Tropical Agricultural Research and Extension. 2 (1): 30-32, 1999

Performance of seed pelletization in *Acacia leucophloea* (Roxb.) under different soil types

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Accepted 27 May 1999

ABSTRACT

***Acacia leucophloea* seeds were pelleted with Diammonium phosphate (30g kg^{-1} of seed), commercial micronutrients mixture (19.7g kg^{-1} of seed), *Rhizobium* (50 g kg^{-1} of seed), Sevin (2g kg^{-1} of seed) and *Trichoderma viride* (4g kg^{-1} of seed). The pelleted seeds along with unpelleted control were evaluated in calcareous, sandy loam, acidic and sodic soils. Pelleted seeds registered significantly higher germination and seedling vigour compared to unpelleted control under all soil types. However, higher germination and seedling vigour were recorded in calcareous soil. In the acidic soil also pelleted seeds recorded significantly higher germination and seedling vigour than the unpelleted control. Hence, pelleting of seeds could be recommended for augmenting germination and seedling vigour under adverse soil conditions.**

Key words: *Acacia leucophloea*, germination, seed pelletization, *Rhizobium*, *Trichoderma*, seedling vigour.

INTRODUCTION

Acacia leucophloea (Roxb.) willd ex Del known as white barked *Acacia* belongs to the family Mimosaceae. It is a constituent of dry tropical thorn forests and tropical dry evergreen forests. The tree grows well in regions having high temperature and an average rainfall of 450-1500 mm per annum. It thrives on a variety of soils ranging from shallow and gravelly on hilly slopes to deep alluvial. The tree is common in dry regions of India and attains a height of 2.90m and a girth of 15.2cm in 5 years. It flowers during August-November and pods ripe in April-June. The ripe pods are beaten off the tree with a stick, on the ground previously swept clean. Pods are collected and spread in the sun to dry, and then beaten with a stick or wooden mallet to extract seeds. Seeds are dark brown, elliptical and rhomboidal in shape. For large scale afforestation programmes, aerial seeding is being increasingly adopted in India. For this purpose, the seeds should be pelleted to increase their ballistic properties while aerial seeding and to withstand adverse habitat and extreme situations. Pelleted seed increased the capacity of aerially sown seed to penetrate in standing vegetation compared to raw seed (Scott 1989). He also reported that nutrient seed coating can cause damage during germination or that they supply little nutrients to seedlings and the literature nevertheless contained numerous reports of cases in which the supply of nutrients by coatings has been substantial. Magini (1962) enlisted the advantages of pelleting such as (i) incorporation of fertilizer which will furnish to the young germinating seedlings (ii) plant growth regulators and bio-fertilizers to promote rooting or hasten the emergence and seedling growth, (iii) fungicides and insecticides are more effective when in direct contact with the seeds (iv) protection against rodents by adding unpalatable substances and (v) small seeds become larger and heavier which improves the ballistic property in aerial seeding. Protective measures to assist individual seeds after sowing are not practical and pelleting is the only possible mean of achieving some degree of protection (Anon. 1985). In this context, the effect of seed pelletization of *Acacia leucophloea* on germination and seedling vigour in different soil types were assessed.

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MATERIALS AND METHODS

The seeds of *Acacia leucophloea* were scarified using commercial sulphuric acid for 20 min and washed 4 or 5 times using tap water. The scarified seeds after shade drying were pelleted with following pelleting materials using gum acacia @ 30 ml kg^{-1} of seed as adhesive and gypsum @ 200g kg^{-1} of seed as the filler. The pelleting materials were diammonium phosphate (DAP) @ 30g kg^{-1} of seed to supply 0.5% of N and 1.5% of P_2O_5, commercial micronutrient mixture @ 19.7g kg^{-1} of seed to supply 0.1% of zinc, manganese and iron and 0.05% of

copper, boron and molybdenum, *Rhizobium* (commercial) @ 50g kg^{-1} of seed, sevin @ 2g kg^{-1} of seed and *Trichoderma viride* @ 4g kg^{-1} of seed.

For pelleting, the following treatment combinations were tried:

1. Unpelleted control
2. Sevin + *T. viride*
3. DAP + micronutrient mixture
4. *Rhizobium*
5. DAP + micronutrient mixture + *Rhizobium*
6. Sevin + *T.viride* + DAP + micronutrient mixture
7. Sevin + *T.viride* + *Rhizobium*
8. Sevin + *T.viride* + DAP + micronutrient mixture + *Rhizobium.*

Pelleting was done using a hand operated pelletizer. The seeds were first placed in the drum and rotated. While rotating, the adhesive was added intermittently and mixed thoroughly to give a uniform coating over the seeds. Then the gypsum was added and rotated until required size was obtained. The adhesive was then added for the second time. Subsequently pelleting material was applied and coated over the filler by rotating the drum of the pelletizer.

The pelleted seeds were germinated in different soil types such as calcareous, sandy loam, acidic and sodic soils in a germination room maintained at 25 ± 2°C temperature and 90 ± 5% relative humidity.

The design used was completely randomized design with four replications. In each replication 10 seeds were sown in tea cups. Twenty one days after sowing, counts were made and germination was expressed as the percentage of seeds producing normal seedlings. (ISTA 1985). Thereafter, ten random seedlings were dried in a hot air oven at 85°C temperature for 16 hrs and dry weight was recorded in mg $seedling^{-1}$. The vigour index was calculated as described by Abdul-Baki and Anderson (1973) using the equation. Vigour index = Germination percentage x Dry weight of seedlings (mg).

RESULTS AND DISCUSSION

The highest germination percentage of 86 was observed in calcareous soil followed by sandy loam soil (75%). Minimum germination of 34% was observed in the acidic soil. Among the treatments, DAP + micronutrient mixture (65%) followed by DAP + micronutrient mixture + *Rhizobium*, sevin + *T.viride* + DAP + micronutrient mixture and sevin + *T. viride* + DAP + Micronutrient misture + *Rhizobium* recorded higher germination of 64% while lower germination of 55% was noticed in unpelleted control (Table 1). Similar results were also recorded for dry weight of seedlings (Table 2). Seedlings grown in calcareous soil showed the highest vigour index followed by sandy loam soil. The vigour index was the lowest in acidic soil. Among the treatments, sevin +*T.viride* + DAP + micronutrient mixture exhibited greater vigour index compared to unpelleted control (Table 3).

Thus pelleted seeds registered significantly higher germination and seedling vigour than the unpelleted control under all soil types. However, the performance of pelleted seeds in terms of higher germination and seedling vigour was superior in

Table 1. Germination (%) of pelleted seed under different soil types in *Acacia leucophloea.*

Treatments	Soil types			
	Calcareous soil	Sandy loam soil	Acidic soil	Sodic soil
Unpelleted Control	82 (65.06)[1]	71 (57.46)	30 (33.20)	38 (38.05)
Sevin + *T. viride*	84 (66.77)	73 (58.74)	31 (33.81)	49 (44.43)
DAP + Micronutrient mixture	88 (69.87)	77 (61.40)	38 (38.05)	56 (48.45)
Rhizobium	84 (66.77)	74 (59.36)	32 (34.43)	50 (45.00)
DAP + Micronutrient mixture + *Rhizobium*	89 (70.69)	76 (60.71)	35 (36.27)	55 (47.88)
Sevin + *T. viride* + DAP + Micronutrient mixture	88 (69.87)	77 (61.40)	36 (36.86)	56 (48.45)
Sevin + *T. viride* + *Rhizobium*	83 (65.61)	73 (58.71)	34 (35.66)	52 (46.15)
Sevin + *T. viride* + DAP + Micronutrient mixture + *Rhizobium*	87 (69.04)	78 (62.09)	36 (36.86)	54 (47.01)
		SEd	CD (P=0.05)	
	Soil	0.644	1.278	
	Treatment	0.910	1.807	
	Soil x Treatment	1.821	NS	

[1]Figures in parentheses indicate arc sine transformation, SEd- Standard error deviation, CD- Critical difference

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

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

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 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.

ACKNOWLEDGEMENTS

We are thankful to our colleagues of Mutation Breeding Group for their help in designing the field experiments and analysis of the experimental data.

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