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Efficacy of botanical extracts against termites on maize (*Zea mays* (L.)) under field condition in western Ethiopia

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ABSTRACT*:* Maize *(Zea mays L.)* is grown popularly in the world. It is severely attacked by termites. Insecticides are widely used to control, but could not minimize termites' damage mainly because of resistance development and easily break down of the active ingredients. Hence, field experiment was conducted with the aim of evaluating different botanical crude extracts from leaves of *Croton macrostachys* (*Hochst*), *Jatropha curcas L. and Phytolacca dodecandra L.* for the management of termites. The experiment was conducted at Wollega University (WU) under irrigation and rain fed conditions. Leaves of the botanicals were collected from experimental sites in western Ethiopia and dried under shade. The dried leaves were grounded to a fine powder using a small hand-operated manual grinder and the powder was further sliced with analytical mill and sieved through a 0.25 mm pore size mesh to make uniform fine dust particle. The treatments were *C. macrostachys*, *P. dodecandra, J. curcas, C. macrostachys* + *P. dodecandra, C. macrostachys* +*J. curcas, P. dodecandra* + *J. curcas, C. macrostachys* + *P. dodecandra* + *J. curcas*. Untreated check was used for comparison. For treatment preparation, 300 g. of each botanical leaf powder was soaked in 1000 ml distilled water for 72 hrs. The mixtures were filtered with clean cheese cloth and stored in a beaker of 250 ml capacity. The experiment was laid-out in a Randomized Complete Block Design (RCBD) in four replications. Shallow holes for maize seed planting were prepared well ahead of planting on the experimental plots. From the stock solution of each botanical, 20 ml was drenched to each planting hole 10 days before planting and continued at all maize growth stages. Treatments were applied using 30 ml capacity Syringe. Data on termite damage symptoms were collected two days before planting and two days after treatment application at every growth stage. The results revealed that mixed botanicals treatments were significantly ($p<0.05$) superior to non-mixed botanical treatments in the management of termites. The highest number of foraging termites, galleries and mounds were recorded in the untreated check plot, while the lowest was recorded in the mixed botanical treatments. Moreover, the highest number of maize stand count, maize cobs and maize yield were recorded from plots that received mixed botanicals and the lowest were recorded from the untreated plot. In conclusion, mixtures of *C. macrostachys, J. curcas and P. dodecandra* can be used as part of an integrated termites' management.

Keywords/Phrases: ***Croton macrostachys, Foraging termite, Foraging tunnel, Jatropha curcas,Phytolacca dodecandra.***

INTRODUCTION

Maize (*Zea mays* L.) is the most popular crop grown in the world. It is a staple food for millions of people living in the developing world including Ethiopia. Maize grows in nearly all agro-ecological zones (FAO, 2011). African farmers grow maize more than any other cereals as maize can adapt to various agro-ecology from lowland to highland and due to its lucrative yield. Maize accounts for over 30% of poor farmers' income and contribute to 60% of dietary calories and 50% of protein intake in Africa (IITA, 2009). In Ethiopia, maize grows across varied agro ecological zones (Emana Getu *et al*., 2006). Since its arrival to Ethiopia between 1600 and 1700 centuries probably from Mexico, maize grows well between 500 to 2400 meters above sea level (m.a.s.l.) (Emana Getu *et al*., 2006). Maize production received a great attention in Ethiopia because of several reasons such as high productivity (12 tons ha^{-1}), short growth period (3-5 months) and its suitability for different dietary forms among others (CSA, 2013). However, the high yielding potential of maize is constrained by a number of factors including insect pests and diseases. From the insect pests, the damage inflicted by termites is tremendous (30-100%) in Ethiopia in general and western Ethiopia in particular (Emana Getu *et al*., 2006; Sileshi Gebre *et*

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al., 2005; Ketema Hirpa and Tufa Bulto, 2016). Termites damage maize starting from the early stage of sowing to the maturity stage of the crop and in the store. Termite genera involved in the infestation of maize in western Ethiopia include *Macrotermes*, *Odontotermes* and *Pseudacanthotermes* (Abdurahaman Abdulahi, 1990; Emana Getu *et al*., 2006). Different control options of termites are available including queen removal and use of termiticides such as fipronil, imidacloprid and chlorantraniliprole (Thomas *et al*., 2011; Emana Getu *et al*., 2006; Mulatu Wagari and Emana Getu, 2015). The use of queen removal proved to be in effective as secondary female reproductive from the colony can immediately replace the mother and rescue the colony unless the operation is immediately followed by flooding and poisoning using termiticides (Emana Getu *et al*., 2006). The use of termiticides has different negative impacts including environmental pollution, non-target effect, high cost and resistance development among others (Grdisa and Grsic, 2013). Thus, looking for alternative termite control method is crucial. Due to its availability at users premise and its low negative impacts a number of scientists recommended the use of botanical plants as an alternative to the use of pesticides in general and termiticides in particular (Nyeko *et al*., 2010). Farmers of western Ethiopia rectified the failure of termiticides under use in controlling termites (Temesgen Beyene, unpublished data). Therefore, the objective of the current study was to evaluate botanical leaf extracts against termites in western Ethiopia on maize under field condition.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Wollega University (WU) on station Research site located in Nekemte town and WU Uke sub-station (Figure 1). Both study sites were found in East Wollega zone. Detail descriptions of the study sites are presented in Table 1.

Table 1. Coordinates, elevations, mean annual rainfall, relative humidity and temperatures of the study sites.

Location	Coordinates	*Elevation (m.a.s.l.)	Mean annual rainfall (mm)	Relative humidity (%)	Mean annual Temperature (°C)	
					Maximum	Minimum
Nekemte	9°5′.887″N,36°34.647′E	2080.00	1862.33	55.45	21.66	13.62
Uke	8°11′52′′N, 0°94′44′′E	1500-1700	1666.00	50.02	31.00	16.00

Source: National Meteorological Agency of Ethiopia (Average of 10 years).
****meters above sea level***

Wollega University on station field is located in the western direction of Nekemte town. Nekemte is located 335 km away from Addis Ababa to the West. Uke sub-station field site is found 375 km away from Addis Ababa and 44 km away from Nekemte on Nekemte to Burae- Bahirdar road. The soil type of the study areas is loam, clay and sandy, which favour the growth of different types of crops including maize. Maize and sorghum are the major crops grown in the study areas. Savannah type grasses and forest trees are dominating the areas. The socio-economy of the study areas is predominantly mixed farming. Cows, sheep, Goat and Equines are dominating the livestock sector.

Termite Identification

Termite solider sample involved in the infestation were collected and preserved in a vial containing 80% alcohol (Abdurahaman Abdulahi, 1990; Daniel Getahun and Bekele Jembere, 2006). The specimens were taken to Addis Ababa University, Insect Science Laboratory for identification. Identification Keys for the Genera of Ethiopian Termites, books, pictures and reference collections were used for the identification (Emana Getu *et al*., 2006).

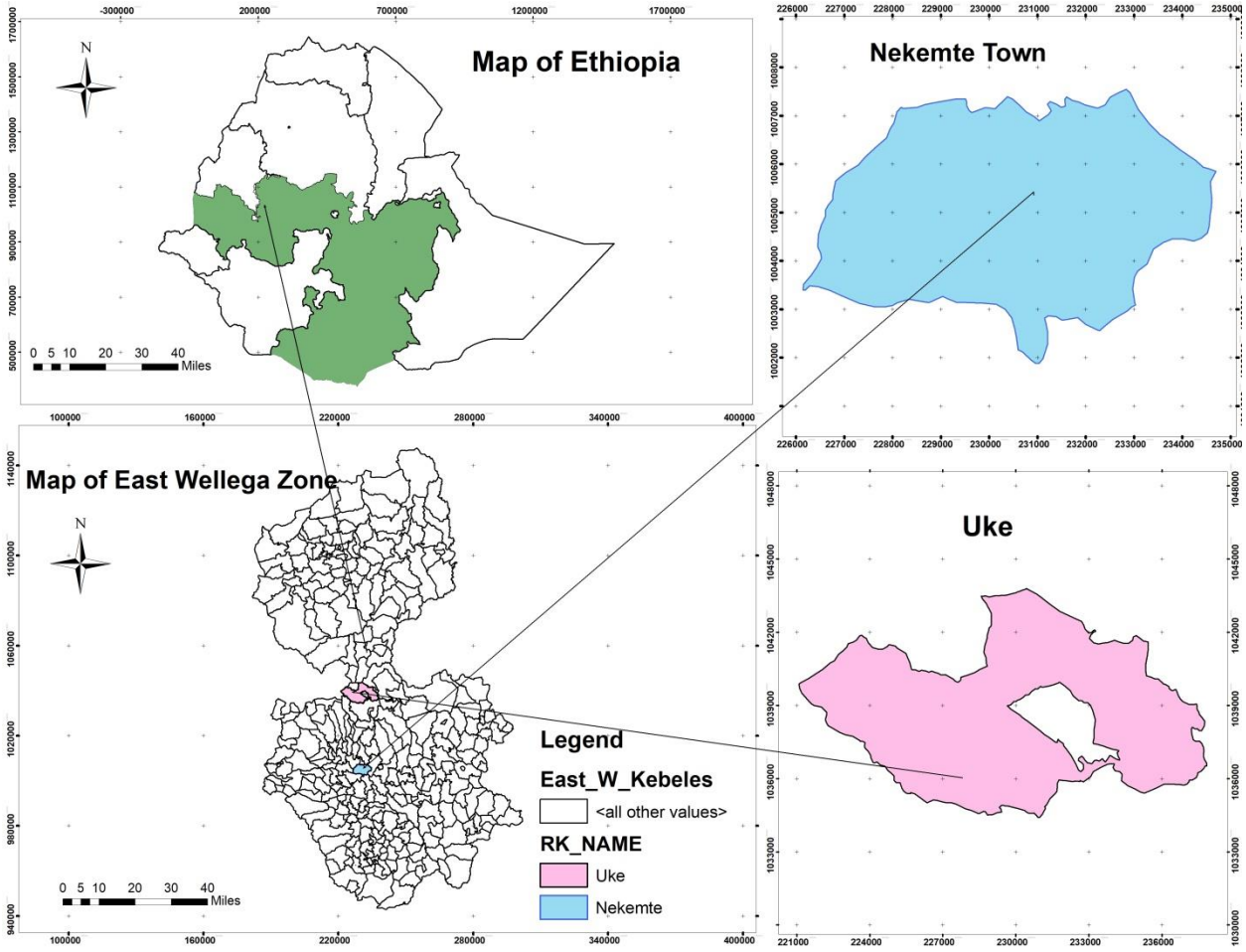

Figure1. Map of the study areas.

Experimental materials

Three botanical plants: *Croton macrostachys* (*Hochst*), *Phytolacca dodecandra* L. *and Jatropha curcas* L. were selected based on their social ties to the community in terms of their use and availability (Weldesenbet Beze *et al.,* 2019). The botanicals used for the study were collected from Wollega University campus and Diga district in Eastern Wollega zone. Maize variety, BH-661 obtained from Bako Research Centre was used for the experiment.

Preparation of Botanical Extracts

Leaves of each botanical were dried under shade for three weeks in Wollega University Biology department before extraction (Addisu Silesh *et al.*, 2014; Cynthia *et al.,* 2016). The dried leaves were grounded in to a fine powder using a small hand-operated manual grinder. The powder was further sliced with analytical mill and sieved through a 0.25 mm pore size mesh to make uniform fine dust particle. Each sieved botanical powder was collected in polythene bag and separately stored on shelf at room temperature prior to use.

Experimental Design and treatments

The experimental fields were prepared as per the recommendation for maize planting in the study areas (2-3 times ploughing). Maize variety, BH-661 was planted on a plot size of 3 mx7.5m with intra and inter spacing of 0.30 m and 0.75 m, respectively. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Spacing between plots and blocks were 1m and 2m, respectively. The on

station experiment was conducted using irrigation, while the Uke was in rain fed. DAP and UREA were used at the rates of 100 kg/ha and 200 kg/ha, respectively. DAP was applied at planting, while UREA was applied both at two leaf stage and knee height of maize plant. The botanicals used were *C. macrostachys*, *P. dodecandra, J. curcas, C. macrostachys + P. dodecandra, C. macrostachys +J. curcas, P. dodecandra + J. curcas, C. macrostachys + P. dodecandra + J. curcas*. Untreated check was used for comparison.

Treatment preparation and Application

From the stored botanical powder of each botanical 300 g was weighed and soaked in 1000 ml distilled water in flask of 1500 ml capacity and shacked to mix thoroughly. The mixtures were kept for 72 hrs. The mixtures were filtered with clean cheese cloth and stored in a beaker of 250 ml capacity. This method was adopted from Addisu Sileshi *et al.* (2013) with minor modification. Planting holes were prepared on each row at the distance of 0.30 m. From the stock solution of each treatment, 20 ml was drenched to each hole 10 days before planting. Similar amounts of single and mixed treatments were applied at different growth stages of maize by making drench at the base of maize plants. For the application of the treatments, 30 ml capacity calibrated syringe was used (Weldesenbet Beza *et al*., 2019).

Data collection

Data on the number of foraging termites, foraging galleries and mounds were recorded two days before planting and every two days after treatment application at all growth stages of maize plant (Daniel Getahun and Emana Getu, 2014).

At harvesting stand counts were recorded from two central rows of each plot and maize cobs were collected from each plot and weighed. For analysis yield per plot (kg/plot) was converted to yield per hectare (kg ha-1).

Data Analysis

ANOVA was employed for the analysis of data using SAS software version 9.1. Significant means ($P<0.05$) were separated using Tukey's Studentized Range test (HSD) (SAS, 1999).

RESULTS AND DISCUSSION

Termite's Genera composition

Genera composition of termites of Nekemte irrigation site and Uke substation rain fed site are shown in Table 2. Out of the 2000 solider samples collected from the two sites, the genus *Macrotermes*, *Odontotermes* and *Pseudocanthermes* were identified. However, 60% and 80% of the termites were from the Genus Macrotermes in Nekemte and Uke, respectively.

Table 2. Termites' Genera composition of Nekemte and Uke sites.

Location	Termite Genera	Percent Genera composition	No. of termite soldiers sampled per location
Nekemte	Macrotermes	60	800
	Odontotermes	16	
	Pseudcanthotermes	24	
Uke	Macrotermes	80	1200
	Odontotermes	12	
	Pseudcanthotermes	8	

Efficacy of botanical extracts on the management of termites on irrigated maize at Nekemete

The effect of pre-planting botanical extracts on mean number of foraging termites, number of termite galleries and termite mound on irrigated field at Nekemete is shown in Table 3. The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received 3 botanicals mixed treatment, while the highest was recorded on the untreated check plots. Plots that received the 2 mixed botanicals were found to be more effective than the plots that received single botanical treatment in the management of termites.

The effect of botanical application on mean number of termites and their symptoms at seedling stage is shown in Table 4. The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received the 3 botanicals mixture treatment, while the highest was recorded on the untreated check plot. Plots that received the 2 botanicals mixture treatments were found more effective in the management of termites than plots that received single botanical treatments.

Table 3. Effect of pre-planting botanical application on mean (±se) of termites and their symptoms in irrigated field 8 days before planting.

Treatments	Number of termites and their symptoms		
	Number of foraging termites	Number of termite galleries	Number of termite mound
Untreated check	116.7 ± 3.05^{f}	32.33 ±0.96^{f}	4.33±0.23^{c}
C. macrostachys	85 ± 3.05^{e}	27.7 ± 0.96^{e}	2 ± 0.23^{b}
P. dodecandra	78.3 ± 3.05^{d}	25 ± 0.96b^{d}	0±0.00^{a}
J. curcas	57.7 ± 3.05^{c}	23 ± 0.96^{d}	0±0.00^{a}
C. macrostachys +P. Dodecandra	48.7 ± 3.05^{bc}	22.7 ±0.96^{cd}	0±0.00^{a}
C. macrostachys + *J. Curcas*	44 ± 3.05^{ab}	20 ± 0.96^{c}	0±0.00^{a}
P. dodecandra + *J. Curcas*	38.33 ± 3.05^{b}	16 ± 0.96^{b}	0±0.00^{a}
C. macrostachys + *P. dodecandra* + *J. curcas*	26.33 ± 3.05^{a}	10.7 ± 0.96^{a}	0±0.00^{a}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Tukey's Studentized Range test (HSD).

Table 4. The effect of botanical application on mean (±se) number of termites and their symptoms at seedling stage on irrigated maize.

Treatments	Number of termites and their symptoms		
	number of foraging termites	number of termite galleries	number of termite mound
Untreated check	120.3 ± 1.84^{g}	31.7 ± 0.99^{f}	4 ± 0.20^{c}
Croton macrostachys	93 ± 1.84^{f}	27.7 ± 0.99^{e}	2 ±0.20^{b}
Phytolacca dodecandra	87 ± 1.84^{e}	25 ± 0.99^{de}	0±0.00^{a}
Jatropha curcas	78 ±1.84^{d}	23 ± 0.99^{d}	0±0.00^{a}
C. macrostachys+ P. Dodecandra	67.7 ± 1.84^{c}	22.7 ± 0.99^{cd}	0±0.00^{a}
C. macrostachys + *J. Curcas*	47 ± 1.84^{b}	16 ± 0.99^{c}	0±0.00^{a}
P. dodecandra + *J. Curcas*	44 ± 1.84^{ab}	20 ± 0.99^{b}	0±0.00^{a}
C. macrostachys + *P. dodecandra* + *J. curcas*	36.33 ±1.84^{a}	10.7 ± 0.99^{a}	0±0.00^{a}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD).

As shown in Table 5, the effect of botanical application on mean number of termites and their symptoms at vegetative stage is significantly different ($P<0.05$). The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received the 3 botanical mixtures, while the highest was recorded on the untreated check plot. Plots that received *P. dodecandra* + *J. curcas* were found to be more effective in the management of termites than single botanical treatments.

Table 5. The effect of botanical application on mean (±se) number of termites and their symptoms at vegetative stage on irrigated maize at Nekemete.

Treatments	Number of termites and their symptoms		
	number of foraging termites	number of foraging galleries	number of termite mound
Untreated check	89.7±1.81^{h}	26.7±0.91^{g}	3.7±0.12^{b}
Croton macrostachys	85±1.81^{g}	23.7±0.91^{f}	0±0.00^{a}
Phytolacca dodecandra	77±1.81^{f}	21±0.91^{e}	0±0.00^{a}
Jatropha curcas	62.7±1.81^{e}	17±0.91^{d}	0±0.00^{a}
C. macrostachys+ P. Dodecandra	49.7±1.81^{d}	14.3±0.91^{cd}	0±0.00^{a}
C. macrostachys + *J. Curcas*	42.7±1.81^{c}	11.7±0.91^{c}	0±0.00^{a}
P. dodecandra + *J. Curcas*	36.7±1.81^{b}	8.7±0.91^{b}	0±0.00^{a}
C. macrostachys + *P. dodecandra* + *J. Curcas*	24.7±1.81^{a}	6±0.91^{a}	0±0.00^{a}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD).

The mean number of termites and their symptoms are shown in Table 6. The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received *C. macrostachys* + *P. dodecandra* + *J. curcas*, while the highest was recorded on the untreated plot. All plots that received the 2 treatments combinations were found to be effective in the management of termites when compared to a single botanical treatment.

Table 6. The effect of botanical application on mean (±se) number of termites and their symptoms at flowering stage of maize on irrigated maize at Nekemete.

Treatments	Number of termites and their symptoms		
	number of foraging termites	number of termite galleries	number of termite mounds
Untreated check	89.7± 1.81^{h}	26.7± 0.91^{g}	3.7± 0.12b
Croton macrostachys	85± 1.81^{g}	23.7± 0.91^{f}	0±0.00^{a}
Phytolacca dodecandra	77± 1.81^{f}	21± 0.91^{e}	0±0.00^{a}
Jatropha curcas	62.7± 1.81^{e}	17± 0.91^{d}	0±0.00^{a}
C. macrostachys+ *P. Dodecandra*	49.7± 1.81^{d}	14.3± 0. 91^{cd}	0±0.00^{a}
C. macrostachys + *J. Curcas*	42.7± 1.81^{c}	11.7± 0.91^{c}	0±0.00^{a}
P. dodecandra + *J. Curcas*	36.7± 1.81^{b}	8.7± 0.91^{b}	0±0.00^{a}
C. macrostachys + *P. dodecandra* + *J. Curcas*	24.7± 1.81^{a}	6± 0.91^{a}	0±0.00^{a}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD).

The analysis of variance for mean of termite symptoms and yield & yield components in irrigated field showed statistically significant ($p<0.05$) differences among the treatments applied separately or in combination (Table 7). The result revealed that there was high termite symptom and low yield and yield components from the untreated check plot and low termite symptoms and high yield and yield components from the plot that received three treatments combination. Plots that received the two treatments combination were found to be effective in the management of termites when compared to single botanical treatment. The three mixture treatments provide high protection by repelling termite from maize plant. Consequently, maize plant performance increased and more yields obtained.

Table 7. The effects of botanical application on mean (±se) termite symptoms and yield &yield components at harvesting stage on irrigated maize at Nekemete.

	Number of termites and their symptoms		yield & yield components				
Treatment	Foraging termites	Foraging tunnel	Mound	Plant height	Stand count	Number of cobs/plot	Yield (kg/ha)
C. macrostachys	127.5±5^{b}	51.3±1^{d}	2.0±1^{d}	3.5±1^{a}	49.5±2^{b}	86.3±3^{c}	3813±9^{bc}
P. dodecandra	91.5±3^{c}	28.8±^{c}	1.8±1^{b}	3.6±1^{a}	52.3±2^{a}	117.3±5^{a}	6042±9^{ab}
J. curcas	91.8±3^{c}	27.5±^{c}	2.0±1^{b}	3.6±1^{a}	52.0±2^{ab}	130.0±5^{a}	6708±9^{a}
C. macrostachys + *P. dodecandra*	55.0±2^{d}	28.0±1^{c}	2.3±1^{b}	3.5±1^{a}	50.5±2^{ab}	125.5±5^{a}	5583±9^{abc}
C. macrostachys + *J. Curcas*	55.0±2^{d}	24.3±1^{c}	1.8±1^{b}	3.6±1^{a}	52.3±^{a}	130.5±5^{a}	6771±9^{a}
P. dodecandra + *J. Curcas*	47.5±1^{d}	19.8±1^{c}	1.8±1^{b}	3.5±1^{a}	52±^{ab}	129.8±5^{a}	6667±9^{a}
C. macrostachys + *P. dodecandra* + *J. curcas*	15.0±1^{e}	7.5±1^{d}	0.3±1^{b}	3.6±1^{a}	52.8±2^{a}	144.8±56^{a}	7333±9^{a}
Untreated check	192.5±8^{a}	71.3±1^{a}	9.3±1^{a}	3.5±1^{a}	44.8±2^{c}	89.5±3^{c}	3646±9^{c}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD).

Efficacy of botanical extracts on the management of termites on rain fed maize at Uke

The effect of pre-planting botanical application on mean number of termites and their symptoms on rain fed maize at Uke is presented in Table 8. The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received the three botanicals combination, while the highest was recorded on the untreated check plot. All plots that received the two treatments combinations were found to be more effective in the management of termites than plots that received single botanical treatments.

Table 8. Effect of pre-planting botanical application on mean (±se) number of termites and their symptoms on rain fed maize 8 days before planting.

Treatment	Number of termites and their symptoms		
	number of foraging termites	number of termite galleries	Number of termite Mounds
Untreated check	60.5± 0.71^{h}	16.75± 0.7^{c}	1.5± 0.12^{c}
Croton macrostachys	55.5± 0.71^{g}	10.5± 0.7^{b}	0.75± 0.12^{b}
Phytolacca dodecandra	45.5± 0.71^{f}	8.5± 0.7^{ab}	0.55±0.12^{ab}
Jatropha curcas	40.5± 0.71^{e}	7.5± 0.7^{ab}	0.45±0.12^{ab}
C. macrostachys+ P. Dodecandra	30.5± 0.71^{d}	6.25± 0.7^{ab}	0.25±0.12^{ab}
C. macrostachys + J. Curcas	25.5± 0.71^{c}	5.25± 0.7ab	0.2±0.12ab
P. dodecandra + J. Curcas	14.5± 0.71^{b}	3.75± 0.7^{ab}	0.085±0.12a
C. macrostachys + P. dodecandra + J. Curcas	10.5± 0.71^{a}	2.25± 0.7^{a}	0.05±0.12^{a}

Means followed by the same letter within a column are not significantly different from each there at 5% level, Turkey's Studentized Range test (HSD).

The effect of botanical application on mean number of termites and their symptoms at seedling stage of maize is shown in Table 9. The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received the three treatments combination, while the maximum number was recorded on the untreated check plot. All plots that received the two treatments combination were found to be more effective in the management of termites than the plots that received single botanical treatment.

Table 9. The effect of botanical application on mean (±se) number of termites and their symptoms at seedling stage on rain fed maize at Uke.

Treatments	Number of termites and their symptoms		
	number of foraging termite	number of foraging galleries	number of termite mounds
Untreated check	72.75± 0.86^{a}	7.75± 0.38^{d}	1.25± 0.104^{e}
Croton macrostachys(Cr)	61.5± 0.86^{g}	6.75± 0.38^{d}	0.775± 0.104^{d}
Phytolacca dodecandra (Ph),	50.7±0.865^{f}	4.5± 0.38^{c}	0.7± 0.104^{c}
Jatropha curcas (Ja)	41.25± 0.86^{e}	4.25± 0.38^{c}	0.55± 0.104^{bc}
C. macrostachys+ P. Dodecandra	34.5± 0.86^{d}	2.25±0.38^{bc}	0.15± 0.104^{b}
C. macrostachys + J. Curcas	29.5± 0.86^{c}	2.5± 0.38^{bc}	0.25±0.104^{ab}
P. dodecandra + J. Curcas	20.75± 0.86^{b}	3.00± 0.38^{b}	0.00^{a}
C. macrostachys + P. dodecandra + J. Curcas	12.5± 0.86^{a}	1.5± 0.38^{a}	0.00^{a}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD).

The effect of botanical application on mean number of termites and their symptoms at seedling is shown in Table 10. The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received the three treatments combinations, while the highest was recorded on the untreated check plot. Plots that received all the two treatments combinations were found to be more effective in the management of termites than single botanical treatments.

Table 10. The effect of botanical application on mean (±se) of termite symptoms at knee height/vegetative stage on rain-fed maize.

Treatments	Number of termites and their symptoms		
	number of foraging termites	number of termite galleries	number of termite mounds
Untreated check	51.5± 0.85h	13± 0.42e	1.5± 0.12c
Croton macrostachys (Cr)	41.5±0.85g	8.75± 0.42d	0.875± 0.12b
Phytolacca dodecandra Ph)	35.5± 0.85f	4.00± 0.42de	0.675± 0.12bc
Jatropha curcas(Ja)	25.75±0.85e	3± 0.42de	0.475± 0.12ab
C. macrostachys+ P. Dodecandra	19.75±0.85d	2.5±0.42c	0.35± 0.12ab
C. macrostachys + J. Curcas	19.25±0.85c	4.25± 0.42b	0.25± 0.12ab
P. dodecandra + J. Curcas	16.75±0.85b	4.0± 0.42ab	0.25± 0.12ab
C. macrostachys + P. dodecandra + J. Curcas	10.75± .85a	0.25± 0.42a	0.0± 0.00a

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD).

The effect of botanical application on mean number of termites and their symptoms at the flowering stage of maize is shown in Table 11. The lowest mean number of foraging termites, termite galleries and number of mounds were recorded on the plots that received the three treatments combination, while the highest was recorded on the untreated check plot. All plots that received the two treatments combination were found to be more effective in the management of termites than a single botanical treatment.

Table 11. The effects of botanical application on mean (±se) number of termites and their symptoms at flowering stage on rain fed maize at Uke.

Treatments	Number of termites and their symptoms		
	N0. of foraging termite	No. of termite galleries	N0. of termite mounds
Untreated check	40.5± 1.08^{g}	14.25± 0.54^{f}	1± 0.00^{c}
C. macrostachys	29.75±1.08^{f}	10± 0.54^{e}	0.5± 0.12^{b}
P. dodecandra	28± 1.08^{e}	9.25± 0.54^{d}	0.00± 0.00^{a}
J. curcas	24.75± 1.08^{d}	4.75± 0.54^{c}	0.00± 0.00^{a}
C. macrostachys+ P. Dodecandra	10.75± 1.08^{c}	3.5± 0.54^{bc}	0.00± 0.00^{a}
C. macrostachys + J. Curcas	6.25± 1.08^{b}	2.25± 0.54^{bc}	0.00± 0.00^{a}
P. dodecandra + J. Curcas	4.5± 1.08a^{b}	1± 0.54^{b}	0.00± 0.00^{a}
C. macrostachys + P. dodecandra + J. curcas	3± 1.08^{a}	1± 0.54^{a}	0.00± 0.00^{a}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD).

As shown in Table 12, the mean number of termites and their symptoms, yield and yield components at harvesting stage of rain fed maize at UKE are significantly different ($p<0.05$) due to different treatments. The results obtained revealed that there was low number of termites and their symptoms, and high yield and yield components in plot that received the three treatments combination and high number of termites and their symptoms, and low yield and yield

components in the untreated check plot. These results depict inverse relationship between termite symptoms and yield and yield components. All plots that received the two botanical treatments combinations were more effective than a single botanical treatment.

Table 12. The effects of botanical application on mean (±se) number of termites and their symptoms, yield and yield components at harvesting on rain fed maize.

Treatment	Number of termites and their symptoms sytheir symptoms			Yield and yield components			
	Foraging termites	Foraging tunnel	Mound	Plant height	Stand count	No.cob/plot	Yield(kg)/ha
.C. macrostachys	127.5±5^{b}	51.3±3^{b}	2.0±1^{b}	3.6±1^{a}	49.5±3^{b}	86.3±3^{c}	3813±8^{b}c
P. dodecandra	91.5±3^{c}	28.75±2^{c}	2.0±1^{b}	3.5±1^{a}	52.3±3^{a}	117.3±5^{ab}c	6042±8^{ab}
J. curcas	91.75±3^{c}	27.5±2^{c}	2.0±1^{b}	3.6±1^{a}	52±3^{ab}	130.5±6^{a}	6708±8^{a}
C. macrostachys + P. dodecandra	47.5±3^{d}	28±2^{c}	2.3±1^{b}	3.5±1^{a}	50.5±3^{ab}	125.5±6^{ab}	5583±8^{a}bc
C. macrostachys + J. Curcas	55.0±3^{b}	24.3±2^{c}	1.8±1^{b}	3.6±1^{a}	52.3±3^{a}	130.5±6^{a}	6777±8^{a}
P. dodecandra + J. Curcas	47.5±3^{d}	19.8±2^{c}	1.8±1^{b}	3.5±1^{a}	52±3^{ab}	129.8±6^{a}	6667±8^{a}
C. macrostachys +P. dodecandra + J. curcas	15.0±2^{e}	7.5±1^{d}	0.3±0^{b}	3.6±1^{a}	52.8±3^{a}	144.8±7^{a}	7333±8^{a}
Untreated check	192.5±7^{a}	71.3±5^{a}	9.2±1^{a}	3.5±1^{a}	44.8±3^{c}	89.5b±5^{c}	3646±8^{c}

Means followed by the same letter within a column are not significantly different from each other at 5% level, Turkey's Studentized Range test (HSD)

DISCUSSION

Mixture application of *C. macrostachys, P. dodecandra* and *J. curcas* leaf extracts were found to be highly effective in the management of termites on maize when the termites species composition are *Macrotermes*, *Odontotermes* and *Pseudacanthotermes*. The fact that single botanical treatments are less effective than both the two botanicals mixture treatments and the three botanicals mixture treatment implies that botanicals combination has a synergetic effect in controlling termites. The synergetic effect was demonstrated by the fact that plots that received botanicals treatment at 2 levels and 3 levels highly reduced the number of foraging termites, foraging galleries and number of termite mounds. The synergetic effect also increased the number of standing plants at harvesting. Moreover, it has increased the yield and yield components. The current findings is in line with Cynthia *et al*. (2016) who reported mixing of *Zingiber officinale* and *Allium sativum* significantly reduced termite damage on hot peppers. In the current study, maximum termites and their symptoms reduction realized on the plots that received mixtures of *C. macrostachys, P. dodecandra* and *J. Curcus*. Tadele Shiberu *et al*. (2014) reported that the combination of *P. dodecandra* and *J. Curcas* gave 100% termites mortality in 2 hrs exposure time in the laboratory. Simon Kebede and Nnah (2018) and Qwarse Michael *et al*. (2017) demonstrated the effects of some botanicals applied in the soil hinder termites from forming extensive galleries. Ahmed Ibrahim and Girma Demisse (2013) compared the seed and leaf extracts of C. *macrostachys* and found out that seed extract significantly shortened termites galleries. Ibe *et al*. (2018) demonstrated the efficacy of *J. Curcas* applied to the soil significantly prevent subterranean termites from making of tunnels. Tilahun Mola (2018) reported that Chomo grass (*Brachiaria humidicola* (Rendle) Schweick)) hinder termite further infestation by reducing the formation of tunnels. Moreover, the extent of termites' galleries formation depends on the potential of each botanical extract (Shahid *et al*., 2012).

CONCLUSION AND RECOMMENDATIONS

The findings of this study showed that application of leaf extracts of *C. macrostachys*, *P. dodecandra* and *J. curcas* applied alone and in mixtures at the rate of 20ml/plant significantly reduced number of

termites particularly Macrotermes, Odontotermes and Pseudacanthotermes. This ultimately led to subsequent reduction of termite galleries and mounds under irrigated and rain fed conditions before planting, at seedling, flowering and at harvesting stages of maize plants. From the current study it can be concluded that the tested botanicals in mixture or singly can be considered as an alternative termites control where multiple species of termites occur in maize culture.

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