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Effects of Different Termite Management Practices on Maize Production in Assosa District, Benishangul Gumuz Region, Western Ethiopia

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Abstract
Termite is one of the most important serious insect pests of maize facing severe problem in western part of Ethiopia. The present study was conducted to evaluate the effectiveness of four different management practices, their combined and their integration. The treatments consisted of chemical control (Malathion 50% E.C at rate of 2L/ha), botanical control (Echinops kebericho at rate of 3l/ha), cultural (ash at rate of 2.5kg/plot), and physical soil and water conservation (terrace 30cm in width*60cm in depth) and their integration and untreated control was used to check the significance. The experiment was laid out by randomized complete block design with twelve treatments and three replications which is thirty six total observations. The termite infestation was appeared after 20 days of germination emergency within the plots and immediate treatment application was carried out. The integrated treatment, Malathion 50% E.C X Echinops kebericho X Terrace X Ash showed significance difference ($P<0.05$) and the least number of maize root damage (1%, no damage) and stem damage (0.67% and 0.67%) were recorded at seedling stage and harvesting time respectively. Whereas, cob damage was registered at harvesting time (1%) and the maximum number of normal maize stand count (178.67) was recorded by the integrated and contributed highest yield (6617.3kg/ha which is 93.06% of which only 6.94% yield was lost by termite infestation) whereas, untreated control showed higher number of root damage (6.33% and 5%), stem damage (6.33%, 9%) and cob damage (9%) and recorded least number of normal stand count (139) revealed with the lowest yield (5148.1kg/ha and contributed to72.4% yield of which 27.6% of yield was lost by termite infestation). Generally, the plots applied with the four integrated treatment contributed a good protection of termite infestation and recorded high yields than combined, separately applied treatments and untreated control and recommended for future use.
Keywords: - management practices, termite, insect pests, infestation, damage

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most popular crops grown in the world, ranking second next to wheat and followed by rice (Vasal, 2000). It occupies an important position in the world economy as food, feed, and industrial grain crop. It is a staple food for several million people in the developing world where they derive their protein and calorie requirements from it. Maize is among the leading cereal crops selected to achieve food self-sufficiency in Ethiopia (Benti *et al*., 1993).

The low yield is attributed to a combination of several constraints among maize production mainly to lack of improved production technologies such as varieties and pest management practices, moisture stress, low fertility and poor cultural practices. Among them Termites is one of the most economically important insect pests by eating wood and wood-based cellulosic materials, cause more destruction to crops and paper products and the most difficult and expensive to control in the world than any other insects (Xing *et al.,* 2001).

Termites are small animals belong to insect group (Isopteran: Termitidae) found primarily in the tropical regions of the world. They are so named because the primary reproductive adults usually referred to as “swarmers”, which have two pairs of equal length wings. There are approximately 2,761 named termite species in 282 genera worldwide (Paul, 2005).

1.1 Statement of the Problem

Termite control is scarce throughout much of the tropics and subtropics where the majority of destructive termite species are found. Although the tolerance or action threshold for many rural pests (equivalent to the economic threshold for agricultural pests) is considered low or even absent in developing countries, control action against termites may not be economically feasible in many countries where these destructive pests are most abundant. In rural areas of many developing countries, for example, severe termite damage to vegetation, crops and forests are often tolerated because the control cost which means chemical cost is higher and beyond the capacity of individual farmer (Nan-Yao and Rudolf, 1998).

In Ethiopia, termites are one of the major threats to agricultural crops facing severe problem in western part of the country. Assosa District is one of the termite infested areas. This wide area infestation of termites have brought a multidirectional problem on the livelihood of human beings reside in the area. The main victim of the problem is the farming communities found in the rural areas in this District those depends on agriculture for their

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livelihood income. Termites destruct crops on the field starting from the early stage of sowing to the maturity stage of the crops and even at storage.

The research was helped to know the effectiveness of the five termite management practices (cultural practices (ash), botanical control practices (*Echinops kebericho*), applying physical soil and water conservation practice (terrace at 30cm in width *60cm in depth), chemical application (Malathion 50% E.C), their combination and their integration) on a separate maize experimental plot. Therefore, the present study was carried out to evaluate the effectiveness of different termite management practices on maize production.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Assosa woreda is located in Benishangul-Gumuz National Regional State, Assosa Zone. The woreda's administrative town is known as Assosa. It is also the Zonal and Regional administrative town. The town is 668 km away from Addis Ababa through the Nekemte road in western direction. Assosa woreda is bordered in the North-western direction by Kurmuk and Komosha woreda, North-eastern direction bordered by Mange woreda, southern direction by Mao-Komo, Western direction by Sudan and in the Eastern direction bordered by Bambasi woredas of Benishangul-Gumuz Region.

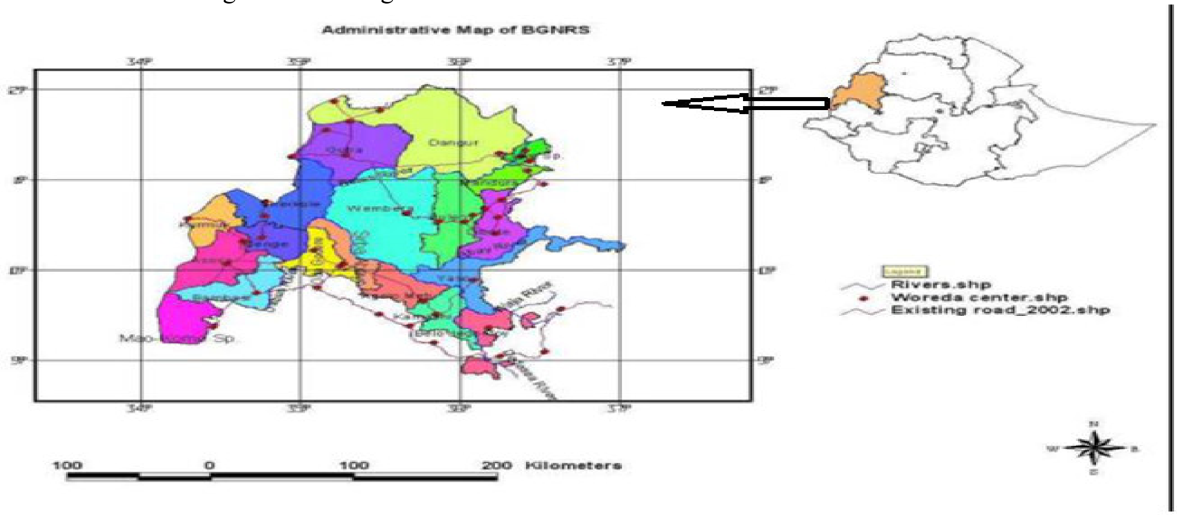

Figure 1: Map of Benishangul-Gumuz Region in Ethiopia

Figure 2: Map of Assosa woreda in Benishangul-Gumuz Region

2.1.2 Climate

The agro-ecological zone of Assosa woreda is about 90% kola and less than 10% is "Weyna Dega". The average temperature of the woreda is 27^0C. The rainfall pattern is mono-modal rainfall distribution. The annual rainfall of the woreda ranges between 900mm to 1400mm by using the moisture available from rainwater most of the crops are cultivated in the woreda.

2.2 Sources of Data

The primary data was collected from the maize management practices such as number of damaged maize parts (root damage, stem damage and cob damage at seedling to harvesting time) which were treated by different termite management practices (such as cultural (ash) method, applying physical soil and water conservation (terrace), botanical methods (*Echinops kebericho)*, chemical application (malathion 50% E.C.), their combination and integration and control plot). The untreated plot was served as a control. The secondary data was collected from different sources of reviews, published journal sources (thesis, discertation, reports, and books)

2.3 Sampling Techniques

Assosa woreda is purposively selected for the purposes of potential production of maize. Then the reconnaissance survey was carried out in the PA of kebele from Woreda where severe termite infestation available was identified. From the identified Kebele; two peasants were selected and the peasants' land was selected with the size of 6m x 6m dimension of plot and 1m x1m from one plot to the other which gave the total area of 1311m^2 of land for study.

2.4 Maize planting materials

The seed type used for this research was BH-540 variety which was taken from Ethiopian Agricultural Research Center (Assosa Agricultural Research Institute). The seed was remained packed and stored under safe and low temperature till sowing. The total weight of seed used for the study was 25kg/ha which were 3.24kg/ha. The maize seed was sowed on a plot size of 6mx6m = 36m^2 with the distance between inter row and row to row is 25cm to 75 cm respectively. Two seeds were put within the row with the fertilizer and covered with soil. There were 8 inter rows and 24 plants within rows, the total number of maize seedlings were 24*8=192 without the border effects. After 15 days of germination emergency, the germination percentage was counted from each plots and checked.

2.5 Experimental Design and Treatments

The experiment was laid out in Randomized Complete Block Design (RCBD) with twelve treatments and three replications and the total observations were 36. There were four treatments applied separately, the four treatments were combined and integrated. Control was used to check the effects of the treatments. The treatments include Cultural (ash= 2.5kg/plot) method, applying physical soil and water conservation (terrace= 30cm in width*60cm in depth), botanical methods (*Echinops kebericho* at rate of 3l/ha), chemical application (malathion 50% E.C. at rate of 2l/ha), their combination, integration and control plot).

2.6 Data Collection

The data was collected from maize parts (damaged root, stem, cob) treated by different termite management practices and control, the data was taken from the number of maize stand those which was normally protected at harvesting time and infested and damaged by termite from all plots which were taken at different crop growth stage (seedling stage, maturity stage at harvesting time) and the yield was collected after harvested.

Waiting period

Waiting period involved from the time of sowing to germination emergency and from emergency to towards up to the termite infestation was started before application. So, as soon as the germination emergency appeared critical observation is required around all plots. At this time the treatments must be prepared for immediate application as soon as termite damage started.

Days to first termite damage appearance

Days to first termite damage to the maize plants by termites were recorded for all the treatments.

Root damage: At each assessment fifteen maize plants was randomly selected plants per plots (from 8 rows next to border) was taken as root systems damage and assessed for termite damage. The assessment was conducted five times, seedling stage, maturity stage at harvesting time, which was 60, 150 days after treatment application. Root damage samples were expressed as the proportion of plants showing termite attack out of the total sampled plants.

Stem damage: fifteen plants per row were arbitrarily taken from the middle six rows of each plot to assess termite damage on maize stem. Sampled plants were tagged and assessed for termite damage throughout the cropping season. Each tagged plant was inspected for stem damage by termite 60 and 150 days after treatment application. Stem damage was expressed as the proportion of plants showing termite attack out of the total sampled plants for all treated and control plots

Cob damage: ninety maize plants, which were previously tagged for stem damage assessment, were assessed for cob damage due to termite attack. Each tagged plant was inspected for cob damage immediately up to harvesting. Cob damage was expressed as the proportion of plants showing cob attack out of the total sampled plants.

Yield: At physiological maturity, maize cobs were harvested from the middle six rows of each plot. The threshed grains moisture content was adjusted at 11%. Maize grains were weighed to determine the magnitude of yield, extrapolating plot yields to kg ha-1.

2.7 Data Analysis

Data was exposed to analysis of variance employing inferential statistics. The least significance difference (LSD) test was used to separate significantly within means. The Statistical Analysis System (SAS 9.2) software was used to analyze the maize. Finally, the analyzed data were mentioned in the form of tables or graphs, figures and interpreted accordingly.

3. RESULTS AND DISCUSSION

3.1 Days to First Termite Damage Appearance

As soon as the germination emergency of the maize appeared, observation was carried out to undertake the first termite damage emergency which was a waiting period of termite damage. Thus, there was no treatment application unless the damage was recorded. Therefore, each plot was observed from hour to hour to record the first termite damage for applying the treatments. After the germination emergency of maize (after 20 days of sowing, after ten days of germination emergency), termite infestation was registered. Then the first termite damage appearance data was recorded from each plots before application and then followed by treatment application.

The first termite damage appearance showed significance difference among the treatments of *Echinops kebericho* X Terrace recorded maximum seedling damage (3.33%) and *Echinops kebericho* X ash (0.00%), no seedling damage recorded. High percent damage of seedling was recorded in treatments Malathion 50% E.C x Terrace (2.33%) and low number of seedling was recorded in ash (0.33%).

3.2 Effects of Management Practices after 60 Days of Application

After 60 days of application, the root and stem damage maize were also observed, in root damage, the treatments showed highly significance difference at ($p<0.05$), the integrated treatment, Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash, Terrace X Ash, Malathion 50 % E. C X Ash, Malathion 50% E.C x Terrace, Malathion 50% E.C X *Echinops kebericho*, ash and Malathion 50% E.C showed high protection and recorded least number of root damage which were (1.00%, 1.67%, 1.67%, 1.00%, 1.33% and 2.00%) respectively. However, untreated plots showed higher number of root damage and followed *Echinops kebericho,* Terrace, *Echinops kebericho* X Terrace and *Echinops kebericho* X ash which obtained (6.33%, 3.33%, 3.33%, 3.00% and 2.67%) respectively.

In similar way, there was highly significance difference in maize stem damaged among the treatments. High number of stem damaged in control (6.33%) and terrace obtained higher stem damage next to untreated control (3.67%). The integrated treatment registered the least number of maize stem damage (0.67%), then followed by Malathion 50% E.C (1.00%) and Malathion 50% E.C X *Echinops kebericho* (1.00%) from low to high stem damage (table 1).

Similarly, UNEP (2000) also reported that *Macrotermes* spp. cause to start damage to maize was at seedling stage similarly, the present investigation agreed with this report in which similar result was showed. The conserved moisture promotes the development of above ground vegetation; these helps to maintain the productivity level of the soil by increasing the biomass development Sileshi *et al*., (2005).

Table 1: Cumulative Effects of first termite damage appearance (20 days after germination) and Management practices on maize root damage and stem damage after 60 days of application

Treatments	Days to 1st root damage %	No. root Damage (%)	No. of stem damage (%)
Malathion 50% E.C	3.00^{ab}	2.00^{b}	1.00^{b}
Echinops kebericho M.	0.67^{abc}	3.33^{ab}	2.00^{b}
Terrace	1.33^{abcv}	3.33^{ab}	3.67^{ab}
Ash	0.33^{bc}	1.33^{b}	2.33^{b}
Malathion 50% E.C X *Echinops kebericho*	1.00^{abc}	1.00^{b}	1.00^{b}
Malathion 50% E.C x Terrace	2.33^{abc}	1.67^{b}	2.00^{b}
Malathion 50 % E. C X Ash	1.33^{abc}	1.67^{b}	2.33^{b}
Echinops kebericho X Terrace	0.00^{c}	3.00^{ab}	2.00^{b}
Echinops kebericho X ash	3.33a	2.67^{ab}	1.67^{b}
Terrace X Ash	2.00^{abc}	1.00^{b}	2.33^{b}
Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash	2.33^{abc}	1.00^{b}	0.67^{b}
Untreated control	1.00^{abc}	6.33^{a}	6.33^{a}
MSE	**2.52**	**5.27**	**4.02**
CV	**38.71**	**2.37**	**24.76**
LSD (0.05)	**2.67**	**3.87**	**3.38**

**** Means with the same letter in a column are not significantly different at P<0.05***

3.3 Effects of Different Termite Management Practices after 150 Days /at harvesting time

There were significantly different among treatments at harvesting time. At harvesting time, the number of maize stand count was collected and to compare with the damaged and the yield of maize after dried, harvested and threshed by decreasing the moisture content of maize between 11 to 12%. The integrated treatment, Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash recorded for about 178.67 mean numbers of maize stand plant and

93.05% percent of protection at harvesting time.

Treatments such as Malathion 50% E.C X *Echinops kebericho (*171.33*)* or (89.23%) of protection, Malathion 50% E.C x Terrace (170.00) or (88.54%) of protection, *Echinops kebericho* X ash (169.33) or (88.19%) and Malathion 50 % E. C X Ash (172.67) or (89.93%) of maize protection and registered the second important mean number of maize stand crop whereas, Malathion 50% E.C (166.67) or (86.80%), *Echinops kebericho* (166.00) or (86.45%), Ash (164.33) or (85.58%), *Echinops kebericho* X Terrace (168.00) or (87.5%) and Terrace X Ash (167.00) or (86.98%) showed the third important treatments recovering the mean number of maize stand.

However, Terrace (158.67) or (82.64%) was used as the fourth and least controlling mean number of maize against termite next to control (139.00) or (72.39%) in which 27.60% of maize stand number was lost from germination emergency up to harvesting time. This showed that the integrated treatment contributed higher protection of maize from termite damage which the difference from the control was 20.65% and the least protector of maize from termite was terrace (10.04%) when compared to untreated control (table 2).

Michael, 2005 indicated that among the diversity of practiced and potential methods, the option of using cultural practices, botanical control agents against termites, applying physical soil and water conservation, using narrow spectrum pesticides and using the integration of the four management measures; continues to attract a great deal of attention and provide good successful management from insect pests and diseases, our result showed strongly agreed with this reports, but no clear rate was mentioned

In root damage, the mean number of damaged maize showed significance difference among treatments and untreated plots; treatments; malathion 50% E.C (1.00%), terrace (1.33%), ash (1.33%), Malathion 50% E.C x Terrace (1.00%) and Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash (0.67%) and control (5.00%), but the remaining treatments showed no significantly difference when compared with control.

In stem damage of maize, plots applied by integrated treatments from the control plots which registered 0.67% and 9.00% mean number of damaged maize crops respectively. All the rest treatments did not show significantly difference from untreated plots. The stem damage was increased at harvesting time than at maturity time and highly increased under control plots.

In cob damage, there were significance differences among the applied treatments with control, all the treatments registered almost similar mean number of maize cob damage which means the infestation of maize within all applied treatments in plots were same, But untreated plots was significantly different and registered 9.00% mean number of maize cob damage. Terrace (5.67%), Echinops kebericho (4.33%), malathion 50% E. C. (3.67%) and ash (3.00%) after untreated maize plots (table 2). The number mean damage of maize cob was increased at the time of harvesting than at the time of maturity. From observation, at the time of harvesting some of the maize crops were fell down due to the heavy rain with winds than other stages of growth and became the major factor of increasing cob damage.

According to the investigation of (Alembrhan, 2008), showed root of maize plants due to termite damage was attacked at all stages, however, increased towards the end of the three months of emergence and high stem damage was recorded after102 days of seedling emergence similarly, the present investigation showed similar result with this report.

Table 2: Cumulative Effects of Management practices on maize stand count, root damage, stem damage and cob damage after 150/ at harvesting time days of application

Treatments	Normal stand count	%root damage	% of Stem damage	% Cob damage
Malathion 50% E.C	166.67^{bc}	1.00^{b}	5.00^{ab}	3.67^{bc}
Echinops kebericho	166^{bc}	2.00^{ab}	4.67^{bc}	4.33^{bc}
Terrace	158.67^{c}	1.33^{b}	5.33^{ab}	5.67^{ab}
Ash	164.33^{bc}	1.33^{b}	3.00^{bc}	3.00^{bc}
Malathion 50% E.C X *Echinops kebericho*	171.33^{ab}	2.00^{ab}	3.33^{bc}	0.67^{c}
Malathion 50% E.C x Terrace	170^{ab}	1.00^{b}	3.67^{bc}	0.67^{c}
Malathion 50 % E. C X Ash	172.67^{ab}	2.33^{ab}	2.33^{bc}	1.00^{c}
Echinops kebericho X Terrace	168^{bc}	2.67^{ab}	3.00^{bc}	1.00^{c}
Echinops kebericho X ash	169.33^{ab}	2.00^{ab}	2.67^{bc}	0.67^{c}
Terrace X Ash	167^{bc}	3.33^{ab}	3.33^{bc}	1.00^{c}
Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash	178.67^{a}	0.67^{b}	0.67^{c}	1.00^{c}
Untreated control	139^{d}	5.00^{a}	9.00^{a}	9.00^{a}
MSE	**37.61**	**4.19**	**5.72**	**6.66**
CV	**3.69**	**33.21**	**27.63**	**17.94**
LSD	**10.33**	**3.45**	**4.03**	**4.35**

***** *Means with the same letter in a column are not significantly different at P<0.05***

3.4 Effects of Different Termite Management Practices on Maize Yield

The analysis of variance for mean grain yield showed significantly ($p<0.05$) differences among the treatment combinations for the main and interaction effects of grain yield (Table 3). The result revealed that there was significant ($p<0.05$) difference in grain yield between Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash and untreated control; the mean yield of maize registered was 6617.03 kg/ha and 5148.1kg/ha or 93.06% and 72.4% respectively (Table 3). This was mainly due to the fact that the integrated treatment revealed high protection of maize growth and performance from termite infestation.

According to the report of Constantino R., 2002 showed that more than 77 species are pests for structure or agriculture and managed by different traditional techniques like the use of ash.

However, terrace was significantly difference when compared with untreated control which was (5876.5 kg/ha) and (5148.1kg/ha) and 82.64% and 72.4% respectively. The rest treatments were showed significantly difference when compared with control and registered the yields ranged between 5888.89- 6305.56 kg/ha or 81.89% and 87.67% respectively.

Among treatments used in this experiment, the highest mean yield losses were recorded from plots treated with terrace and untreated control which gave (1234.6 kg/ha) and (584.75kg/ha) and percent of yield loss were 17.36% and 27.60%) respectively whereas, plots treated with the integration, Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash was registered the least mean yield losses which is (493.80kg/ha and the percent loss is 6.94%). The remaining treatment also showed significantly lower grain yield loss than the untreated check.

Gemechu *et al*. (2012) reported that moth mortality (27.80%) was registered *E. kebericho* followed by minimum dose at 0.5 g of root powder after 20 days of exposure.

Table 3: Cumulative Effects of Management practices on maize yield after harvested

Treatments	obtained Yield (kg/ha)	yield (%)	Yield loss (Kg/ha)	Yield loss (%)
Malathion 50% E.C	6172.80bc	86.81	938.3bc	13.19
Echinops kebericho	6148.10bc	86.46	963bc	13.54
Terrace	5876.5c	82.64	1234.6b	17.36
Ash	6086.4bc	85.59	1024.7bc	14.41
Malathion 50% E.C X *Echinops kebericho*	6345.7ab	89.24	765.4cd	10.76
Malathion 50% E.C x Terrace	6296.3ab	88.54	814.8cd	11.46
Malathion 50 % E. C X Ash	6395.1ab	89.93	716.0cd	10.07
Echinops kebericho X Terrace	6222.2bc	87.5	888.9bc	12.5
Echinops kebericho X ash	6271.6ab	88.19	839.5cd	11.81
Terrace X Ash	6185.2bc	86.98	925.9bc	13.02
Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash	6617.3a	93.06	493.8d	6.94
Untreated control	5148.1d	72.4	1963.0a	27.60
CV	**3.69**		**23.56**	
LSD	**382.77**		**382.77**	

**** Means with the same letter in a column are not significantly different at P<0.05***

4. CONCLUSION AND RECOMMENDATION

Termites are one of the major threats to agricultural crops facing severe problem in western part of the country; the present study was aimed to conduct to evaluate the effectiveness of different termite management practices on maize production.

The highest and lowest root and stem damage at seedling were recorded by control 6.33% and 6.33% and by integration 1.00% and 0.67% respectively. There were also higher mean number of root damage (6.00%) and stem damage (7.00%) under untreated plot whereas; lower root damage (1.00%) and stem damage (0.87%) was revealed by the integration. The maximum and minimum mean yield of maize was recorded by Malathion 50% E.C X *Echinops kebericho* X Terrace X Ash (6617.03 kg/ha) and untreated control (5148.1kg/ha) and the mean percent of yield registered were 93.06% and 72.4% respectively,

In conclusion, separately applied treatments provided more termite inhibition than untreated control; the combined treatments showed better protection than separate treatments and the integrated treatments provided higher protection of termite infestation and least number of root, stem and cob were damaged and contributing high yielder of maize than other plots applied by treatments

It is recommended that the result indicated the four integrated treatments provided higher pest repellency and the best protection of termite pest. The combined treatments of malathion 50% E.C X echinops kebericho and malathion 50% E.C X ash will be helped in the future prospects.

Developing another alternative rates, types and formulation will be needed. Identification of pest species, assist pest prevalence and the relationship with other organisms will be developed Conservation and maintaining of soil fertility will be done.

Application of new technology and Proper agronomic production of maize will be encouraged tinning of maize and removing of weeds is also the means to minimize pest infestation in the crop field.

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