Role of Soil and Water Conservation Terraces in Integrated Termite Management

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Abstract

Field experiment was conducted in randomized block design in 2012 and 2013 on the role of soil and water conservation terraces on managing *Macrotermes* and *Microtermes* pest species of termite using wooden baits between adjacent terraces in Ghimbi district of Western Ethiopia. The zero gradient terraces range from 5 m to 20 m in length. Some of the terraces are said to be closed when the ends of adjacent terraces were connected by vertical right and left terraces. Ten wooden baits of 10 cm diameter had been inserted in the holes dug in the ground for this purposes between each of the terraces that was inspected by taking out five of the baits randomly at three months intervals. Terraces longer than 15 m protected termite damage and damage severity to the baits starting from six months after application of the treatments and significantly differed from the rest of the treatments. In conclusion, soil and water conservation terraces should be considered as one component of integrated termite management especially in areas where multiple species are involved in causing damage. Further investigation is also required on lengths and widths of level terraces as well as on the duration of the effectiveness of the terraces.

Keywords: Macrotermes, Microtermes, pest, bait, damage severity

Introduction

Termites are very serious pests in several parts of Ethiopia, particularly in the Western parts of the country. They cause considerable damage on agricultural crops, rangelands, forestry seedlings, and wooden structures such as wooden houses, stores, fences and bridges crossing streams (Assefa 1990; BARC 1998). Abraham (1998) reported 45, 50 and 18 % yield losses of cereal crops due to termites at Bako, Didessa and Asossa, respectively. Among the recorded termite species in Ethiopia the sub family Macotermitinae, Macrotermes and Microtermes in particular, constitute the greatest threat to agriculture and wooden structures in Western Ethiopia.

The use of organo-chlorines and queen removal has been in practice as a major component of termite control in Western Ethiopia (Emana and Gure 1997). While the reliance on organo-chlorines stopped following its ban and shortage on market, the use of queen removal became questionable because of continued survival of the colony upon the death of primary reproductive. The effectiveness of the control using queen removal was not evaluated and is questioned after several decades of practices in Ethiopia

(Emana and Gure 1997). Although termites are important structural pests in the country the research on the development of alternative pesticides and methods of control has not yet received the necessary attention (Sileshi *et al.* 2009).

Termite management practices should begin from the study of termite biology, ecology and behavior. Unfortunately, the third component has received scant and often rather selective attention, which may reduce the appropriateness and efficacy of any given management system in differing situations. Termites, especially Macro-termitinae construct foraging tunnels from their nest to the foraging site which may extend up to 50 m away from the nest. These tunnels are galleries or runways either just below or on the soil surface (Darlington 1982). Campora and Grace (2001) also reported that once a food source is found, further tunneling activity is in the direction of that food source.

Researches on termite species, colony survival after the death of the primary reproductives, and IPM have been reported as areas that requires special consideration (Sileshi *et al.* 2009; James *et al.* 1990). Ecological rehabilitation, chemical treatment, use of lodging resistant crops, queen removal aided by flooding and/or chemical poisoning and use of some botanical plants are some of the components to be integrated for effective control of termites according to Emana and Gure (1997).

Western Ethiopia is mainly characterized by sloppy topography where flooding occurs from higher slopes to the lower ones. Terraces are usually constructed for soil and water conservation purposes on sloppy areas in Western Ethiopia. These terraces are made perpendicular to the slopes. When water flows in the form of flooding, it fills these soil terraces and meets the termite tunnels that lead to the royal chamber of termites. It is a common phenomenon to observe termite fungus garden at the bottom of some terraces that are constructed for soil and water conservation. It means it destroyed the termite nests, killed the termite reproductives and destroyed their fungus comb. But these effects are not systematically evaluated so far in a way that it could be integrated for the management of termite pest. The role of soil and water conservation structures on termite pests in western Ethiopia including terraces of different lengths, width and gradients has never been reported. Therefore, this research was aimed at assessing the effect of level terraces or zero gradients (Fanya juu terraces) on termite pest incidence and damage severity. Besides, the objective of this study was to evaluate the effects of open and closed terraces on termites damaging wooden baits and the severity of the damage on the baits.

Materials and Methods

Description of study area

The study was conducted in Ghimbi District of Western Ethiopia in Oromia Regional State. The study site is 441 km away from Addis Ababa, the capital City of Ethiopia. Its elevation ranges from 1500-2000 m above sea level with moderately gentle to sloppy topography. The area is characterized by bigger and smaller rivers such as Didessa, Gelel, Bambi and others that are tributaries of Baro and Abbay which drain to Sudan (Ethiopian Mapping Authority 1988).

The district receives single rainy season that starts at the beginning of May and continues to the first half of September and is one of the most termite affected areas of the country. The rainfall is transported by south westerly winds. The rain fall is usually low with about two weeks dry spells in May that gradually becomes heavier through June, July and August (Daniel 1977). The mean maximum temperature ranges from 24-27 °C while the mean minimum temperature ranges from 13-15 °C.

The soils of the study area are predominantly Nitosols reddish brown to red in color (Regional Planning office for Western Ethiopia 1986). These soils are strongly acidic with pH less than 5.4 (Murphy 1968; Adugna 1984). The soils are highly deficient in available phosphorous which indicates that the soil requires heavy fertilization of phosphorous with some amount of lime (Murphy, 1968; Desta, 1982; Adugna, 1984).

Treatments

Terraces were constructed with five meter width at different lengths with closed and open ends. The different lengths were 5, 10, 15 and 20 m (Fig.1). The five meter width was closed in some of the treatments to compare its effect with open ones. The term closed was used when the end of the terrace is connected to the next by constructing terraces so that the terrace appeared rectangular in shape. The terraces were level terraces or zero gradients (Fanya juu terraces) to retain water in the terrace during the rainy season. This water flows through the canals that take to the royal chamber of termites that kills termite colonies. The treatments were:

1. Two 5 meter long terraces with their ends open (5 m open)
2. Two 5 meter long terraces with their ends closed (5 m closed)
3. Two 10 meter long terraces with their ends open (10 m open)
4. Two 10 meter long terraces with their ends closed (10 m closed)
5. Two 15 meter long terraces with their ends open (15 m open)
6. Two 15 meter long terraces with their ends closed (15 m closed)
7. Two 20 meter long terraces with their ends open (20 m open)
8. Two 20 meter long terraces with their ends closed (20 m closed)
9. Untreated

Figure 1. One block of level terraces

These treatments were laid in April 2012 in a Randomized Block Design with three replications. Ten wooden sticks (dry *Eucalyptus* spp) of 10 cm diameter were made in dug holes in the ground as baits between each of the two terraces of a treatment at one meter intervals to evaluate the damage caused by termites and severity of damage to the baits. *Eucalyptus* spp are one of the most affected construction materials in the study area. The untreated plot was ten meter length by five meter width measured area where similar baits with the treatments were used in the same manner. Five randomly selected wooden baits from each treatment were inspected at three months intervals. The damage done to the baits, the severity of the damage and the termite species involved were recorded. The damage done to the bait was made by simply observing the presence or absence of termite damage symptoms on the baits. But damage severity was assessed based on a scale of 1 - 5 (Smith *et al.* 1994); where 1 is no damage, 2 is up to 25%, 3 is 26-50 % damage, 4 is 51-75 % damage and 5 is more than 75 % damage. The species of termite involved were identified (Fig. 2) using termite identification key developed by Abdurahman (1992). The collected data were analyzed using NCSS soft ware for analysis of variance.

Results and Discussion

Results

The damage caused to the wooden baits did not differ significantly until six months after the application of the treatments. Terraces longer than 15 m protected termite damage to the baits starting from six months after application of the treatments and significantly differed from the rest of the treatments (Table 1). Closed terraces of 10 m and 15 m length were also statistically different from the open ones but on par with 20 m long ones. The rest of the treatments (5 m long open, 5 m long closed, 10 m long open, 15 m long open) terraces did not differ significantly from the untreated ones and did not protect termite attack except the 15 m long open terraces (1.4 and 1.6) that protected the wooden baits until 9 months after application of the treatments.

Table 1. The effect of open and closed level soil and water conservation terraces on mean number of baits damaged by termites from 3rd month to 15th month after application of treatments

Treatments	Months after application				
	Three	Six	Nine	Twelve	Fifteen
5 m open	1.1 (1.7)	1.6 (3.5)a	1.9 (3.7)a	2.1(4.3)a	2.2(4.7)a
5 m closed	1.4 (2.2)	1.1(2.3)b	1.7 (3.0)a	2.0(4.0)a	2.1(4.3)a
10 m open	1.5(2.3)	1.7(3.7)a	1.9(3.7)a	2 1(4.3)a	2.1(4.3)a
10 m closed	1.2(2.0)	1.3(2.7)b	1.5(2.3)b	1.7(3.0)b	1.8(3.3)b
15 m open	1.5(2.3)	1.4(2.8)b	1.6(2.7)b	2.0(4.0)a	2.1(4.3)a
15 m closed	1.3 (2.1)	1.3(2.7)b	1.5(2.3)b	1.6(2.7)b	1.8(3.3)b
20 m open	1.0 (1.6)	1.3(2.7)b	1.6(2.7)b	1.6(2.7)b	1.7(3.0)b
20 m closed	1.1 (1.7)	1.1(2.3)b	1.5(2.3)b	1.7(3.0)b	1.8(3.3)b
Untreated	1.5 (2.3)	1.8 (4.7)a	2.2(4.7)a	2.2(4.7)a	2.1(4.3)a
SE	0.3	0.1	0.1	0.1	0.1
CV	3.41	2.89	4.72	6.61	4.32

Means with in a column followed by the same letter (s) are not significantly different at 5% using Tukey's Honestly Studentized Test (HSD).

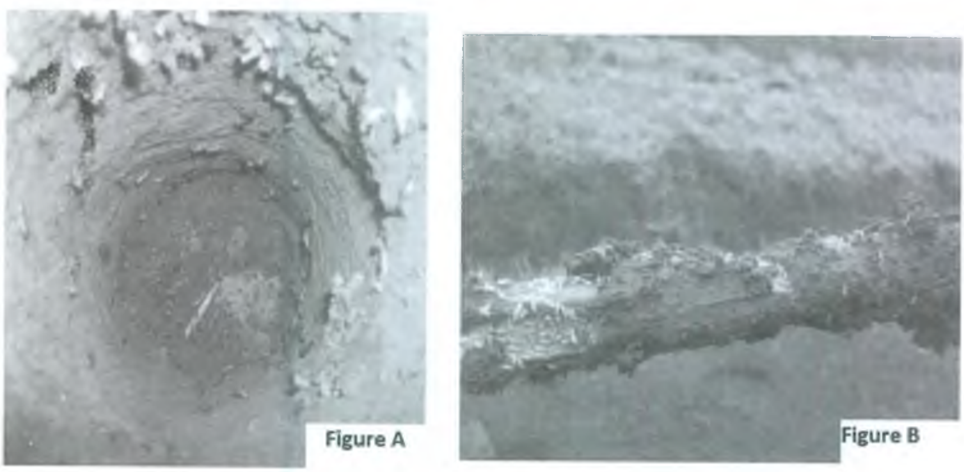

Figure 2 A) *Macrotermes subhyalinus* (Macrotermitinae) royal chamber along with queen, soldiers and workers B) *Microtermes* species

Damage severity to the baits was also analyzed starting six months after construction of the terraces. Data were square root transformed and numbers in parenthesis are actual number of baits damaged (Table 2). Terraces of all lengths except 5 m long open terrace (5.1) reduced severity of damage to the wooden baits six months after construction of the terraces. Terraces of 15 m long and above significantly reduced the severity of damage to the baits starting from six months after constructing the terraces until the end of the experiment. The rest of the treatments did not differ significantly from the untreated ones starting from nine months after construction of the terraces except 10 m long closed terrace (5.7) that produced significant difference 15 months after construction of the terraces.

In conclusion, 15 m and longer level terraces protected wooden baits from both genera of termite attack. Therefore, level terraces of soil and water conservation should be considered as one component of integrated termite management especially in areas where multiple species are involved in causing damage. Further investigation is also required on lengths and widths of level terraces as well as on the duration of the effectiveness of the terraces. The efficacy of the terraces was due to the fact that non gradient ability to hold water that was forced to find ways in termite galleries to flow (Fig.3). The flows of water in the galleries led to the destruction of the royal chamber and death of the colony.

Table 2. The effect of open and closed level (zero-gradient) water and soil conservation terraces on bait damage mean severity percentage by termites from 9th month to 15th months after application of treatments

	Months after application of treatment			
	Six	Nine	Twelve	Ffteen
5 m open	5.1 (26.7)b	6.2(40.0)b	7.7(60)b	8.1(66.7)b
5 m closed	4.5(20.0)a	5.7(33.3)b	6.6(46.7)b	7.2(53.3)b
10 m open	4.5(20.0)a	5.7(33.3)b	6.8(53.3)b	6.8 (46.7)b
10 m closed	4.5(20.0)a	4.5(20.0)b	6.2(46.7)b	4.5(20.0)a
15 m open	4.5(20.0)a	3.0(13.3)a	5.1(26.7)a	5.7(33.3)a
15 m closed	4.5(20.0)a	3.0(13.3)a	5.1(26.7)a	5.7(33.3)a
20 m open	4.5(20.0)a	3.0(13.3)a	5.1(26.7)a	5.1(26.7)a
20 m closed	4.5(20.0)a	3.0(13.3)a	3.0(20)a	4.5(20.0)a
untreated	5.7(33.3)b	6.8(46.7)b	7.7(66.7)b	8.1(66.7)b
SE	0.3	1.0	0.8	0.6
CV	2.61	4.68	6.62	8.26

Means with in a column followed by the same letter (s) are not significantly different at 5%. Mean separation was done using Tukey's Honestly studentized Test (HSD)..

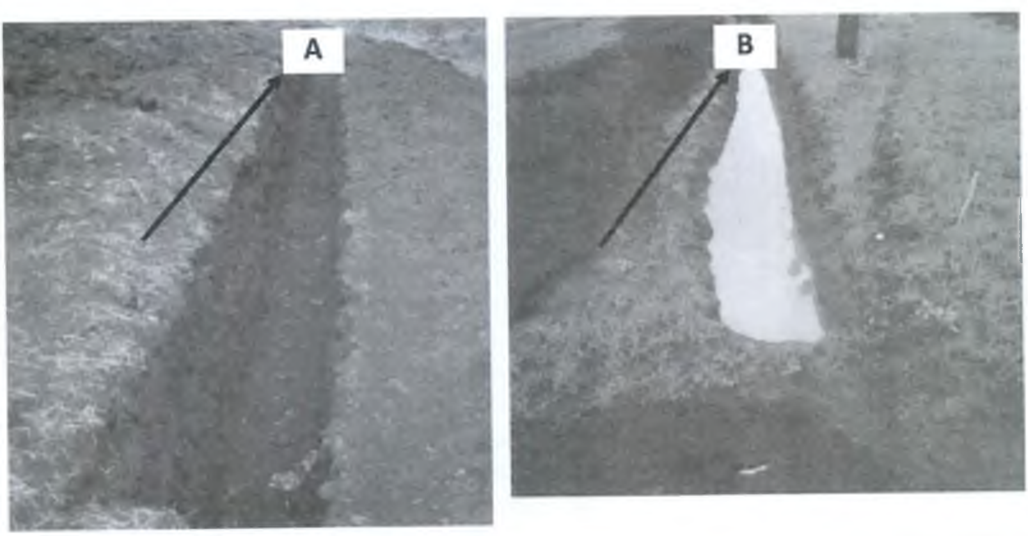

Figure 3. Level terrace and its water holding: arrows denote newly constructed terrace (A) and the water that filled the same terrace during the rainy season (B)

Discussion

The current finding is in accordance with the Darlington (1982) who reported that termites move in tunnels or galleries or runways either just below or on the soil surface. The damage to these galleries is not only detrimental to the worker termites that move to and from their nest to foraging areas but also permits flow of water into the royal chamber and fungus garden. The water that comes in contact with the royal chamber and the fungus garden destroys and moves away to the lower slopes by flooding. Le page (1977) also reported that *M. subhyalinus* forage near the nest during rains indicating that they could be damaged by flooding when moved further away from their nest.

There is no much published information regarding the effect of terraces on termite colonies and therefore, it became difficult to compare or contrast the result of the present findings. But Johnson *et al.* (1981) reported negative relationship between percentage of baits attacked and the duration of rainfall in *M. subhyalinus* that shows the impact of water on the species. Abdurahman (1992) also reported that tractor plowed areas are less prone to the attack of *M. subhyalinus* and *Microtermes* species (Fig. 2) because of the destruction of the foraging tunnels.

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