis* F.—The insects were exposed to the insecticides in cages containing the host plants where the plants alone were treated and also where the internal surface of the cage as well as the plants were treated. In the former case the insects were retained in the original cages into which they were introduced. In the latter they were transferred to untreated cages after a specific period of exposure in the treated cage. Mortality was taken as the point at which the insect was unable to support itself upright on its legs, and observations regarding mortality were noted only up to a period of 48 hours after the time of initial introduction of the insects. Insecticidal preparations used were made from Geigy's Gesarol (DDT) and Imperial Chemical Industries products, D025 and D919.

Preliminary tests showed that there was no appreciable difference between effects on adults and effects on 3rd and 4th instar nymphs, and final tests were made only using adults. Dust applications of lower than 3 per cent. active principle were not sufficiently effective when applied only on the plant surface, giving an incomplete and inconstant mortality. Dusts containing 3 per cent. and over of active principle were very effective producing 100 per cent. mortality. The effectiveness was retained on the walls of the cage for a period extending up to 3 weeks, but was not sufficiently retained on the plant surface to produce effective mortality for a period longer than 5–7 days. Gammexane seemed to be more toxic to the insects than DDT, producing quicker mortality and longer residual effect.

DDT was tried also as a spray. A spray containing .1 per cent. active principle produced no appreciable effect unless insects were exposed to it for a continuous period of not less than 6 hours in cages which had all surfaces treated with the insecticide. Spray application containing .5 per cent. active principle gave 100 per cent. mortality after exposure for 2 hours. The effectiveness of the spray application was retained for nearly one week on plant surfaces and up to nearly 2 weeks on the surface of the cage.

*Dacus cucurbitae* Coq.—Insects were obtained from material collected from Cucumber and Snakegourd. Treatment was similar to that given to *Leptocorisa*. With insecticidal dusts containing 3 per cent. active ingredient, a 5-minute exposure to the treated surface was sufficient to produce 100 per cent. mortality. The mortality was reduced to 20 per cent. on the 5th day after application, the count being taken only up to 48 hours after original introduction. An exposure of two hours to the insecticidal surface gave 100 per cent. mortality, effectiveness being retained for nearly 2 weeks. Exposure to a surface sprayed with .1 per cent. DDT gave 100 per cent. mortality with 6 hours continuous exposure, the surface remaining effective for 2 weeks. Insects exposed in cages in which plants alone were treated gave a 100 per cent. mortality up to the fifth day of treatment and over 50 per cent. mortality up to 8 days in the case of dusts containing 3 per cent. active ingredient.

*Aularches miliaris* L.—The insects used were 4th and 5th instar nymphs. Preliminary trials showed that at least 2 hours exposure period is necessary to bring about appreciable mortality as the movement of insects in the cage is relatively little. The insects were very much more sensitive to Gammexane than to DDT. A 2 hour exposure to dust containing 1 per cent. Gammexane produced 100 per cent. mortality. The effectiveness of the treated surface was retained for 1 week. With DDT a 2 hour exposure to a 3 per cent. dust failed to produce any mortality, while continuous exposure produced appreciable but not total mortality.

*Agromyza phaseoli* Coq.—Insects were kept in cages in which the plant surface alone was treated. A mortality of 100 per cent. was obtained for periods extending up to 10 days after initial application of dusts containing 3 per cent. active ingredient. The spray containing .1 per cent. DDT was slightly less effective. In the application of the insecticides to garden plots it was found that appreciable mortality of plants through *Agromyza* attack was obtained when the insecticide application was carried out at intervals longer than 4 days. Both insecticides appeared to be equally effective.

*Prodenia litura* F.—Caterpillars of the 3rd and 4th instars were used for trials. The insects showed much reluctance to feed on treated leaves. Total mortality was obtained with both insecticides in dusts containing 3 per cent. active ingredient. A residual effect was maintained for over 4 days which was as long as leaves could be maintained in a suitable condition for feeding the caterpillars. A spray containing .1 per cent. DDT was also effective and produced a mortality of 80 per cent. as compared with a 15 per cent. mortality in a parallel test in which Lead Arsenate was used at the rate of 1 oz. in 2 gallons of water. Observations were only carried out up to 2 days after the original introduction of the insects.

*Miscellaneous insects.*—Mortality ranging from 80–100 per cent. was obtained in the treatment of a number of insects attacking growing plants in the field, using a 3 per cent. Gammexane dust prepared from D025. Amongst these were *Ragmus importunitas* Dist. on Sunn-hemp: *Bagrada picta* F. on Radish: *Aulacophora intermedia* Jac. on cucumber: *Crocilodonia binotalis* Z. on cabbage: *Dorylus orientalis* Westw. on Radish: toxicity towards Honey Bees and parasitic Hymenoptera was found to be extremely high and comparatively greater than towards any of the destructive insects tested.

*Phytocidal effects.*—No appreciable scorching was produced on mature foliage by dust preparations containing less than 5 per cent. active ingredient of either insecticide. Slight scorching was produced by 3 per cent. dusts and .1 per cent. sprays of both insecticides on tender foliage of Cucurbitaceous plants and French beans.

#### DISCUSSION AND CONCLUSIONS

It appears from a comparison of these results with those obtained in other countries that the general insecticidal effects of these insecticides on crop pests in Ceylon have not been of such a high degree of potency as that which seems to be obtained from trials carried out in temperate countries. It is likely, therefore, that generally slightly higher dosages will be necessary in Ceylon. The degree of toxicity obtained however is quite relevant to claims made for these insecticides and definitely surpasses that of the older insecticides in common use. Despite this potency very much field experimentation is necessary before their economic value can be properly estimated and definite recommendations made for their use for general agricultural purposes in Ceylon. Even laboratory tests have indicated that the high insecticidal effects obtained for these insecticides may not be reflected by a corresponding high mortality in the field. Much will depend on the general habits and activities of the insects under natural conditions and the ecological factors of the area.

On the other hand the high insecticidal value of the substances can make them akin to a two-edged sword, as they could act equally effectively against beneficial insects, a factor of relatively negligible importance in the case of the older insecticides in use. In countries like Ceylon this is specially significant, as a large number of crop pests are normally kept at negligible population levels through the activities of insect parasites and predators. It would be essential therefore to watch the effects produced by the use of these insecticides on parasites and predators in any particular case. Honey bees would be also adversely affected by the application of these insecticides unless these applications are so timed as to avoid periods of major flowering, especially on crops regularly visited by bees.

The eventual economic efficiency of these insecticides can, therefore, only be properly ascertained after extensive and repeated field trials carried out in relation to specific pests in their natural environment. The preliminary trials carried out have shown, however, that they can be recommended for use on a restricted scale under special circumstances such as, minor pest epidemics in restricted areas where the natural balance has already been upset, and the sudden appearances of a pest in relatively large numbers in small or domestic gardens. Effective applications in this connexion, which can be recommended on the basis of the tests carried out, are, the use of dusts containing from 3–5 per cent. of the active ingredient in weekly applica-

tions, or, the use of aqueous sprays containing .1-.5 per cent. of the active ingredient applied twice weekly. Dusts should be applied only under relatively dry conditions. It would also not be generally advisable to continue the application of the insecticides for periods longer than a fortnight at one stretch.

It may also be said that these two insecticides have good possibilities with regard to the control of the majority of serious economic pests of this country, for which at present the degree of control that can be achieved through insecticidal or other means is inadequate or uneconomic. In such cases, however, extensive trials will have to be carried out and detailed schedules of application obtained in connection with each specific pest.

At present Gammexane appears to be superior in toxic value to DDT for insects on plants and therefore the more promising of the two insecticides for agricultural use, but much may still depend on the ability of manufacturers to produce water miscible sprays with high insecticidal contents.

#### REFERENCES

- Annand, P. N. *et al.*—Tests conducted to appraise the usefulness of DDT as an Insecticide. *J. Econ. Ent.*, Vol. 37, No. 1, 125-158.
- Bruce, W. G. and Blakeslee, E. B. DDT to control Insect Pests affecting Livestock. *J. Econ. Ent.*, Vol. 39, No. 3, 367-374.
- Carman, G. E., and Fleshner.—Laboratory tests on Oriental Fruit moth with special reference to DDT. *J. Econ. Ent.*, Vol. 37, No. 1, 122.
- Cotlam, C.—DDT and its effect on Fish and wildlife. *J. Econ. Ent.*, Vol. 39, No. 1, 44-51.
- Davis, J. J.—DDT to control household and stored grain insects. *J. Econ. Ent.*, Vol. 39, No. 1, 59-61.
- Driggers, B. F.—Performance of DDT used against the Oriental Fruit moth. *J. Econ. Ent.*, Vol. 37, No. 1, 120.
- Eckert, J. E.—The effect of DDT on Honey Bees. *J. Econ. Ent.*, Vol. 38, No. 3, 369-374.
- Filmer, R. S., and Smith, C. L.—DDT as a contact poison for honey bees. *J. Econ. Ent.*, Vol. 37, No. 4, 537.
- Ginsbury, J. M.—Toxicity of DDT to *Blatella germanica* as compared with Sodium fluoride, Derris and Pyrethrum.
- Granovsky, A. A.—Tests of DDT for the control of Potato Insects. *J. Econ. Ent.*, Vol. 37, No. 4, 493-499.
- Gyrisko, Jodka and Rawlins.—DDT to control Potato insects. *J. Econ. Ent.* Vol. 38, No. 2, 169-173.
- Ivy, E. E. *et al.*—DDT for Boll worm control during 1944. *J. Econ. Ent.*, Vol. 38, No. 5, 534-536.
- Ivy, E. E., and Ewing, K. P.—Benzene Hexachloride to control Cotton Insects. *J. Econ. Ent.*, Vol. 39, No. 1, 38-40.
- Jones, S. C.—Ground treatment with DDT to control Pear Thrips in soil under Prune Trees. *J. Econ. Ent.*, Vol. 38, No. 1, 122.
- Knipling, E. F.—DDT to control insects affecting Man. *J. Econ. Ent.*, Vol. 39, No. 3, 360-366.
- Lindgren, D. L., and Boyce, A. M.—Results with Dichloro-diphenyl Trichloroethane in control of California Red Scale. *J. Econ. Ent.*, Vol. 37, No. 1, 123-124.
- Lindquist, Jones and Madden.—DDT residual type sprays as affected by light. *J. Econ. Ent.*, Vol. 39, No. 1, 55-58.
- Osburn, M. R.—DDT to control the little Fire Ant. *J. Econ. Ent.*, Vol. 38, No. 2, 167-168.
- Page, A. B.—Insecticides and their application, 1939-1945. *Emp. Cotton Growing Rev.*, Vol. 23, No. 2, 90-101.
- Parancia, Ivy and Ewing.—Control of Boll worm and Cotton Flea Hopper by DDT. *J. Econ. Ent.*, Vol. 39, No. 3, 329-335.
- Raucort, M.—Déconverte récente d'un Novel insecticide l'hexachlorocyclohexane. *La Nature* No. 3093, 235-236.
- Shaw, H.—Some uses of DDT in Agriculture Nature. Vol. 157, No. 3984, 285.
- Slade, K.—A New British Insecticide. *Chem. Trade J.* 116, No. 3017, 279-281.
- Smith, C. L., and Driggers, B. F.—Toxicity of DDT to *Macrocentrus Ancylivorus*. *J. Econ. Ent.*, Vol. 37, No. 4, 538.

- Smith, C. N. and Gouck, H. K.—DDT to control ticks on vegetation. *J. Econ. Ent.*, Vol. 38, No. 5, 553-555.
- Snapp, O. I.—DDT to control Bugs that cause deformed peaches. *J. Econ. Ent.*, Vol. 39, No. 1, 41-43.
- Stammers, F. M. G., and Whitfield, F. S.—Toxicity of DDT to man. *Nature*, Vol. 157, No. 3994, 658.
- Stevenson, W. A.—DDT compared with other insecticides for control of Hemipterous insects on Cotton. *J. Econ. Ent.*, Vol. 38, No. 5, 531-533.
- Wigglesworth, V. B.—A case of DDT poisoning in man. *Brit. Med. J.*, No. 4397, 517.
- Wilson, J. D. and Slesman, J. P.—Possible influences of new organic Pesticides on experimental test procedure. *Bi-m Bull. Ohio Agric. Exp. Stn.*, Vol. 30, No. 232, 27-30.
- Yeager, J. F., and Munson, S. C.—Physiological Evidence of a site of action of DDT in an Insect. *Science* 102, No. 2647, 305-306.

TABLE I.  
Effect of Gammexane (666) and DDT on Stored Grain.

Grain.	Initial Infestation.		Treatment.	Later Infestation.			
				After 3 months.		After 6 months.	
				Treated.	Control.	Treated.	Control.
Green gram	.. 5%	..	.05% 666	.. 6%	.. 19%	.. 4%	.. 25%
Cowpea	.. 6%	..	.025% 666	.. 6%	.. 12%	.. 7%	.. 56%
Wheat	.. 8%	..	.05% 666	.. 9%	.. 42%	.. 12%	.. 64%
Wheat	.. 8%	..	.012% DDT	.. 7%	.. 42%	.. 9%	.. 64%
Wheat	.. 10%	..	.025% 666	.. 11%	.. 35%	.. 12%	.. 52%
Wheat	.. 10%	..	.012% DDT	.. 10%	.. 35%	.. 12%	.. 52%

TABLE II  
Effect of Gammexane and DDT on Various Insects.  
(Insecticides applied both on plant surface and sides of cage).

Insect.	Insecticide Nature and Strength.	Period Exposure.	Mortality noted up to 48 hours after introduction.			
			Day of applica- tion.	5 days later.	10 days later.	14 days later.
			Per Cent.	Per Cent.	Per Cent.	Per Cent.
<i>Leptocorisa varicornis</i>	.. 3 per cent. 666 Dust	.. 2 hrs.	.. 100	.. 100	.. 100	.. 100
	.. 3 per cent. 666 Dust	.. 15 min.	.. 100	.. 60	.. 40	.. 0
	.. 3 per cent. DDT Dust	.. 2 hrs.	.. 100	.. 100	.. 100	.. 100
	.. 3 per cent. DDT Dust	.. 15 min.	.. 100	.. 20	.. 20	.. 0
	.. 5 per cent. DDT Spray	.. 2 hrs.	.. 100	.. 0	.. —	.. —
	.. 1 per cent. DDT Spray	.. 6 hrs.	.. 100	.. 40	.. 0	.. —
<i>Dacus cucurbitae</i>	.. 3 per cent. 666 Dust	.. 2 hrs.	.. 100	.. 100	.. 100	.. —
	.. 3 per cent. 666 Dust	.. 15 min.	.. 100	.. 100	.. 20	.. —
	.. 3 per cent. DDT Dust	.. 2 hrs.	.. 100	.. 40	.. 20	.. —
	.. 3 per cent. DDT Dust	.. 15 min.	.. 100	.. 100	.. 20	.. —
	.. 1 per cent. DDT Spray	.. 6 hrs.	.. 100	.. 60	.. 0	.. —
<i>Aularches miliaris</i>	.. 1 per cent. 666 Dust	.. 2 hrs.	.. 100	.. —	.. —	.. —
	.. 3 per cent. 666 Dust	.. 2 hrs.	.. 100	.. 100	.. —	.. —
	.. 3 per cent. DDT Dust	.. 2 hrs.	.. 0	.. —	.. —	.. —
	.. 5 per cent. DDT Spray	.. 24 hrs.	.. 0	.. —	.. —	.. —

10 insects were used for each test ; a control was kept in all cases and percentage mortality was determined by taking the numbers alive at the end of the test as determining numbers with the numbers alive in control as maximum.

Table III.

## Effect of Gammexane and DDT on Various Insects.

(Insecticides applied on plant surfaces only to which insects were continuously exposed.)

Mortality noted up to 48 hours after introduction.

Insect.	Insecticide Nature and Strength.	Phytocidal effect on host plant.	Mortality noted up to 48 hours after introduction.		
			Day of applica- tion. Per Cent.	5 days later. Per Cent.	10 days later. Per Cent.
<i>Leptocorisa varicornis</i>	3 per cent. 666 Dust ..	None	100	100	10
	3 per cent. DDT Dust ..	None	100	80	0
	1 per cent. DDT Spray..	None	40	40	0
<i>Dacus cucurbitae</i>	3 per cent. 666 Dust ..	Slight scorching tender foliage	100	100	40
	3 per cent. DDT Dust ..	do.	100	40	0
	1 per cent. DDT Spray..	None	100	0	0
<i>Aularches miliaris</i>	3 per cent. 666 Dust ..	None	100	100	20
	3 per cent. DDT Dust ..	None	800	0	0
	1 per cent. DDT Spray..	None	30	20	0
	5 per cent. DDT Spray (emulsion)	Slight scorching	60	10	0
<i>Prodenia litura</i>	3 per cent. 666 Dust ..	None	100	80	—
	3 per cent. DDT Dust ..	None	100	60	—
	1 per cent. DDT Spray..	None	80	0	—
<i>Agromyza phaseoli</i>	3 per cent. 666 Dust ..	Slight scorching tender foliage	100	100	100
	3 per cent. DDT Dust ..	None	100	100	60
	1 per cent. DDT Spray..	Slight scorching tender foliage	100	80	20

10 insects were used for each test and treated plants retained in cage till observations were over; a control was kept in all cases and percentage mortality determined by taking the numbers alive at the end of test as the determining numbers with the numbers alive in control as maximum.