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# Effect of DDT residues in soil on productivity of oil seed crops

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## ABSTRACT

**DDT (1,1'bis(p-chlorophenyl) 2,2,2-trichloroethane) is detrimental to oil seed crops such as peanut, soybean and mustard. The effect was directly proportional to DDT concentration in soil. A small-scale field trial showed significant reduction in total biomass and economic yield of these crops with DDT treatments. Soybean and mustard plants showed chlorosis in DDT contaminated plots to a great extent while nodule formation in peanut was reduced considerably and was proportional to DDT concentration in soil. Yield of soybean and mustard was reduced significantly at the lowest dose i.e. routine spray of DDT without any DDT residues in soil. Peanut, however, showed significant reduction at the higher doses of DDT treatments i.e. routine spray along with DDT residues in soil. Less detrimental effect in peanut plants compared to two other crops could be due to large canopy size of this crop diluting DDT concentration in the photosynthetic tissues, affecting plant metabolism to a lesser extent.**

*Key words*: DDT residues, mustard, peanut, productivity, soybean, vigour.

## INTRODUCTION

The use of organochlorine insecticides like DDT and BHC is banned in most of the advanced countries for plant protection and public health purposes. However, in many tropical countries their use was continued until the last decade (Hussain *et al.* 1988) due to high effectiveness, low cost, safe handling, and broad spectrum of insect control. Prolonged and indiscriminate use of these highly persistent compounds resulted in accumulation of these chemicals in soil (Yeadon and Perfect 1981) causing great concern for agricultural ecosystem. Presence of DDT residues in soil and plants may cause injury to the plants (Cullinan 1949; Lichtenstein *et al.* 1962; Martin 1972) and reduction in crop productivity (Thakre and Saxena 1972; Perfect *et al.* 1979). In India, use of DDT in agriculture was restricted to few crops only and about 50,000 tonnes of DDT was reported to be used in agriculture sector till date (Mehrotra 1985). High levels of DDT and BHC in food products in India was found to be due to the use of these pesticides in public health programmes and their abuses in preserving food products against recommendation (Bami 1987). DDT is still manufactured in India in large quantities and exported to different countries (Mathur 1998). Thus soil environment is continuously contaminated with the spray drift, irrigation water and factory affluent. Due to the high recalcitrant nature of this compound, residue level of DDT builds up in the soil, which is the major environmental sink for all agrochemicals (Khan 1980).

Detrimental effect of DDT on high oil containing vegetables such as capsicum was reported recently (Mitra and Raghu 1998). Raghu *et al.* (1981) reported DDT residues in groundnut oil, which was taken up by plants from contaminated soils. Our earlier study showed inhibitory effect of DDT on oil seed crops (Mitra and Raghu 1989). Calcium (Ca) and potassium (K) uptake was found to be inhibited considerably in the seedlings of these plants and also in peanut plants at harvest (Mitra *et al.* 1991). Since several vital functions in the growing plants are controlled by these mineral nutrients, it was decided to study the effect of DDT on the productivity of oil seed plants. The present report deals with the effect of DDT on the growth and yield of three oil seed crops.

## MATERIALS AND METHODS

### Crops

Three important oil seed crops viz. peanut (*Arachis hypogaea* cv. TG-17), soybean (*Glycine max* cv. Bragg) and mustard (*Brassica juncea* cv. Varuna) were used for this study. The plants were grown under laboratory and field conditions in the experimental field of Bhabha Atomic Research Centre, Trombay, Mumbai, India.

### Pesticides

Commercial grade DDT (SULDIT-50 W.P.) having 50% active ingredient and manufactured by Sulphur

Mills Pvt. Ltd., Mumbai, India, was used for soil treatment and insecticide spray. Dimecron (Phosphamidon, 85%) from Hindusthan Ciba Geigy Ltd., Mumbai, India, was alternately used (0.3%) for 'untreated control' treatment.

**Laboratory experiments**

The experiments were carried out with Vertisol soil of pH-7.6; and with 0.8% O.C; 61.8% clay; 17.8% silt and 20.4% sand. Soil was collected from the field from a depth of 0-15 cm and passed through a 2-mm sieve. The sieved soil was artificially contaminated with DDT at 2.5-100 ppm (mg a.i. $kg^{-1}$) level using a mechanical mixer (Mitra and Raghu 1988) to find out the effect of DDT in soil on these plants. Plants of three crop species were grown in aluminium trays for three to four weeks depending upon the crop in a growth chamber with 12h photoperiod of 9000 lux at tray level at 22± 2°C. The moisture content of soil in the tray was maintained at 60-80%. Soil without DDT was used as control for comparison. An average of 50 plants for each treatment was taken into consideration.

**Field experiments**

Field trials were carried out during Rabi (winter) season between 1988-1991. Crops were grown in 9.9mX3.6m plots in rows. Plots were laid down in a series for each treatment at a distance of 5.0 m from each other and were surrounded by a 45-50 cm high bund or boundary wall to avoid cross contamination. Plots, before sowing were ploughed (17 cm depth) and treated with SULDIT-50 at 5 kg a.i. $ha^{-1}$ (81g/plot) or 50 kg a.i. $ha^{-1}$ (810 g/plot) following the method of Jackson (1967) to add DDT at 5 and 50 ppm levels. Minimum dose was selected on the basis of typical application rate recommended at the time of use (1.12 mg $kg^{-1}$ of DDT a.i. per application) and the number of application in one crop season which varied from 4-7 depending upon the intensity of pest infestation. Ten times of minimum dose which earlier showed more than 30% reduction in laboratory experiments, was also used to estimate the extent of damage in the crop by high residuelevels in soil. Soils were mixed with DDT thoroughly, levelled and used for sowing. Control plots received no DDT.

**Fertilizers and planting**

Soil was treated with dry farm yard manure (40 t $ha^{1}$) before sowing. Seeds were sown in rows at 30 cm spacing. The spacing between plants was 15 X 40 cm for peanut and soybean, and 20 X 40 cm for mustard.

Nitrogen and phosphorus were applied in the form of urea and superphosphate 45 days after sowing, at the rate of 20 and 40 kg $ha^{-1}$ respectively for peanut and soybean and 50 and 40 kg $ha^{-1}$ respectively for mustard.

**Treatments**

Different treatments were AC (absolute control i.e. no DDT in soil and no pesticide spray), UC (untreated control i.e. no DDT in soil and sprayed with Dimecron instead of DDT), C (treated control i.e. no DDT in soil but sprayed with DDT for pest control), T-1 (soil treated with 5kg a.i. $ha^{-1}$ of DDT and sprayed with DDT) and T-2 (soil treated with 50 kg a.i. $ha^{-1}$ of DDT and sprayed with DDT). The treatments are presented in Table 1.

DDT was sprayed at the rate of 1.5-2.0 kg $ha^{-1}$ per application, 5-7 times depending on pest infestation at manufacturer's recommended dose for caterpillars and different types of insects and flies. In addition to DDT, mustard received two applications of 0.03% Dimecron at an interval of one week to check aphids which were resistant to DDT. UC plots were sprayed with 0.03% Dimecron to study the effect of DDT spray alone on these plants.

**Observations**

AC plots were completely destroyed by insect pests. It was difficult to make direct comparison of yield between sprayed and unsprayed crops because of variable incidence of insect attack during the crop development, which was the main reason for yield difference. Comparison was, therefore, made among treatments where all the plots were sprayed with DDT and the main variable was the level of DDT (Perfect *et al.* 1979). The first observation was made six weeks after sowing. Five plants at random were removed from each row for all the treatments in each crop. The leaf area was measured by automatic area meter model AAM-7 (Hayoshi Denkoh Co., Tokyo, Japan). Total leaf area for peanut and soybean and of third and fourth leaf for mustard was taken into consideration. Chlorophyll content of leaves was determined following the method described by Arnon (1949). Leaves were collected from ten plants in each treatment. Leaves from each treatment were mixed thoroughly and chopped fine before use. One-gram material in triplicate from each sample was extracted with 80% acetone for chlorophyll

estimation. Leaf nitrogen was estimated from oven dried leaf samples by Autoanalyzer (Industrial Method No. 334-74 W/B - Technicon). Oil content of seeds was measured by Soxhlet extraction with petroleum ether (Gadgil and Mitra 1983). Pollen sterility was studied under microscope after staining with acetocarmine. Flowers from ten plants in each treatment were collected in the early hours of morning. About one thousand tetrads from each treatment were analysed and % sterility was compared. Standard error of mean was computed for all parameters studied and the yield data were analysed using analysis of variance.

## RESULTS AND DISCUSSION

### Growth and development

Laboratory studies on the effect of DDT on plant growth showed inhibition in seedling height at a concentration as low as 2.5 ppm (mg $kg^{-1}$ soil) in peanut and soybean. At this concentration seedling heights at one-month growth period were 7.1±2.0 and 15.1±0.9 cm respectively compared to 10.0±0.5 and 18.1±1.2 cm in control plants growing in soil without any DDT. Inhibitory effects increased with the increase of DDT concentrations in soil. However, mustard at this concentration did not show any inhibitory effect probably due to greater tolerance to DDT or lesser uptake of DDT due to small size of the seeds. Earlier it was shown that uptake of DDT during germination was directly proportional to seed size (Mitra and Raghu 1989). At highest concentration of DDT in soil (100ppm) plant growth reduced considerably and the seedling height of peanut and soybean were 2.9±0.2 and 13.4±0.9 cm respectively and in mustard it was 2.2±0.1 cm compared to 5.0±0.1 in control plants.

Effect of DDT on early vegetative growth in the field (results not shown) showed marginal reduction of germination percentage in peanut and mustard. The emergence in soybean on the other hand showed little delay with DDT treatments. It could be due to imbibition damage in these seeds as reported earlier by MacDonald *et al.* (1988). They proposed leakage of intracellular substances from these seeds due to non-regulated imbibition affecting seed metabolism and delaying emergence period.

Effect of DDT on vegetative growth at 6-week stage in different treatments is shown in Table 2. Reduction in plant height, fresh/dry weights, leaf number and leaf area in all the crops were observed in DDT treated soils. Nitrogen concentration of leaf decreased considerably in soybean and mustard with DDT treatments. In peanut there was no reduction in N concentrations but total leaf nitrogen and chlorophyll per plant decreased considerably due to reduction in the number and size of leaves with DDT treatment.

Chlorophyll concentration of the leaves at different stages of plant growth is shown in Table-3. The decrease in chlorophyll level in the leaves was observed throughout the growth period in soybean and mustard. More chlorophyll in the leaves of T-2 plants in peanut compared to other treatments was recorded during the later period of plant growth. This may be due to slow growth rate of T-2 plants. These plants remained green for a longer period compared to other treated plants. Highest degree of chlorosis was observed in soybean plants where DDT spray

**Table 1. Details of treatments used in the field experiment.**

| Experimental condition | Treatments | | | | |
|---|---|---|---|---|---|
| | AC | UC | C | T-1 | T-2 |
| Foliar spray | none | dimecron | DDT | DDT | DDT |
| DDT in soil | none | none | none | 5ppm | 50 ppm |

AC: absolute control, UC : untreated control, C : treated control, T-1: 5ppm DDT (5 kg $ha^{-1}$) in soil, T-2: 50ppm DDT ( 50kg $ha^{-1}$ ) in soil.

**Table 2. Effect of DDT on oil seed crops in the field after 6 weeks of sowing.**

| Crop | Tr | Height (cm) | Fresh weight (g) | Dry weight (g) | No. of leaves | Leaf area ($cm^2$) | mgN/g dry wt. Leaf |
|---|---|---|---|---|---|---|---|
| Peanut† | UC | 11.4 | 82.3 | 4.5 | 9.0 | 1014.5 | 50.4 |
| | | (0.3) | (1.0) | (0.5) | (0.3) | (19.9) | (3.7) |
| | C | 6.9 | 77.8 | 5.3 | 8.0 | 857.1 | 53.0 |
| | | (0.2) | (1.0) | (0.3) | (0.2) | (13.3) | (3.0) |
| | T-1 | 6.4 | 62.4 | 4.4 | 8.0 | 697.1 | 50.0 |
| | | (0.2) | (0.6) | (0.9) | (0.2) | (13.6) | (0.9) |
| | T-2 | 5.7 | 55.6 | 3.8 | 7.0 | 589.5 | 54.6 |
| | | (0.2) | (1.8) | (0.2) | (0.4) | (62.5) | (4.7) |
| Soybean† | UC | 16.5 | 8.2 | 1.3 | 15.0 | 551.0 | 46.4 |
| | | (1.1) | (3.0) | (0.1) | (1.0) | (52.6) | (0.5) |
| | C | 13.4 | 6.4 | 1.0 | 8.0 | 516.7 | 39.9 |
| | | (7.5) | (2.0) | (0.1) | (0.5) | (39.0) | (0.6) |
| | T-1 | 12.7 | 4.9 | 0.8 | 7.0 | 533.6 | 40.8 |
| | | (1.0) | (0.8) | (0.1) | (0.3) | (109.8) | (0.4) |
| | T-2 | 11.3 | 4.7 | 0.7 | 7.0 | 300.2 | 37.0 |
| | | (0.5) | (1.5) | (0.1) | (0.2) | (18.9) | (1.1) |
| Mustard†† | UC | 10.0 | 126.9 | 5.7 | 13.0 | 682.1 | 45.7 |
| | | (3.9) | (3.6) | (1.2) | (4.0) | (97.0) | (0.8) |
| | C | 9.7 | 118.3 | 3.8 | 12.0 | 984.6 | 43.6 |
| | | (2.9) | (3.6) | (0.8) | (4.0) | (154.2) | (1.4) |
| | T-1 | 10.2 | 76.6 | 2.7 | 8.0 | 607.5 | 36.9 |
| | | (2.0) | (8.0) | (0.6) | (0.5) | (82.1) | (0.9) |
| | T-2 | 5.6 | 73.4 | 1.7 | 7.0 | 626.0 | 40.9 |
| | | (2.3) | (2.2) | (0.3) | (2.0) | (182.0) | (0.2) |

Figures in parenthesis indicate standard error of mean,
† mean of 3 yr., †† mean of 2 yr
UC: untreated control, C: treated control, T-1: 5 kg $ha^{-1}$ DDT and T-2: 50 kg $ha^{-1}$ DDT in soil, Tr- Treatment

**Table 3. Effect of DDT on chlorophyll content of the leaves at different stages of plant growth.**

| Growth period in weeks | Chlorophyll content (mg / g fresh weight of leaves)* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Peanut | | | | Soybean | | | | Mustard | | | |
| | UC | C | T-1 | T-2 | UC | C | T-1 | T-2 | UC | C | T-1 | T-2 |
| 3 | 1.94 (0.3) | 1.89 (0.0) | 1.89 (0.01) | 1.87 (0.3) | 1.76 (0.05) | 1.00 (0.07) | 0.85 (0.01) | 0.77 (0.03) | 0.77 (0.01) | 0.72 (0.0) | 0.81 (0.02 | 0.68 (0.00) |
| 6 | 1.70 (0.3) | 1.40 (0.33) | 1.67 (0.36) | 1.21 (0.26) | 1.69 (0.2) | 1.13 (0.3) | 0.78 (0.06) | 0.67 (0.03) | 0.59 (0.11) | 0.34 (0.04) | 0.23 (0.01) | 0.20 (0.02) |
| 9 | 1.32 (0.00) | 1.58 (0.04) | 1.12 (0.04) | 1.68 (0.01) | 1.12 (0.18) | 1.31 (0.3) | 0.62 (0.06) | 0.83 (0.13) | 0.32 (0.01) | 0.23 (0.11) | 0.25 (0.02) | 0.19 (0.02) |
| 12 | 0.81 (0.3) | 0.74 (0.32) | 0.72 (0.06) | 1.9 (0.2) | NA | NA | NA | NA | NA | NA | NA | NA |

* mean of 3 readings; NA- not analysed (leaves mostly dried); Figures in paranthesis indicate standard error of mean.
UC: untreated control, C: treated control, T-1: 5 kg ha$^{-1}$ DDT in soil, T-2: 50 kg ha$^{-1}$ DDT in soil

**Table 4. Effect of DDT on the growth and productivity of oil seed crops at harvest (Mean of two years observations).**

| Plant | Treatment | Height (cm) | Dry wt. (g) | Leaf N (mg/g dry wt.) | No. of pods | Dry wt. pods (g) | No of seeds | Dry wt. seeds (g) | 100 seed weight (g) | immature seeds (%) | % oil in dry seeds |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Peanut | UC | 31.5 (3.5) | 31.5 (1.0) | 40.7 (0.3) | 34.0 (4.0) | 31.3 (7.5) | 39.0 (2.0) | 17.5 (2.2) | 44.2 (3.7) | 2.2 (1.1) | 52.3 (1.0) |
| | C | 27.2 (4.2) | 34.5 (1.0) | 39.0 (0.3) | 32.0 (9.0) | 26.7 (8.0) | 35.0 (5.0) | 13.9 (2.0) | 39.6 (0.1) | 5.1 (0.6) | 48.2 (1.0) |
| | T-1 | 26.2 (2.5) | 35.3 (0.9) | 40.4 (0.3) | 34.0 (11.0) | 23.6 (9.0) | 35.0 (13.0) | 12.3 (4.7) | 34.3 (0.8) | 5.7 (0.1) | 48.3 (0.4) |
| | T-2 | 26.8 (4.3) | 34.6 (1.5) | 40.4 (0.2) | 26.0 (4.0) | 14.9 (0.9) | 27.0 (5.0) | 8.5 (1.4) | 31.9 (0.1) | 6.0 (0.4) | 48.0 (0.0) |
| Soybean | UC | 28.1 (1.2) | 17.2 (0.4) | 47.9 (0.5) | 18.0 (2.0) | 9.7 (2.9) | 39.0 (5.0) | 4.3 (0.3) | 13.3 (1.7) | 21.8 (0.1) | 21.4 (0.2) |
| | C | 25.2 (1.0) | 12.0 (4.6) | 41.4 (0.6) | 12.0 (1.0) | 6.0 (0.8) | 26.0 (2.0) | 3.2 (1.2) | 11.7 (2.0) | 25.6 (1.4) | 21.7 (0.2) |
| | T-1 | 23.3 (0.1) | 10.9 (6.1) | 42.2 (0.4) | 9.0 (1.0) | 3.3 (0.1) | 20.0 (2.0) | 1.8 (0.4) | 9.1 (0.8) | 29.3 (3.7) | 20.8 (0.1) |
| | T-2 | 22.4 (0.1) | 9.9 (6.9) | 38.5 (1.0) | 8.0 (1.0) | 2.1 (0.2) | 17.0 (1.0) | 1.4 (0.4) | 8.4 (1.5) | 29.5 (3.8) | 21.1 (0.2) |
| Mustard | UC | 140.4 (3.9) | 14.5 (0.8) | 47.3 (0.3) | 228.0 (32.0) | 7.0 (0.7) | - | 3.3 (0.5) | 0.23 (0.002) | - | 32.4 (2.0) |
| | C | 131.5 (1.8) | 12.5 (0.6) | 45.1 (1.4) | 146.0 (27.0) | 6.0 (0.6) | - | 3.0 (0.) | 0.24 (0.002) | - | 34.2 (3.7) |
| | T-1 | 113.7 (3.2) | 8.6 (0.6) | 38.3 (0.9) | 109.0 (13.0) | 3.6 (0.4) | - | 1.7 (0.2) | 0.23 (0.003) | - | 31.6 (0.7) |
| | T-2 | 107.4 (2.7) | 6.6 (0.4) | 42.4 (0.2) | 102.0 (10.0) | 3.1 (0.3) | - | 1.5 (0.2) | 0.21 (0.01) | - | 31.6 (0.8) |

Figures in parenthesis indicates standard error of mean UC: untreated control, C: treated control, T-1: 5 kg ha$^{-1}$ DDT, T-2: 50 kg ha$^{-1}$ DDT in soil

alone was found to be detrimental for chlorophyll synthesis as was reported earlier in ornamental plants by certain insecticides and acaricides (Dennis and Edwards 1961) and in vegetables by malathion (Smith *et al.* 1976).

The nodulation in peanut plants in the field at six week growth period was found to be inhibited by DDT treatment. Nodulation was reduced by 46.9, 48.2 and 58.4 % in C, T-1 and T-2 plants respectively compared to UC plants, indicating inhibition with DDT spray alone. This is in agreement with observations made earlier with DDT in peanut plants in a pot study (Murthy and Raghu 1978). Nodulation in the early growth period is important as fertilizer was applied only after six weeks.

DDT treatments on pollen sterility showed no inhibitory effect on pollen sterility even with highest exposure (T-2 treatment) in any of these crops.

## Productivity and yield

DDT adversely affected plant growth and

productivity of the three oil seed crops. Inhibition in plant growth and fruit formation at 12-week growth period was also observed in all the crop plants (data not presented). Effect on growth and yield is shown in Table 4. Average values of three year's observation in peanut and soybean; and of two years in mustard are presented since mustard was completely destroyed by aphid attack during the first year due to DDT resistance. In the subsequent years mustard was sprayed with Dimecron in addition to DDT. Results show reduction in plant growth (height and dry weight of plant) and in yield components (number and dry weights of pods and seeds) in soybean and mustard plants at harvest. Peanut, however, showed reduction in height only with DDT treatment while dry weight of plant was more in treated plants compared to control (UC) plants. It was observed that leaves of treated peanut plants remained healthy and green for a longer period as compared to control plants. The difference in leaf nitrogen levels of treated and untreated plants was non-significant. The delayed growth effect was also seen in seed maturity. A higher percentage of immature seeds without any effect on pod number in peanut indicate no effect of DDT in pod setting but slow seed filling in the pods. The poor photosynthetic rates due to chlorophyll deficiencies in soybean and mustard could be responsible for poor yield in C and T-1 plants. The oil content (%) of seeds in soybean and mustard showed no change while in peanut it decreased in treated plants.

The economic yield from field experiment is given in Table-5. Statistical analysis of yield components showed highly significant reduction in plant productivity in all the three species due to DDT. Reduction in all parameters in soybean and mustard and in dry weight of pods and seeds in peanut with DDT treatment was highly significant. No significant reduction in pod number in T-1 plants of peanut indicated that at lower concentrations, DDT had no effect on pod setting. However, in T-2 plants inhibition was significant. The lower number of seeds could be due to poor pod filling as indicated by higher percentage of immature seeds in this treatment. In soybean and mustard both fruit setting and seed formation in treated plants were significantly affected at this dose and was probably due to extreme chlorosis. Significant reduction in 100 seed weight of peanut and soybean further supports poor seed filling in these plants. In soybean and mustard total oil yield per plant or per unit area was reduced significantly in treated plants. The effect was less in peanut. Significant reduction in the economic yield in all the oil seed crops studied was also observed in DDT treated plots (Table 5).

The total biomass (%) of C, T-1 and T-2 plants compared to UC plants were 107.7±10.1, 114.1±3.6 and 92.2±10.3 respectively in peanut; 71.7±12.5, 66.8±13.8 and 46.7±13.2 in soybean; and 85.5±14.1, 55.8±4.3and53.0±8.8 in mustard. This indicated more detrimental effect of DDT on soybean and mustard compared to peanut plants. Less inhibitory effect in peanut was probably due to its profuse vegetative growth diluting DDT concentration in the photosynthetic tissues. Thus the metabolic activity of peanut was reduced to a lesser extent with the same treatment compared to other plants.

Thus our study showed that DDT in general is

**Table 5. Economic yield of oil seeds per square meter area.**

| Plant | Crop duration | Treatment | No. of fruits | Dry wt. fruits, g | No of seeds | Dry wt. seeds, g | 100 seed wt., g | Oil yield, g |
|---|---|---|---|---|---|---|---|---|
| Peanut | 120 days | UC | 508.22 ab | 561.92 a | 670.17 a | 358.71 a | 58.47 a | 148.91 a |
| | | C | 534.59 a | 479.17 ab | 550.65 ab | 326.63 ab | 55.89 b | 147.58 a |
| | | T-1 | 504.20 abc | 389.65 abc | 538.56 abc | 302.82 abc | 53.79 c | 119.54 b |
| | | T-2 | 335.59 d | 317.70 bcd | 351.29 d | 180.58 d | 53.33 cd | 91.78 b |
| Soybean | 90 days | UC | 335.76 b | 171.71 a | 518.02 a | 59.91 a | 11.67 a | 17.71 a |
| | | C | 189.90 b | 92.08 b | 312.29 b | 32.69 b | 9.90 b | 11.12 b |
| | | T-1 | 121.38 b | 64.43 bc | 309.56 bc | 19.97 bc | 9.87 bc | 5.38 c |
| | | T-2 | 107.23 b | 32.46 cd | 177.92 bcd | 14.70 bcd | 8.30 d | 4.88 c |
| Mustard | 110 days | UC | 970.43 b | 50.42 a | - | 23.91 a | 0.20 | 13.57 |
| | | C | 1124.00 a | 41.48 ab | - | 19.94 ab | 0.24 | 9.67 |
| | | T-1 | 775.44 bc | 33.69 c | - | 9.09 cd | 0.23 | 4.87 |
| | | T-2 | 596.73 bcd | 17.35 cd | - | 9.65 c | 0.21 | 4.68 |

For each crop, within each column figures followed by the same letter denote samples not significantly different (1% level).
- not counted, UC: untreated control, C: treated control,
T-1: 5kg ha$^{-1}$ DDT, T-2: 50kg ha$^{-1}$ DDT

detrimental to oil seed crops. The detrimental effect was more in soybean and mustard. It could be due to poor photosynthetic activity as a result of chlorosis in these plants. It appears that DDT being more fat soluble, probably dissolves readily and gets dispersed in cytoplasmic fats of the cell in oil seed plants affecting cell metabolism (Mitra and Raghu 1989). It is also possible that by inhibiting mineral nutrition uptake (especially potassium and calcium in plants), several vital processes in the plant cells are affected causing growth retardation in this group of plants as predicted earlier (Mitra *et al.* 1991). According to Mengel and Kirkby (1978) potassium deficiency reduces plant growth first, followed by chlorosis. Our earlier studies (Mitra *et al.* 1991) showed that at 50mg $kg^{-1}$ level of DDT, potassium uptake was reduced by 24.5, and 59.4 and 29.7% in peanut, soybean and mustard respectively. More reduction of potassium uptake in soybean and mustard probably explains extreme chlorosis in these two plants, which in turn showed greater reduction in the yield.

In conclusion, it appears that DDT has pronounced inhibitory effects on growth and yield of soybean and mustard even at the lowest dose without any residue of DDT in soil (treatment C - Table 1). In peanut, the inhibitory effect is relatively less compared to the other two crops and was discernible only at higher concentration of DDT.

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## REFERENCES

Arnon DI 1949 Copper enzymes in isolated chloroplasts polyphenol oxidases in *Beta vulgaris*. Plant Physiol. 24: 1-15.

Bami HL 1987 Pesticides- their industrial and health hazards and environmental pollution in India. Pesticides Information 13: 16-20.

Cullinan FP 1949 Some new insecticides. Their effect on plant and soils. J. Econ. Entomol. 42: 387-391.

Dennis EB and Edward CA 1961 Phytotoxicity of insecticides and acaricides 1. Foliar sprays. Plant Pathol. 10: 54-60.

Gadgil JD and Mitra R 1983 Chemical composition of seeds in induced groundnut mutants and their derivatives. Indian J. Agric. Sci. 53: 295-298.

Hussain H, Tirmazi H and Barbar Z 1988 Studies on degradation and dissipation of DDT in a sandy loam soil under laboratory and field conditions. International Atomic Energy Agency-TECDOC-476 : 9-18.

Jackson ML 1967 Soil chemical analysis. Prentice Hall, New Delhi, India. pp. 498.

Khan, SU 1980 Pesticides in the soil environment. Elsevier Scientific Publishing Co., New York. pp. 280.

Lichtenstein EP, Millingyon WF and Cowly GT 1962 Effect of various insecticides on growth and respiration of plants. J. Agr. Food Chem. 10: 251-256.

MacDonald MB, Vertucci CW and Ross EE 1988 Soybean seed imbibition: Water absorption by seed parts. Crop Sci. 28: 993-997.

Mathur SC 1998 Pesticides industry in India. Pesticides Information 23 : 17-29.

Martin JP 1972 Side effects of organic chemicals on soil environment. In. Vol: 2. Goring CAI. and Hamaker JW (eds), Marcel Dekker Inc. New.York. pp. 735-792.

Mehrotra KN 1985 Use of DDT and its environmental effects in India. Proc. Indian Natn. Acad. Sci., B51: 169-184.

Mengel K and Kirkby EA (ed) 1978. Principles of plant nutrition. International Potash Institute Worblaufen-Bern, Switzerland pp.381.

Mitra J and Raghu K 1988 Influence of green manuring on the persistence of DDT in soil. Environ. Technol. Letters. 9: 847-852.

Mitra J and Raghu K 1989 Effect of DDT on the growth of crop plants. Environ. Pollut. 61: 157-170.

Mitra J, Ramachandran V and Nirale AS 1991 Effect of DDT on plant mineral nutrition. Environ. Pollut. 70: 71-80.

Mitra J and Raghu K 1998 Detrimental effects of soil residues of DDT on chillies (*Capsicum annuum*). Fresenius Envir. Bull. 7: 8-13.

Murthy NBK and Raghu K 1978 Effect of organochlorine insecticides on plant growth, nodulation and soil microflora. Proc. Symp. Nuclear Techniques in Studies of Metabolism, Effects and Degradation of Pesticides. Department of Atomic Energy, Tirupathi, India. pp. 160-167.

Perfect TJ, Cook AG, Critchley BR, Critchley U, Davies AL, Swift MJ, Russel-Smith A and Yeadon R 1979 The effect of DDT contamination on the productivity of a cultivated forest soil in the sub-humid tropics. J. Appl. Ecol. 16: 705 - 719.

Raghu K, Murthy NBK and Ferreira J 1981 DDT residues in groundnut and changes in residues during processing of groundnut oil. In: Nuclear Techniques for Studying Chemical Residue Problems in Edible Oil Seeds and Related Products. International Atomic Energy Agency, TECDOC-243, Vienna. pp. 49-54.

Smith CA, Gunther FA and Adams JD 1976 Worker environment research III. A rapid method of the semiquantitive determination of some dislodgable pesticide residues on citrus foliages. Bull. Environ. Contam. Toxicol. 15: 305.

Thakre SK and Saxena SN 1972 Effects of chlorinated insecticides on plant growth and uptake of nutrients by wheat and maize. J. Ind. Soc. Soil Sci. 20: 45-48.

Yeadon R and Perfect TJ 1981 DDT residues in crop and soil resulting from application to Cowpea *Vigna unguiculata* (L) Walp in subhumid tropics. Environmental Pollution (Series B) 2: 275-294.