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# EFFECTS OF MULCHES ON FORAGING BEHAVIOUR OF *MICROTERMES OBESI* AND *ODONTOTERMES* SPP. IN INDIA

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**Abstract**—Termites are important agricultural pests in the semi-arid tropics. Conventional methods of control have relied on persistent organochloride insecticides with accompanying health and environmental problems. In contrast, cultural control methods provide untested, but environmentally sound options to farmers. This study reports results from three experiments on the use of mulches to reduce *Microtermes obesi* and *Odontotermes* spp. damage with relevance to groundnut production in India.

Termites scarification of groundnut was 80–90% lower for pods dried in neem cake or *Ipomoea fistulosa* mulches than for pods dried directly on the soil. Similarly, subterranean attack by termites on bamboo baits was 20–40% lower in mulched plots than in controls. However, mulches were ineffective in protecting bullock manure from removal by termites.

Successful use of mulches in termite control may be related to food source concentration. Termite location of concentrated food sources, such as bullock manure, was followed by recruitment of workers and construction of protected runways. In contrast, termites foraging on limited food sources, such as groundnut pods, did not construct runways and had greater exposure to mulches.

*Key Words*: Termites, *Microtermes*, *Odontotermes*, groundnut, neem, *Ipomoea*, sunnhemp, *Celosia*, mulches

**Résumé**—Dans les zones tropicales semi-arides, les termites sont des ravageurs importants des cultures. Les méthodes de lutte traditionnelles sont fundées sur l'utilisation répétée d'insecticides organochlorés nuisibles pour la santé et l'environnement. En revanche, les méthodes de lutte culturales non encore expérimentées, constituent une solution écologiquement saine pour les agriculteurs. Ce document rapporte les résultats de trois expériences portant sur l'utilisation de paillis pour réduire l'ampleur des dégâts occasionnés par *Microtermes obesi* et *Odontotermes* spp. dans le cadre de la production d'arachide en Inde.

Le taux de scarification de l'arachide par les termites était de 80–90% inférieur pour les gousses séchées dans des tourteaux de neem ou des paillis de *Ipomoea fistulosa* par rapport aux gousses séchées à même le sol. De même, les attaques souterraines de termites sur les appâts en bambou étaient inférieures de 20 à 40% dans les parcelles recouvertes de paillis par rapport aux parcelles témoins. Toutefois, le paillis s'est révélé inefficace pour éviter que le fumier de boeufs ne soit emporté par les termites.

L'efficacité de l'utilisation de paillis pour lutter contre les termites peut s'expliquer par la concentration de la source d'alimentation. En effet, le repérage par les termites de sources d'alimentation concentrées, telles que le fumier, donnait lieur au recrutement d'ouvrières et à la construction de voies de passage protégées. En revanche, les termites n'ayant trouvé que

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**des sources alimentaires limitées, telles que les gousses d'arachide, ne construisaient par de voies de passage et se trouvaient de ce fait beaucoup plus exposés aux paillis.**

*Mots Cléfs*: Termites, *Microtermes*, *Odontotermes*, arachide, neem, *Ipomoea*, *Crotolaria juncia*, *Celosia*, paillis

## INTRODUCTION

In the semi-arid tropics, termites, *Microtermes* spp. and *Odontotermes* spp. may reduce groundnut yields by 50% (Johnson et al., 1981; Hebblethwaite and Logan 1985; Logan, 1988; Wightman and Amin, 1988). Additionally, termite scarification of groundnut pods is associated with higher aflatoxin levels and lower market prices (McDonald and Harkness, 1963, 1967; Narasimhan et al., 1985). Termites also remove manure and other organic matter from fields (Wood, 1976) which may reduce soil fertility and crop production.

*Microtermes* spp. and developing colonies of *Odontotermes* spp. live in subterranean nests which are difficult to locate and destroy. As a result, control methods are heavily dependent on prophylactic chemical barriers of organochloride insecticides which persist from planting to harvest. Economic, environmental and health problems related to pesticide use have created a critical need to find alternative termite control strategies (Wightman et al., 1989).

Many plants have insecticidal, insect repellent or anti-feedant properties. Cowie and Logan (pers. commun.) list 67 species which have been reported as being toxic or repellent to termites; however, only two plant products have been field tested. Nevertheless, incorporating such plants and/or derivatives into annual cropping systems may provide an ecologically sound method of termite control (Waller and LaFage, 1987). Such strategies would be most appropriate for small farming systems if insecticidal or repellent plants are locally available, do not compete with crops or support insect pests, and have active ingredients which require little or no preparation (Logan et al., 1990).

Mulching offers a virtually untested possibility of protecting crops against termite damage. This paper reports data from preliminary experiments on the use of mulches to reduce termite activity in groundnut fields. The first experiment was designed to test anti-termite activity of four locally available plants: *Azadirachta indica* A. Juss (neem), *Ipomoea fistulosa* Mart ex Choisy (= *I. carnea* Jacq.), *Crotalaria juncea* L. (sunnhemp) and *Celosia argentea* L. Subsequent experiments were designed to further test the two most promising mulches under different field conditions.

Neem products have been used in India in pest control for over 50 years (Saxena, 1989). Its effects against over 200 arthropods and modes of action have been well documented (Schmutterer et al., 1981; Schmutterer and Ascher, 1985, 1987; Saxena, 1989). These include repellency, feeding deterrence, and interference with reproduction. However, to date there is little published information on neem's effects on termites.

*I. fistulosa* is a common roadside weed in India which is seldom attacked by insects, toxic to livestock (Tartour et al., 1974; Tirkey et al., 1987) and used as a hedge to protect crops from grazers (Dubey et al., 1982). *I. fistulosa* extracts, reportedly reduce incidence of nematodes (Siddiqui et al., 1987), mosquitoes (Saxena and Sumithra, 1985) and bruchids (Pandey et al., 1976).

Sunnhemp, a common green manure in India, has been used successfully against soil insects in Colombia (Vargas et al., 1987). *C. argentea* was the dominant weed within the experimental fields.

## MATERIALS AND METHODS

### *Field site*

Trials were conducted at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), near Hyderabad, India (17°N latitude, 500 m a.s.l.). There are two planting seasons: kharif (rainy) in mid June and rabi (irrigated post-rainy) in November. Fields are fallow between April to June (summer) when daytime temperatures are 35–45°C and there is no rain. At ICRISAT, the highest daytime termite populations occurred on non-irrigated fields which are planted only in the kharif.

### *Experiment 1: Effects of mulches on groundnut scarification*

The effects of mulches on termite damage to drying groundnut pods was tested in a field with a history of high *Microtermes obesi* and *Odontotermes* spp. populations.

The four mulch treatments were: (a) neem cake, (b) *I. fistulosa* leaves and stems (chopped), (c) sunnhemp leaves and (d) *C. argentea* leaves and flowers. Groundnut pods were placed either on top of or mixed into the mulches. In control plots, pods were placed directly on bare soil. Plot size was 0.6 x 2.0 m and plots were separated by 1.2 m alleys. Mulch depth was 3 cm for neem cake and 6 cm for other treatments.

Each replicate contained 10 plots: Four treatments with pods placed on top of the mulch, four with pods mixed in the mulch and two controls. Treatments were placed in a split plot design with 20 replicates and main plots reflecting placement of ground pods. Approximately 300 groundnut pods (300 g) were placed in each plot. The plots were covered with cloth mesh to protect against rodents.

Mulches and pods were placed in the field on 11 Jan 1989 (rabi season). Each plot was inspected for termites at 29, 36 and 49 days. Pods were collected 49 days after mulching and scarification on each pod was scored from 0 to 4 (0 = no damage; 1 = 1–25% of pod surface scarified; 2 = 26–50% scarification, etc.). Treatment effects (% scarified pods and scarification scores), were determined using ANOVA procedures for split plot designs. Values for percentage damaged pods were arcsine transformed to stabilize variance.

*Experiment 2: Mulch effects on subterranean termite activity*

The effects of neem cake and *I. fistulosa* mulches on subterranean activity of termites were studied in experimental plots containing bamboo baits (pegs), partially submerged into the soil. Replicates contained two plots each of bare ground control, neem cake mulch (3 cm) and *I. fistulosa* mulch (6 cm). One plot of each system was watered twice weekly to facilitate movement of leachates into the soil. Other plots were not watered.

The trial was conducted between 10 April and 18 May 1989 (summer). The six treatments were arranged in a complete block design with 12 replicates. Experimental plots were 1 m$^2$, bunded, and separated by 2 m alleys.

Twenty bamboo baits (20 cm long) were placed in each plot at 30° angles from the ground and to a depth of 8 cm. Presence/absence of termites on pegs was determined at 19, 28 and 48 days after placement. Attacked pegs were shaken free of termites and moved to require rediscovery. Analyses of variance were employed on arcsine transformed values by date and over the entire trial (repeated measures).

*Experiment 3: Mulches and termite activity in bullock manure*

*Odontotermes* spp. rapidly remove both fresh and dried bullock manure from termite infested fields. To determine if neem cake or *I. fistulosa* mulch would prevent or retard termite removal of manure, fresh dung pads (25 cm dia) were field-placed with mulches on 21 June 1989. Five manure treatments, a control, placed on top of neem cake mulch (2.5 cm), mixed with neem cake, placed on top of *I. fistulosa* mulch (5 cm) and mixed with *I. fistulosa*, were placed in a complete block design with 12 replicates.

Presence/absence of termites attacking manure in the different treatments was recorded on five dates from 2 to 18 days after placement. On three sampling dates, extent of termite sheeting and removal of manure were each scored 0 to 10 (representing increments of 10%). Analyses of variance were conducted for sheeting and manure removal for each sampling date.

## RESULTS

*Experiment 1: Termite scarification of drying groundnut pods*

Termite presence in control plots (> 50%) was considerably higher than in neem cake (< 5%) and *I. fistulosa* (< 20%) mulches on all sampling dates (Fig. 1). Termite presence was initially high in *C. argentea* mulches, but declined over time. Termites did not appear to feed on either *I. fistulosa* or *C. argentea*. In contrast, *M. obesi* and *Odontotermes* spp. fed on sunnhemp leaves (pers. observ.) and were encountered in all plots containing this mulch.

*M. obesi*, *Odontotermes obesus*, *O. wallonensis* and possibly other *Odontotermes* spp. scarified pods. Scarification began within 3 days of placing pods in the field and continued for the duration of the trial. In control plots, 36% of the pods were scarified with an average scarification rating (for all pods) of 0.88 (Table 1). Damage in neem cake and *I. fistulosa* mulches was negligible. Scarification in *C. argentea* mulches was also lower than in control plots. Greatest damage was in sunnhemp mulches where termites were attracted, presumably, to the mulch

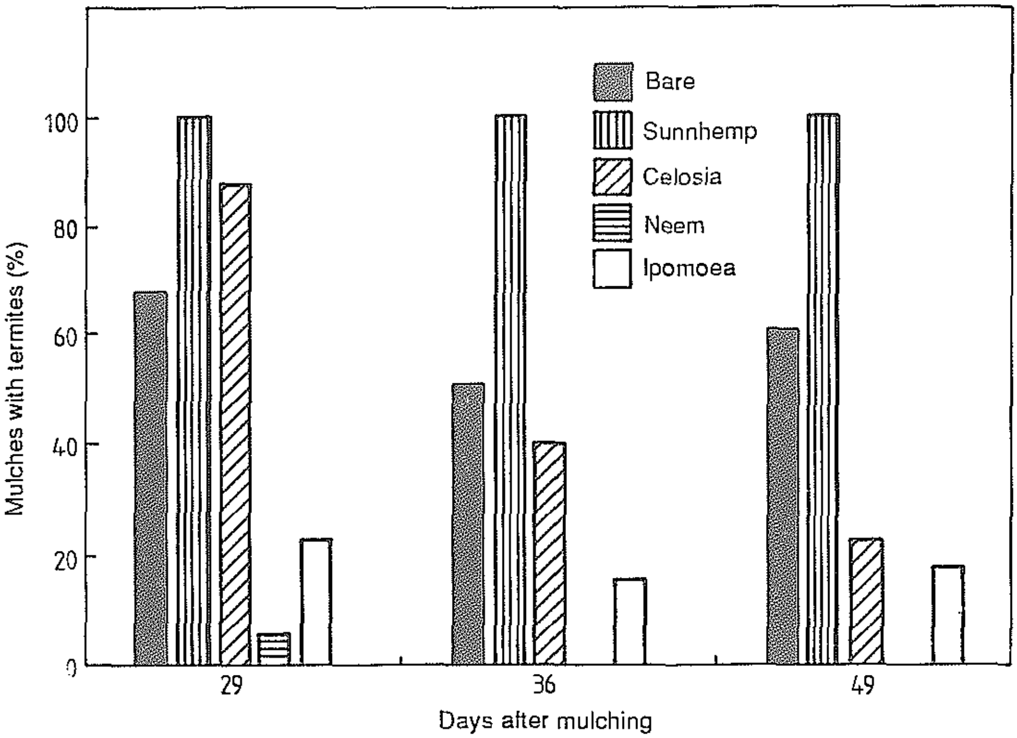


Fig. 1. Presence of termites in experimental plots containing mulches and groundnut pods. Control = pods on bare ground ($N = 40$).

Table 1. Termite damage of groundnut pods in different mulch treatments at ICRISAT Center, Jan. to Mar. 1989 (Split plot design, $N = 20$)

| Position of pods | Per cent pods scarified* | Scarification rating⁺ |
|---|---|---|
| On top of mulch | 20 b | 0.50 b |
| Mixed in mulch | 28 a | 0.75 a |
| $F$ Value | 27.34** | 24.39** |
| Treatment | | |
| Bare ground | 36 b | 0.88 b |
| Sunnhemp | 59 a | 1.69 a |
| *Celosia* | 17 c | 0.38 c |
| Neem cake | 2 d | 0.04 d |
| *Ipomoea* | 7 d | 0.14 d |
| $F$ Value | 156.35** | 118.67** |

*Analysis on arcsin transformed values of radians.
**$P < 0.01$.
⁺Scored 0 to 4 where 0 = no damage, 1 = 2–25% of shell scarified, 2 = 26–50%, 3 = 51–75%, 4 = 76–100%.

itself. Scarification levels were less when pods were placed on top of, rather than mixed in, the mulches.

*Experiment 2: Subterranean termite attack on baits*

Equal numbers of bamboo baits were attacked by *M. obesi* and *Odontotermes* spp. Watering had no effect on rates of attack; therefore, the data for watered and unwatered plots were combined.

Baits in neem cake and *I. fistulosa* mulches suffered less termite attack than in control plots at 19 and 48 days after mulching and over the entire trial (Table 2). At 28 days after mulching, termite presence at pegs was not significantly different among systems.

*Experiment 3: Termite attack and removal of bullock manure*

Mulches did not deter termites from locating manure sources (Table 3). More than 50% of the pads were encountered within 6 days and all but

Table 2. Termite attack on bamboo baits (%) on bare ground and in mulches at ICRISAT Center, Apr. to May 1989 ($N = 12$; two plots per replicate, 20 baits per plot)

| | Days after mulching | | | |
|---|---|---|---|---|
| Treatment | 19 | 28 | 48 | Trial* |
| Bare ground | 15.0 a | 30.3 a | 46.9 a | 30.7 a |
| Neem cake | 6.9 b | 35.4 a | 31.2 b | 24.5 b |
| *Ipomoea* mulch | 5.6 b | 32.1 a | 21.9 c | 19.9 b |
| $F$ value+ | 10.95** | 1.22 | 25.64** | 13.45** |

** $P < 0.01$.
All values are percentages.
*Repeated measures analysis of variance.
+$F$ test on arcsine transformed values. Different letters in same column significantly different by Duncan's new multiple range test; df (2,22).

Table 3. Per cent of bullock pads attacked by *Odontotermes* spp. ($N = 12$)

| | Termite presence | | | | |
|---|---|---|---|---|---|
| Treatment | 2 | 6 | 9 | 14 | 18 DAP |
| Control | 8 | 50 | 83 | 100 | 100 |
| Neem base | 25 | 58 | 83 | 100 | 100 |
| Neem mix | 42 | 50 | 100 | 100 | 100 |
| *Ipomoea* base | 25 | 58 | 75 | 92 | 100 |
| *Ipomoea* mix | 8 | 75 | 75 | 100 | 100 |

DAP: Days after placement in field.
All figures are percentages.

one pad was attacked by termites within 2 weeks. Attack was primarily by *O. wallonensis* and *O. obesus*. *M. obesi* was observed in two pads, but *Macrotermes estherae* (Desneux), although abundant, did not attack manure.

Termite sheeting and removal of manure was significantly lower for pads mixed with *I. fistulosa* mulch: other mulch treatments were ineffective in reducing termite attack (Table 4). 30 days after placement of pads, substantial amounts of manure remained in this treatment, whereas 100% of the manure in all other systems had been removed.

## DISCUSSION

Low levels of termite activity in neem cake and *I. fistulosa* mulch plots in experiments 1 and 2 suggest that these substances act as physical barriers, repellents and/or feeding inhibitors. Although exact mechanisms are unclear, these effects were persistent (lasting 7 weeks), an important consideration in termite control. Termites are late season pests and evidence of attack often appears too late for farmers to respond.

Scarification levels were reduced in neem cake and *I. fistulosa* mulches by 95 and 80%, respectively. Such reductions would represent important savings for farmers. Further work is needed to determine: (1) the mechanisms involved in control and how they might be further manipulated, (2) if similar effects could be obtained with smaller quantities of neem or *I. fistulosa* products, (3) the economic feasibility of using mulches in termite control, and (4) if mulches can be used to protect the growing crop against termite attack.

In contrast, neem cake was ineffective in reducing termite removal of bullock manure while *I. fistulosa* provided limited protection only when mixed into the pads. Differences in the protection provided by mulches against attack of groundnut

Table 4. *Odontotermes* spp. attack of bullock manure in mulch treatments at ICRISAT Center, June/July 1989 (mean scores; $N = 12$ pads)

A. Sheeting*

| Treatment | 9 | 14 | 18 DAP |
|---|---|---|---|
| Control | 5.0 | 7.8 ab | 8.7 a |
| Neem base | 4.9 | 7.4 ab | 8.0 a |
| Neem mix | 5.0 | 9.7 a | 10.0 a |
| *Ipomoea* base | 3.8 | 6.8 bc | 7.5 ab |
| *Ipomoea* mix | 2.5 | 4.3 c | 5.8 b |
| *F* value | 1.13 | 6.41** | 5.57** |

B. Removal*

| Treatment | 9 | 14 | 18 DAP |
|---|---|---|---|
| Control | 3.7 | 6.5 a | 8.5 a |
| Neem base | 3.8 | 6.2 a | 7.8 a |
| Neem mix | 2.7 | 5.3 a | 8.0 |
| *Ipomoea* base | 2.8 | 6.1 a | 7.4 a |
| *Ipomoea* mix | 1.6 | 2.8 b | 4.5 b |
| *F* value | 2.05 | 10.29** | 14.99** |

**$P < 0.01$.
$F$ value df (4,44).
DAP: Days after placement in field.
*Scaled 0 to 10 (estimated percentages).

pods, bamboo baits, and bullock manure might be explained by differences in the nature of the food sources.

Bullock manure presented a concentrated food source to termites which probably attracted foraging workers through breakdown products such as $CO_2$, ammonia and ethylene. The strength of such attractants might overcome deterrent properties of neem cake or *I. fistulosa*. Additionally, termites commonly constructed sheeted runways to manure sources placed on neem cake or *I. fistulosa*, thereby separating foraging workers from the mulch. In contrast, mixing of mulches with the manure insured contact of termites with the mulch. Under these circumstances, *I. fistulosa* provided some deterrent effect, while neem cake did not.

By comparison, groundnut pods offer small, relatively dispersed food sources. Stimuli attracting termites to the pods were probably limited and insufficient to overcome any repellent effects of the neem cake or *I. fistulosa*. Sheeting was never observed in mulches, suggesting that groundnut pods did not provide enough energy return to justify termite energy expenditures in recruitment and construction of protected runways. Under these circumstances, exposure of foragers to mulches was maximal.

Bamboo baits, used in experiment 2, provided intermediate levels of food concentration (and possibly attractant cues) to groundnut pods and bullock manure. In this case, termite exposure to mulches may have been largely restricted to leachates. This could explain the moderate level of success in using mulches in this experiment.

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