https://doi.org/10.29321/MAJ.10.A03357

Madras agric. J. 63 (11—12) : 632—637, Nov.—Dec., 1976

Ameliorative Effect of Farm Compost on the Toxicity of a Chlorinated Hydrocarbon Insecticide Applied to a Tropical Legume

By

A. BALASUBRAMANIAN[1], M. V. SHANTARAM[2], D. P. VISWANATH[3], A. N. A. KHAN[4] and M. B. SUBRAMANYA[5]

ABSTRACT

Field application of BHC to redgram *(Cajanus cajan* L.) at rates higher than the recommended level of 1 ppm a. i. resulted in adverse toxicity towards germination and growth. Dry matter and grain yields were reduced drastically with progressive increase in BHC levels. However, BHC had no deleterious effect on nodulation or nitrogen uptake by the surviving redgram plants. Application of composted farmyard manure (FYM) at 0.2, 0.4 and 0.8% carbon levels in soil overcame the toxic effects of 5,10 and 25 times, respectively of the recommended BHC rate.

INTRODUCTION

The ever increasing use of organochlorine pesticides in the agricultural practice in tropics warrants a detailed investigation on the effect of these chemicals on non-target organisms. A major portion of the pesticides applied on aerial plant parts ultimately reach the soil in varying concentrations. The possibility of their gradual accumulation and the long-range effect they might have on crop yields and soil properties should be considered especially when recalcitrant pesticides like Benzene hexachloride or BHC (1,2,3,4, 5,6 - hexachlorocyclohexane) or its isomers are involved. The persistent nature of several organochlorine insecticides has been reviewed by Alexander (1968) and Edwards (1966). Organochlorine insecticides, applied to or accmulating in soil, are reported to be inhibitory to nodulation and yield of leguminous crops (Appleman and Sears, 1964; Diatloff, 1970; Magu *et al*., 1972; Payne and Fults, 1947). A few reports have also indicated that organic matter additions can reduce the toxicity to plant growth due to accumulations of organochlorine insecticides in soil (Adams and Paulina, 1971; Pareek and Gaur, 1970). The present investigation deals with the effect of BHC application on the nodulation and yield of redgram (*Cajanus cajan* L.), an extensively cultivated tropical legume and the influence of composted farm manure in ameliorating the adverse effect of the pesticide.

MATERIALS AND METHODS

A field experiment was conducted

1 5: Department of Agricultural Microbiology, University of Agricultural Sciences, Bangalore-562142.

in a red sandy loam (Rhodustolf) soil of pH 5.8, organic carbon 0.65 per cent, total nitrogen 0.08 per cent and CEC 11.0 meq/100g. The net area of each experimental plot was four square meters. The experiment was laid out conforming to a completely randomised block design with the following treatments: five levels of BHC, viz., 0 ppm, 1 ppm (normal recommended field rate), 5 ppm, 10 ppm and 25 ppm a.i. and composted farm manure (hence forth referred to as FYM) (organic carbon 21.0 per cent, total nitrogen 1.40 per cent) at 0, 0.2, 0.4 and 0.8 per cent carbon levels based on the weight of 22.5 cm soil depth. The required quantities of the pesticide and FYM were spread out evenly on the surface of each experimental plot and mixed thoroughly to a depth of 22.5 cm. Equal number of healthy, viable redgram seeds (germination per cent 95) treated with the specific *Rhizobium* strain in peat culture, were sown in each plot to maintain uniform plant populaions. Each plot received phosphorus at the rate of 90 kg P_2O_5 per hectare as superphosphate and no nitrogen, before sowing. The plots were irrigated twice weekly. Date on germination and growth of the plants were recorded at 7 and 15 days after sowing. Nodulation counts were obtained on seven week-old plant after carefully uprooting three plants at random from each experimental plot. The root system was washed gently in running tap water, blotted dry, the nodules were carefully detached, counted, dried at 70°C for four days and weighed. The plants were harvested after 12 weeks by uprooting and the pods were separated. Dry weight of plants from each plot was obtained after drying the plants at 70°C for four days. The pods were dried in sunlight for 10 days, shelled and shell and grain weights were obtained. The weight of empty pod shells were added to the corresponding dry weight of plants. The plant and grain samples were analysed for nitrogen by the microkjeldahl method (A. O. A. C., 1975). The data on the number and weight of nodules, plant and grain weights were analysed statistically to ascertain the interaction between FYM and BHC.

RESULTS AND DISCUSSION

The results on germination and growth of redgram plants grown with varying levels of BHC are presented in Table I. In the absence of FYM, the application of BHC at recommended level (1 ppm a. i.) had no deleterious effect on germination and growth of redgram, but at 5 and 10 ppm levels germination and growth of seedlings were adversely affected. At 25 ppm of BHC opplication germination was severely inhibited. However, the addition of FYM at 0.2 per cent carbon level could overcome the initial toxicity due to BHC up to 5 ppm and the ameliorative effect of FYM could be seen only after 7 days. FYM addition at 0.4 per cent carbon level could completely overcome the toxic effect of BHC which could be observed during the first 7 days itself Increased level of FYM (0.8 per cent) ameliorated the toxicity to germination of redgram, but the ameliorative effect was observed

TABLE I. Influence of BHC and FYM on germination and growth of redgram

Treatment	7th day		15th day	
	Germination (%)	Growth	Germination (%)	Growth
FYM-0				
BHC-0	80	Normal	80	Normal
BHC-1 ppm	80	Normal	80	Normal
BHC-5 ppm	40-80	Delayed	40-80	Delayed
BHC-10 ppm	40	Stunted	40	Stunted
BHC-25 ppm	0	No Growth	0	No Growth
FYM-0.2% Carbon				
BHC-0	80	Normal	80	Normal
BHC-1 ppm	80	Normal	80	Normal
BHC-5 ppm	40-80	Delayed	80	Normal
BHC-10 ppm	40	Stunted	40	Stunted
BHC-25 ppm	40	Stunted	40	Stunted
FYM-0.4% Carbon				
BHC-0	80	Normal	80	Normal
BHC-1 ppm	80	Normal	80	Normal
BHC-5 ppm	80	Normal	80	Normal
BHC-10 ppm	40	Stunted	40-80	Stunted
BHC-25 ppm	40	Stunted	40	Stunted
FYM-0.8% Carbon				
BHC-0	80	Normal	80	Normal
BHC-1 ppm	80	Normal	80	Normal
BHC-5 ppm	80	Normal	80	Normal
BHC-10 ppm	40-80	Delayed	80	Normal
BHC-25 ppm	40	Stunted	40-80	Delayed

only after 7 days. The toxic effect of BHC at 25 ppm was prolonged but was found to be ameliorated between 7 and 15 days growth of the crop. However, even after 15 days the growth of the plants was relatively poor. Similar delayed ameliorative effect was recorded with 10 ppm of BHC treatment along with FYM at 0.2 or 0.4 per cent carbon level.

The results on nodulation of redgram plants are presented in Table II. The data on nodule number failed to show any significant difference due to application of BHC and/or FYM. As regards nodule weight, there was no adverse effect when BHC was applied alone. In fact, a progressive increase in nodule weight was observed with increasing levels of BHC and a significant increase in nodule weight was observed at 5 ppm of BHC application. In general, application of BHC alone upto 10 ppm level did not exhibit any inhibitory effect on nodulation and the application of the pesticide with FYM appeared to favour better nodulation.

The results obtained on the yield

TABLE II. Effect of BHC and FYM on nodulation in redgram

BHC level	No. FYM		FYM 0.2% C		FYM 0.4% C		FYM 0.8% C	
	A	B	A	B	A	B	A	B
0 ppm	1.08	7.49	2.16	4.99	6.58	62.33	10.99	24.33
1 ppm	2.99	15.83	11.83	64.99	8.92	51.06	5.92	47.49
5 ppm	5.33	23.66	9.16	19.33	7.24	23.33	6.99	31.66
10 ppm	3.99	15.88	8.74	48.33	7.75	38.33	4.91	24.16
25 ppm	0	0	3.66	20.83	7.66	17.50	7.66	11.96

FYM X BHC interaction significant at 5% probability level
C.D = 1.29 on transformed scale of X + 0.5

A Average number of nodules/plant B Average weight of nodules/plant (mg)

of redgram, presented in Table III, clearly demonstrated that, when the pesticide was applied alone, with progressive increase in BHC concentration the yield was reduced drastically. This was possibly due to the direct toxicity of the pesticide to the plant, as the nodulation or nitrogen uptake (Table IV) of the plant was not affected to any significant extent. The addition of FYM at 0.2 per cent carbon level effectively ameliorated the toxic effect of BHC up to 10 ppm. However, at 25 ppm of BHC, the addition of FYM at 0.2 and 0.4 per cent carbon level apparently had no significant influence in reducing the toxicity to the crop as indicated by the yield of dry matter and grain, which were lower than the yields obtained from the control plots to which no BHC or FYM was added. Addition of FYM at 0.8 per cent carbon level could effectively overcome the phytotoxic effect of 25 ppm of BHC application.

Several investigators have pointed out the toxic effect of BHC accumulation on plant growth (Marth, 1965). The results of the present study also provide similar evidence that BHC accu-

TABLE III. Effect of BHC and FYM on yield in redgram

BHC level	No FYM		FYM 0.2% C		FYM 0.4% C		FYM 0.8% C	
	A	B	A	B	A	B	A	B
0 ppm	422	109	527	132	832	224	722	208
1 ppm	370	89	770	206	665	156	842	198
5 ppm	45	36	584	170	712	126	732	189
10 ppm	35	15	427	130	592	118	730	152
25 ppm	0	0	55	8.5	320	45	702	125

FYM X BHC interaction significant at 5% probability level
A C. D = 0.090 on transformed scale of log (X + 2)
B C. D = 0.034 on transformed scale of log (X + 2)

A : Dry weight of plants (g/plot)
B : Grain weight (g/plot)

TABLE IV Effect of BHC and FYM on nitrogen uptake by redgram plants (g/100 g dry matter)

BHC level	No FYM	FYM 0.2% C	FYM 0.4% C	FYM 0.8% C
0 ppm	2.453	2.631	2.511	2.661
1 ppm	2.499	2.582	2.680	2.663
5 ppm	2.936	2.638	2.684	2.434
10 ppm	2.700	2.874	2.596	2.560
25 ppm	——	2.819	2.915	2.833

mulation in soil can cause acute toxicity to seed germination and plant growth. These results also support the findings of Payne and Fults (1947), Salem *et al*. (1971) and Magu *et al*. (1972) who have reported that normal recommented doses of several organochlorine insecticides applied to soil were not toxic to nodulation of leguminous plants. However, the observation that, eventhough the dry matter yield of plants was not significantly affected, a significant reduction in grain yield when BHC was applied at the recommended level was in contradiction to the findings of some these earlier reports. The expression of toxicity of pesticide to plant growth may vary with soil type and the crop (Bowman *et al*., 1965).

The addition of compost and decomposing cereal straws was reported to influence nodulation favourably(Mase field, 1965). The interactions between organic matter and pesticides in soil and their influence on soil microflora and crop growth are yet to be clearly understood. The mechanism of adsorption of the added pesticide to organic colloids on the addition of organic matter is believed to play a role in reducing the pesticide toxicity (Harris, 1966; Hsu and Bartha, 1973). Also the addition of organic matter is known to increase the biodegradation of several organochlorine insecticides. (Castro and Yoshida, 1974; Yoshida and Castro, 1970). It is probable that both adsorption and increased degradation of the added insecticide might have contributed to the reduction in phytotoxicity. The increased levels of FYM required to ameliorate toxicity due to higher levels of BHC indicated that, probably the added organic matter is providing more adsorption area for the pesticide molecule. The immediate response of FYM in reducing the toxicity to germination and growth of redgram suggested that adsorptive inactivation of the added pesticide may be more pronounced than biodegradation which should involve a time lag. Selective adaptability of the soil microflora to BHC cannot be expected to be immediate and the adaptive microflora can be expected to degrade the pesticide only slowly. These results point to possibility of suppressing phytotoxicity of several organochlorine pesticides in environments where there is a possibility of such toxic levels of accumulations of the pesticide, by the application of composted organic manures.

REFERENCES

ADAMS, R. S., Jr., and L. PAULINA, 1971. Soil properties influencing sorption and desorption of lindane. *Soil Sci. Soc. Amer. Proc.* 36 78-81.

ALEXANDER, M. 1965. Biodegradation: problems of molecular recalcitrance and microbial fallibility. *Advan. Appl. Microbiol.* 7: 35-80.

A. O. A. C. 1975. *Methods of Analysis*, 12th Edn. Association of Official Analytical Chemists, Washington D. C. p-16.

APPLEMAN, M. D., and O. H. J. SEARS. 1964. Effect of DDT upon nodulation of legumes. *J. Amer. Soc. Agron.* 38: 545.

BOWMAN, M. C., M. S. SCHECHTER and R. L. CARTER, 1965. Behaviour of chlorinated insecticides in a broad spectrum of soil types. *J. Agr. Fd. Chem.* 13: 360.65.

CASTRO, T. F. and T. YOSHIDA. 1974. Effect of organic matter on biodegradation of some organochlorine insecticides in submerged soils *Soil Sci. Plant Nutr.* 20: 363-70.

DIATLOFF, A., 1970. The effects of some pesticides on root nodule bacteria and subsequent nodulation. *Cust. J. Expt. Agric. Anim. Husb.* 10: 562.

EDWARDS, C. A. 1966. Insecticide residues in soil. *Residue Rev.* 13: 83-132.

HARRIS, C. R., 1966. Influence of soil type on the activity of insecticides in soil. *J. econ. Ent.* 60: 41-44.

HSU, T. S. and R. BARTHA, 1973. Interaction of pesticide derived chloraniline residues with soil organic matter. *Soil Sci.* 166: 444-52.

MAGU, S. P., A. C. GAUR, and K. V. SADASIVAM, 1972. Effect of lindane on nodulation, grain yield and nitrogen uptake by gram *(Cicer arietinum)* crop. *Proc. Symp. Legume Inoculants*, New Delhi. p. 27.

MASEFIELD, G. B. 1965. The effect of organic matter in soil on legume nodulation. *Expt. Agric.* 1: 113.

MARTH, E. H. 1965. Residues and some effects of chlorinated hydrocarbon insecticides in biological material. *Residue Rev.* 9: 1-69.

PAREEK, R. P. and A. C. GAUR. 1970. Effect of DDT on symbiosis of *Rhizobium* sp. with *Phaseolus aureus* (greengram). *Pl. Soil* 33: 297-304.

PAYNE, M. G. and J. L. FULTS, 1947. Some effects of 2,4-D, DDT and Colorado 9 on root nodulation in the common bean. *J. Amer. Soc. Agron.* 39: 52.

SALEM, S. H., J. SZEGI, and F. GULYAS, 1971. The influence of some insecticides on the symbiosis of rhizobia and legume plants. *Agrokhemia es Talajtan* 20: 581-89.

YOSHIDA, T. and T. F. CASTRO, 1970. Degradation of gamma BHC in rice soils. *Soil Sci. Soc. Amer. Proc.* 34: 440-42.