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Short communication

Impact of Organic Mulches on Soil Physico-chemical Properties in the Presence of Termites

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Intensification of agriculture to increase food production has led to large scale environmental degradation which range from biodiversity losses due to monoculture, habitat losses, pollution of water bodies and deterioration of soil health (Evans *et al*., 2011; Montgomery, 2007). Maintenance and restoration of the natural ecosystem services that reduce the dependence of agricultural systems to human inputs human inputs may be one of the approaches to make agriculture more sustainable agriculture (Evans *et al*., 2011; Hooper *et al*. 2005). Soil macro fauna such as earthworms, ants and termites play an important role in ecosystem functioning by influencing soil structure, aeration, infiltration of water and nutrient cycling (Lal, 1988; Petersen and Luxton, 1982).

Termites are the most dominant macro-arthropod detritivores in the tropics. The estimated abundance in Thailand was 6450 termites m^{-2} (Inoue *et al*., 2000). They are neither conspicuous as individual nor do they attract attention by any fluctuation in numbers. Their small size and cryptic nature help them remain unnoticed. Termites mainly feed on dead plant material, leaf litter, soil or animal dung. Of the estimated 4000 species (2600 taxonomically known) about 300 are economically significant pests that can cause serious damage to crops, plantations, forests and farm structures. Mando (1997) had recommended the use of mulches to trigger termite activity for the restoration of hard crusted Sahelian soils of Africa. With this background, a study was conducted to study the breakdown of organic debris and its effect on the underlying soil in the presence and absence of termites.

The study was carried out in a 1.30 ha *Garcinia indica* orchard having trees at a spacing of 8 m × 6 m at Dapoli, Maharashtra. The 20 years old orchard was already infested by termites indicated by the presence of a few mounds of *Odontotermes obesus*. An area of 3 m x 2 m around each *Garcina indica* tree was taken as the study area. This constituted one replication. The next replication was at least 8 m away. Trees with live termite or ant mounds in their vicinity were not taken for study. The mulching material was selected based on the local availability. Black spear grass - local name kusal (*Heteropogon contortus*) along with some dicot weeds which grows in abundance in the area during the monsoon were selected. Paddy being the main crop of the Konkan, paddy straw was taken as the second mulch. Coconut husks were taken as the third mulch as they are easily available and in the absence of coir industry pose a disposal problem. All the mulches were sun dried for one week before laying down in the trial. The soil samples for the study areas were collected from the top 0-10 cm. The initial soil samples were collected before soil treatment with chlorpyriphos and laying down of the mulch at the beginning of the trial and later at the end of the trial after removal of the mulch. The post-trial soil samples included the soil galleries/soil sheeting created by the termites on and below the mulch material. The trial began after termite sheeting and galleries were observed on the soil surface and on the tree trunks indicating termite foraging activity in second week of Nov, 2014. The trial was concluded in the last week of May, 2015 before advent of the monsoon. The trial was again laid out in the second week of Nov, 2015 and concluded in the last week of May, 2016. A soil drench of 0.5% chlorpyriphos @ 1.0 L m^{-2} was used to ensure termite free soil surface for the trial period of 8 months. The experiment was laid down in a randomized block design with three replications of eight treatments (T_1: paddy straw @ 18 kg per plot, T_2: paddy straw @ 18 kg per plot with chlorpyriphos @ 0.5%, T_3: grass @ 12 kg per plot, T_4: grass @ 12 kg per plot with chlorpyriphos @ 0.5%, T_5: coconut husk @ 25 kg per plot, T_6: coconut husk @ 25 kg per plot with chlorpyriphos @ 0.5%, T_7: only chlorpyriphos @ 0.5% and T_8: control - no insecticide no mulch).

During both the seasons the mulch in all the chloropyriphos untreated plots showed the presence of termite sheeting and galleries. It was noticed that the termite galleries and sheeting was present below the mulch in case of paddy and coconut husks but a large part of the surface of the grass mulch was covered with termite sheeting and galleries. The mulches where the underlying soil was drenched with chlorpyriphos showed a complete control of termites and other insect pests. During the first year, the maximum weight loss of 8.73 kg (72.50%) was recorded in the T_3, untreated grass mulched plot (Table 1). The untreated paddy straw plot recorded a loss of 6.81 kg (37.83%), which was significantly superior to untreated coconut husk 7.00 kg (28.00%). The chlorpyriphos treated plots of both grass and paddy straw were at par while the treated plot of coconut husk reported even lower weight loss. During the second year, again the maximum weight loss of 8.47 kg (70.55%) was recorded in the untreated grass mulched plots. The untreated paddy straw mulched plots stood second with a weight loss of 5.77 kg (32.04%) which was superior to the untreated coconut husk mulch which showed a weight loss of 5.92 kg (23.67%). While in the chlorpyriphos treated plots, the weight loss in all three, paddy straw, grass and coconut husk were at par. Thus, it can be said that the mixed grass and weed mulch was the most preferred by termites and it was consumed to the maximum extent, while the chlorpyriphos treatment prevented the termites from consuming the mulch.

The data on the impact of termites on soil pH (Table 1) showed that, the pH in all the untreated mulched plots was elevated as compared to the chlorpyriphos treated plots at the end of both the seasons of the trial. During the first year, the pH in the untreated grass mulched plots showed the highest rise from the initial 5.23 to 5.99 which was at par with the coconut mulch which rose from 5.23 to 5.83, while the pH in the paddy straw increased only from 5.30 to 5.63. The chlorpyriphos treated plots exhibited a small fall in the pH value ranging from 0.01 to 0.04, while the control plots remained static. In the second year, the grass mulched plots had the same value as earlier but the pH in the coconut mulched plots showed a slight decrease (5.52) making it at par with paddy straw mulch (5.47) but in both treatments the pH was higher as compared to the chlorpyriphos treated and control plots. Rise in the pH of acidic soil towards the neutral value of pH 7 leads to better absorption of macronutrients which is borne out by the reports of a greater biodiversity of plants around termite mounds in the African deserts which are an oasis for herbivores (Pringle *et al*., 2010). Perusal of the bulk density data (Table 1) showed that, during the first year, the untreated plots showed a significant reduction in bulk density. The grass mulched plots showed the maximum reduction from 1.29 to 1.07 Mg m^{-3} while the corresponding figures for paddy straw and coconut husk were 1.15 and 1.16 Mg m^{-3}, respectively. All the three chlorpyriphos treated plots were at par. The lowest value of 0.89 Mg m^{-3} was recorded at the end of the second season in the plots where grass was used as mulch in the absence of chloropyriphos which resulted in a reduction of 31%. This was followed by paddy straw in which the bulk density was 1.05 Mg m^{-3} which is 19% lower than the initial level. A mulch of coconut husk over untreated soil showed the least observation of 1.07 Mg m^{-3} with a reduction of almost 17%. It was noted that, the untreated soil surface below the mulch in all the plots was loose, friable and covered by mud sheeting and numerous termite foraging channels with bits of the mulch being incorporated in the soil parts of which could not be from soil and had to be included in the soil sample lumps for determination of bulk density, which may have lead to lower density readings. Dowuona *et al*. (2012) reported from Ghana that the bulk density of the termite mound was between 1.60 to1.72 Mg m^{-3} while, the bulk density of the surrounding soil was between 1.24 to 1.40 Mg m^{-3}. Mando *et al*. (2000) who carried out mulching trials in the hard crusted soils of Burkina Faso in South Africa observed that in the mulched plots, the sealed surface was perforated by termites, resulting in many visible open voids. These plots were covered by sheetings that consisted of fine soil material transported to the soil surface and linked up by termites. They also reported that termite created voids represented 12% of the top soil (0-7 cm) and were responsible for 60% of the macroporosity in the top soil horizon.

The present study on the role of termites in breakdown of agricultural waste into organic manure has shown that, the presence of termites is necessary for the breakdown of mulch. It was seen that, grass and weeds when used are more readily consumed by the termites as compared to paddy straw or coconut husk.

Table 1. Soil properties in the presence and absence of termites

Treatments	Reduction in wt. (kg)			pH			Bulk density (Mg m^{-3})		
	Initial	2014-15	2015-16	Initial	2014-15	2015-16	Initial	2014-15	2015-16
T_1 - Paddy straw	18	6.81 (37.83)	5.77 (32.04)	5.30	5.63	5.47	1.29	1.15	1.05
T_2 - Paddy straw + CPP	18	3.28 (19.58)	3.22 (17.89)	5.37	5.36	5.33	1.29	1.28	1.28
T_3 - Grass	12	8.73 (72.78)	8.47 (70.55)	5.23	5.99	5.99	1.29	1.07	0.89
T_4 - Grass + CPP	12	2.47 (20.55)	2.43 (17.97)	5.27	5.28	5.26	1.29	1.27	1.27
T_5 - Coconut husk	25	7.00 (28.00)	5.92 (23.67)	5.23	5.83	5.52	1.29	1.16	1.07
T_6 - Coconut husk + CPP	25	3.45 (13.80)	3.57 (14.28)	5.24	5.28	5.26	1.29	1.29	1.3
T_7 - Only CPP	0	0	0	5.25	5.13	5.20	1.29	1.33	1.41
T_8 - Control	0	0	0	5.24	5.24	5.24	1.28	1.29	1.29
S.E. (M±)		1.05	1.37	0.04	0.08	0.06		0.03	0.02
C.D. at 0.05%		3.19	4.15	0.13	0.25	0.17		0.08	0.03

CPP stands for 0.5% Chlorpyriphos soil drench. Figures in brackets are percent decrease over initial.

The lateritic soils in the Konkan are generally quiet shallow and are known to be acidic. The breakdown of grass mulch in the presence of termites resulted in an increase in the soil pH from 5.23 to 5.99, a rise of almost 15%. Any soil with the pH nearer to the neutral level of 7 always shows improved levels of nutrient uptake and hence plant growth. Thus, the presence of termites may aid in better plant growth. Evans *et al*. (2011) reported increase in wheat yield by 36% from increased soil water and improved soil nitrogen due to termite and ant activity. Hard and compact soils of the Konkan are often not conducive to plant growth. Mulching invites the termites to the soil surface and during the process of foraging their tunneling opens up many voids in the soil and they bring along with them the underlying soil layers to the surface in the form of soil sheeting to cover the mulches. Termites are thus known as bioturbators of soil. The soil below the mulches is always loose and friable having a much lower bulk density. The presence of termites in grass mulched plot resulted in a 31% reduction in bulk density of the soil. The reduction in the paddy straw mulched plot was 19% and it was 17% in the plots mulched with coconut husk. While, the soil below the mulches which was treated with chlorpyriphos remained compact and actually in bare plots the soil became more compact as evidenced by a rise in bulk density.

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