Effect of Mulching and Intercropping on Termite Damage to Maize at Bako Western Ethiopia

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Abstract

Non-chemical control of termites in agriculture is attracting renewed interest following increasing restrictions on the use of persistent organoclorine (*cyclodione*) insecticides. The use of maize stover and neem seed powder as mulch, soybean as intercrop with maize and simultaneous use of mulching and intercropping to reduce termite infestations were evaluated at the Bako Agricultural Research Center, Western Ethiopia during 2005 to 2006 cropping seasons. The plot size was 8 m x 8 m. Termite damage on maize was inspected at regular intervals throughout both seasons. In both cropping seasons higher damage to maize plants commenced at latter stage. The study revealed that intercropping, mulching and integration of mulching and intercropping caused a significant ($P<0.05$) reduction in termite attack to maize. The average yield of maize was higher in protected (mulched and intercropped) plots than in unprotected (not mulched and not intercropped) plots. In many instances, grain yield of maize was significantly higher ($P=0.01$) in the plots receiving both mulching and intercropping treatments together. There were positive correlations among damage variables, while the correlation between damage variables and agronomic characters was negative. Intercropping and mulching appear to be among the suitable components of an integrated management strategy for termites in smallholder cropping systems.

Introduction

Termites (*Macroterms* and *Microtermes* spp.) are one of the most important pests of many crops including maize in Ethiopia. They attack maize plants from the seedling stage to maturity. Termites of the genus *Microtermes* are known to damage the root system of crops. Feeding damages on roots stem bases and leaves frequently result in plant lodging and damage to cobs causing yield losses between 15% and 30% in different parts of the country (Abraham, 1990; Devendra *et al*., 1998). Likewise termites caused up to 62% yield reduction on hot pepper (Abdurahman, 1983). In some cases even up to 100% yield losses were reported to occur on maize and hot pepper in the western part of the country, especially at Mendi and Lalokile districts. In general, damage is greater in lowland rather than highland areas, and in plants under stress, because of lack of moisture, disease or physical damage, rather than healthy and vigorous plants. In particular, exotic crops such as maize, groundnuts, sugar cane and cotton are seriously damaged (Johnson *et al*., 1981). The control of termite relied mainly on the use of chemical insecticides. However, according to Logan *et al*., (1990), the use of non-chemical control methods has been emphasized following the ban on persistent organochlorine insecticides. Such methods attempt to (i) prevent termite access to plants, (ii) reduce termite numbers in the vicinity of plants, and (iii) reduce susceptibility or increase resistance of the plants themselves. Although there is little published information on non-chemical control of termites in annual crops, cultural practices such as mulching and intercropping have been reported to reduce termite infestation elsewhere (Sekamattee *et al.*, 2001, 2002).

In the tropics, subsistence farmers who practice low input agriculture use mulching and intercropping to minimize the risk of crop failure and to improve the yields of particular crops (Ofori and Stern, 1987). For example, in Uganda, over 70% of farmers grow maize as an intercrop (Sekamattee, 2001). Gold and Whightman (1991) tested mulches of plants with insect repellent properties (Neem and *Ipomea fistulosa*) and observed significant protection to groungnuts (*Arachis hypopaea* (L.). Sekamattee *et al.* (2001, 2002) observed that provision of maize stover as mulches and intercropping maize with a range of food legumes was associated with a significant reduction in termite attack on maize and an increasing in the nesting of predatory ants in maize fields. The impact of the practice depended largely on the type of legume intercropped with maize. Termite attack was lower in the maize/soybean intercrop than in maize intercrops with groundnut and beans.

Based on available literature, mulching and intercropping were considered to be worthy of detailed evaluation for termite control for subsistence maize farmers. The objectives of the study were therefore to determine the effects of mulching maize with maize stover and neem seed powder and intercropping maize with soybean on severity of termite attack at Bako.

Materials and Methods

Study site

The study was conducted at the Bako Agricultural Research Center (9°6' N and 37°09' E), 250 km west of Addis Ababa. The mean elevation of the area is about 1650 m above sea level. The experiment was conducted in a field with a history of high termite populations for two planting seasons (2005-2006). Bako represents a mid altitude sub-humid zone with high potential for maize production in the country. It receives an average annual rainfall of 1237 mm. The mean minimum, maximum and average air temperatures of the area were 13.5, 29.7 and 21.4°C, respectively.

Treatment and Design

A total of four treatments, viz. maize intercropped with soybean, maize stover as mulch, neem seed powder as mulch and simultaneous use of mulching and intercropping were tested with sole maize as a control and Diazinon 60% EC at 2 lit per hectare as a treated check. Diazinon 60% EC was applied as spray on the soil surface. It was applied three times starting from the appearance of the insect at three weeks interval.

Since the hotspot field selected for the experiment was not too large to accommodate 10 m x 10 m, the experimental plots measured 8 m x 8 m. Maize variety BH-540 was planted in the plots at a spacing of 75 cm between rows and 30 cm between plants. Two seeds were planted per hill and latter thinned to one plant per hill. Soybean (IPB-81-EP-7) was planted at 12.5 cm between plants and 25 cm between rows. In each intercropped plot, two rows of soybean were planted between two rows of maize. Two weeks after seedling emergence, the number of standing plants per plot was determined for each plot. The maize stover and neem seed powder treatments were applied 3 weeks after seedling emergence. There were three replicates for each treatment arranged in a randomized complete block design.

Assessment of termite damage

Maize plants in each plot were assessed for damage to roots, stems and cobs. Assessment was done at seedling, silking, green cob and dry cob stages. Termites' damage symptom is easily distinguished. At each assessment period, the damaged plants were tagged with yellow ribbon to avoid double counting. Since the level of root damage was not scored non-destructive (not uprooted) method was used to assess termite damage to maize plants. At harvest, the total number of plants per plot, field weight and grain yields were recorded.

Data analysis

Data were analyzed by a two-way ANOVA using the PROC GLM procedure (SAS Institute, 2000) to estimate differences in treatments. Data on the percentages of root, stem and cob damage were square root transformed to stabilize heterogeneity of variance. Mean comparisons were made among treatments using the PROC means Tukey's Studentized range test (HSD) (SAS Institute, 2000) on the transformed data. Means were considered to be significantly different at the 5% level of probability. Back transformed means are presented in tables.

RESULTS

Damage variables

The extent of termite damage to maize was significantly (P<0.05) influenced by mulching and intercropping (Table 1). The combined analysis of variance showed significant differences between years for the percentage of root, stem and cob damage. Data from the two years are therefore presented separately. Analysis of variance for seasonal means of percentages of root damage, stem damage and cob damage by termites during the two cropping seasons showed significant differences between the treated and untreated plots (Table 1). Damage was significantly (P<0.05) lower in treated plots than in the untreated plots in both seasons.

In both cropping seasons, no significant (P=0.05) differences in the percentage root and cob damage were observed among treated plots. The mean number of root damaged plants in the 2005 cropping season varied between 7.25% and 17.85% across the treatments (Table 1), while the mean number of stem and cob damaged plants in the same cropping season varied between 1.25% and 7.10%, and 0.4% and 4.25%, respectively, across the treatments. In the second cropping season, a similar pattern was observed in root and stem damage. However, there was more cob damage than in the first cropping season possibly due to strong wind at the time of harvesting which caused lodging of maize plants exposing cobs to termites.

Yield and yield components

Combined analysis of variance of maize yield and yield components showed significant variation between the two years. Maize yield and field weight being higher in 2005 than 2006. As a result, yield and other agronomic data like field weight and stand count at harvest from the two years were presented separately. Maize grain yield, field weight and number of plants at harvest in the two cropping seasons are presented in Table 2. There were significant differences (P<0.05) in maize grain yield, field weight and number at harvest between treated and untreated plots in both seasons. Grain yield, field weight and number of plants at harvest were significantly greater (P<0.05) in plots treated with both intercropping and mulching than the other treatments in both cropping seasons. On the other hand, yield, field weight and number at harvest were significantly lower (40.75, 53.5 kg, 281 and 23.60, 32 kg, 336) in the untreated plot in both 2005 and 2006 cropping seasons, respectively. There was a yield gain over the untreated maize of 12% in the simultaneous use of mulch and intercropping.

Correlation

There were highly significant and positive correlations between percentages of root damage and stem damage and between percentages of root damage and cob damage (Table 3). On the other hand, the number of plants at harvest was highly and negatively correlated with the percentage of stem and root damage (Table 3). Field weight and grain yield were highly and negatively correlated to the percentage of cob damage, but grain yield was positively correlated to field weight.

Table 1. Percentages of maize plants with root, stem and cob damage caused by termites in different treatments

Treatments	Percentages of damaged maize		
	Root	Stem	Cob
First cropping season (2005)*			
Untreated control	17.85 ± 3.05a	7.10 ± 0.30a	4.25 ± 2.05a
Diazinone 60% EC	7.25 ± 3.65b	1.25 ± 0.45c	0.40 ± 0.40b
Neem seed powder	8.80 ± 0.80b	3.20 ± 0.90bc	1.05 ± 0.45b
Intercrop with soyabean	9.00 ± 4.50 b	3.65 ± 0.35b	0.70 ± 0.20b
Intercrop + mulch	9.55 ± 4.75b	4.05 ± 0.25ab	0.70 ± 0.50b
Maize Stover as mulch	9.60 ± 1.60b	5.55 ± 1.95ab	2.4 ± 0.60ab
CV (%)	20.83	12.59	23.62
Second cropping season (2006)			
Untreated control	12.15 ± 8.45a	3.90 ± 1.70a	6.10 ± 1.30a
Diazinone 60% EC	3.50 ± 3.50b	1.10 ± 0.30ab	2.35 ± 1.85ab
Neem seed powder	3.75 ± 3.75b	0.70 ± 0.40b	3.65 ± 0.05ab
Intercrop with soyabean	2.95 ± 2.95b	0.95 ± 0.25b	1.70 ± 0.30b
Intercrop + mulch	4.35 ± 1.35b	1.00 ± 0.03b	2.45 ± 1.15ab
Maize Stover as mulch	3.35 ± 1.55b	0.85 ± 0.15b	1.65 ± 0.15b
CV (%)	39.54	23.49	24.53

*For each cropping season means within a column followed by the same letter (s) are not significantly different at p=0.05

Table 2. Number of plants at harvest, field weight and average grain yield of maize from plots with different treatments in two growing seasons

Season	Treatments	NAH	FW (Kg/plot)	Yield (kg/plot)*
2005	Untreated control	281±3.0b	53.5±0.1c	40.75 ± 0.44c
	Diazinone 60% EC	371.5±13.5a	64.1±0.7b	49.56 ± 0.98b
	Neem seed powder	345.5±3.5a	68.1±0.9ab	52.98 ± 0.39ab
	Intercrop with soyabean	356.5±22.5a	69.1±2.4ab	53.93 ± 2.28ab
	Intercrop + mulch	381.5±38.5a	75.6±4.0a	58.50 ± 4.23a
	Maize Stover as mulch	347±3.5a	62.8±3.2b	48.07 ± 1.59bc
	CV (%)	3.69	5.51	6.29
2006	Untreated control	336.5±50.5b	32±9.0d	23.60 ± 6.28d
	Diazinone 60% EC	393±15.0a	40.6±2.cd	30.08 ± 1.37bcd
	Neem seed powder	342.5±37.5b	43±4.0abc	31.51 ± 2.98bc
	Intercrop with soyabean	406±9.0a	50±10.0ab	36.86 ± 6.98ab
	Intercrop + mulch	414±5.0a	53.3±7.3a	39.61 ± 4.92a
	Maize Stover as mulch	413.5±2.5a	35.8±5.8cd	26.25 ± 3.62cd
	CV (%)	4.76	9.78	9.54

*Means followed by the same letter in a column within growing seasons do not differ significantly at p = 0.05

Table 3. Correlation among termite damage variables and agronomic characters

	%RD	%SD	%CD	NAH	FW	Yield
%RD	1.00	...	...	...	...	...
%SD	0.555**	1.00	...	...	...	...
%CD	0.562**	0.219	1.00	...	...	...
NAH	-0.555**	-0.539**	-0.239	1.00	...	...
FW	0.036	0.359	-0.579**	-0.110	1.00	...
Yield	0.062	0.369	-0.581**	0.115	0.997**	1.00

RD= Root damage **NAH** = Number of plants at harvest
SD= Stem damage **FW** = Field weight **CD**= Cob damage

Discussion

Our study demonstrated that intercropping maize with soyabean and use of maize stover and neem seed powder as mulches was associated with a significant reduction in termite attack on maize. Sekamattee *et al.* (2002) also observed that intercropping maize with a range of food legumes such as soyabean, groundnut and common bean significantly reduced termite attack on maize and an increase in the nesting of predatory ants in the maize field. Similar effects on levels of termite attack were observed in related studies on the effects of mulching maize with different quantities of maize stover. The use of maize stover as mulches above 4.7 $t.ha^{-1}$ significantly reduced *Macrotermes* and *Pseudacanthotermes* (Macrotermitinae) attack on maize (Sekamattee *et al.,* 2001). Coaton (1950) also observed that mulching crops with various items such as hay, manure, wood shavings or threshed maize cobs dramatically reduced attack by termites. The use of maize stover as mulch is used as alternative food for termite to reduce damage on standing plants so unless higher quantities of mulch are used its effectiveness is under question. This supports the long established view that leaving crop residues in the field or adding further organic matter will provide alternative food to which the termites will be attracted there by reducing levels of attack on crop plants (Logan *et al.*, 1990). The reduced termite damage on the plots mulched with neem seed powder could have been a result of repellent effects. Aschalew *et al.*, (2008) reported that neem seed powder and *Maesa lanceolata* leaf powder significantly reduced the damage level of termites on hot pepper at Bako.

The reduction in termite attack on the intercropped maize might be due to the thick legume canopy. Although there is no reported crop-based study on this phenomenon relating to termites, similar observations were made in a forest system (Tho, 1974) indicating that attack by *Macrotermes* sp. on eucalyptus ceased after canopy closure and also that the population of termites disappeared under mature monocultures of eucalyptus plantations.

The negatively correlations of grain yield and field weight with the percentage of cob damage showed that more percentage of cob damage lead to lower yield and field weight. On the other hand, positive correlation among the percentage of root, cob and stem damage indicated that more root damage consequently lead to greater cob and stem damage.

Reports of maize residue effects as reservoirs of lepidopteran stem borer larvae have been published (Sexena *et al.*, 1989). On the other hand, a range of benefits of applying organic material as mulch to the soil has been reported (Webster and Wilson, 1966). They include the reduction of soil erosion hazards, better infiltration of rainwater and less evaporation, lower soil temperatures, supply of organic matter and nutrients, higher biological activity, better root growth and suppression of weeds (Schroth *et al.*, 1992). Adetola *et al.*, (1995) also reported higher densities of detrivore and phytophageous micro arthropods in maize plots mulched with stover compared to those in bare fallow and unmulched control plots. Undoubtedly, a combination of a range of factors could have been responsible for the significantly greater yields of maize in plots with mulch and intercrop. In recent studies involving ant baits, Sekamattee *et al.* (2002) recorded a significant increase in maize yields due to improvement in termite predation by *Lepisiota* and *Myrmicaria* species. The result of this study suggested the importance role of mulch in reducing damage and maize yield loss by termites.

Conclusion

In conclusion, maize-soybean intercrops in appropriate circumstances help to suppress termite damage and to increase grain yield of maize. Soybean suppressed termite attack and improve yield of maize better than monocrop. The greatest impact of intercropping is likely to be in areas where termite infestation is currently a major production constraint.

Under the smallholder conditions in Ethiopia, maize stover is available and, considering the effort needed to mulch the relatively small hectarage compared to the problem of termite could be viewed as a justifiable practice for subsistence farmers. However, until more critical experiments are conducted in which the effect of mulching is isolated from effects due to predation and also to altered soil environments such as moisture and nutrients, the importance of mulch as alternative food for termites remains anecdotal. To reduce the dependency on insecticides and to provide cheap, locally available alternatives for small farmers, appropriate cultural methods, combined with the harnessing of the minimal use of modern or plant based insecticides and formulations in an integrated approach, will provide the best answer.

Acknowledgements

This publication is an output from a research project funded by the Ethiopian Institute of Agricultural Research for the benefit of developing countries.

References

Abdurahman, A. 1983. Termite control campaign in Wollega. Committee of Ethiopian Entomologists' *Newsletter* 3(2): 6-7

Abraham, T. 1990. Termite: Problems and possible methods of their control in agriculture with reference to the Ethiopian condition. In: Proceeding of the 10th Annual Meeting of the Ethiopian Entomologists (CEE). 7-9 February 1990. Addis Ababa, Ethiopia. Pp.50-74

Adetola Badejo, M., Guangton, T. and Brussaard, L. 1995. Effect of various mulches on soil micro arthropods under a maize crop. Biology and Fertility of Soils 20: 294-298.

Aschalew, S., Ahimed, I., and Tdele, T. 2008. Management of Termite (Microtermes adschaggae) on Hot Pepper Using Powdered Leaves and seeds of Some Plant Species at Baku, Western Ethiopia. *East African Journal of Sciences* 2 (1): 41-44

Coaton, W.G.H. 1950. Termite and their control in cultivated areas in South Africa. U.S Africa Department of Agriculture and Forestry Bulletin 305: 1-28.

Devendra, G., Ayo-Odongo, J., Kit, V., Lemma, G., and Mulugeta, N. 1998. A participatory systems analysis of the termite situation in west Wollega, Oromiya Region, Ethiopia.

Gold, C.S., Whightman, J.A., 1991. Effects of intercropping groundnut with sunnhemp on termite incidence and damage in India. *Ins.Sci. Appl.* 12, 177-182.

Johnson, R.A., Lamb, R.W., and Wood, T.G. 1981. Termite damage and crop loss studies in Nigeria - a survey of damage to groundnuts. *Tropical Pest Management* 27, 325-342.

Logan, J.M.W., Cowie, R.H. and Wood, T.G. 1990. Termite (Isoptera) control in agriculture and forestry by non-chemical methods: a review. *Bulletin of Entomological Research* 80: 309-330.

Ofori, F., Stern, W.R., 1987. Cereal-leggume intercropping systems.Adv. Agron. 41, 41-49.

SAS. 2000. SAS Statistical Users' Guide, Statistical Analysis System. SAS Institute Inc., Carry, NC, USA.

Schroth, G., Zech, W. and Heinmann, G. 1992. Mulch decomposition under agroforestry conditions in a sub-humid tropical savanna processes and influence of perennial plants. *Plant and soil* 147: 1-11.

Sekamattee, M.B., 2001. Options for integrated management of termites (Isoptera: Termitidae) in smallholder maize-based cropping systems in Uganda. Ph.D. Thesis, Mekerere University, 289pp.

Sekamattee, M.B., Ogenga-Latigo, M.W., Russell-Smith, A., 2001. The effect of maize stover used as mulch on termite damage to maize and activity of predatory ants. *African Crop Science* 9, 411-419.

Sekamattee, M.B., Ogenga-Latigo, M.W., Russell-Smith, A., 2002. Effects of maize-legume intercrops on termite damage to maize, activity of predatory ants and maize yields in Uganda. *Crop Protection* 22, 87-93.

Sexena, K.N., Reddy, K.V.S., Omolo, E.O., Pala-Okeyo, A. and Ngode, L. 1989. Integrated pest management, pilot trials. Annual report International Center of Insect Physiology and Ecology. Pp. 20-21.

Tho, Y.P., 1974. The termite problem in plantation forestry in Peninsular Malaysia. Malays. For. 37, 278-283.

Webster, C.C. and Wilson, P.N. 1966. Agriculture in Tropics. Longmans, London.