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Evaluation of Botanicals *Crotalaria burhia* Buch-Ham and *Anacardium occidentale* L. against Termite *Odontotermes obesus* Rambur (Isoptera: Termitidae) in Wheat

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ABSTRACT

Background: In recent times, termites have gained importance in agriculture as a pest in wheat crop. Famers are using chemical pesticides for the management of termites, which eventually leads to degradation of soil, insecticide residue, pest resurgence, air pollution, water pollution and also affects human health. In this regard, botanicals as an effective alternate to insecticides in the management of termites is crucial. The root and leaf extracts of *Crotalaria burhia* Buch-Ham and *Anacardium occidentale* L. against termites was evaluated.

Methods: Field experiments were conducted to assess the efficacy of botanicals *viz*., *Crotalaria burhia* Buch-Ham and *Anacardium occidentale* L. along with Indigenous technologies, biofungicide and standard chemicals against *Odontotermes obesus* Rambur in wheat. An experiment was laid at the Research Farm, Institute of Pesticide Formulation Technology, Gurgaon, Haryana during two seasons, *i.e.,* November 2014-March 2015 and during December 2015-April 2016.

Result: The test botanicals incorporated along with indigenous technologies and widely recommended termiticides assessed for their efficacy against *O. obesus* in wheat at two locations proved to be effective in the order of imidacloprid 17.8 SL at 350 ml ha^{-1}> chlorpyrifos 20 EC at 2 l ha^{-1} > *B. bassiana* 2×10^8 at 500 ml ha^{-1} > *C. burhia* root extract (10%) at 50 l ha^{-1} > *A. occidentale* leaf dust (5%) at 25 kg ha^{-1} > irrigating plots > neem oil (2%) > dusting salt at 25 kg ha^{-1}.

Key words: Botanicals, Efficacy, Indigenous technology, Termite, Wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) under family poaceae ranks first among the major cereal crops with annual global production of over 763.06 million tonnes from about 220 million hectares (Sendhil *et al*., 2019). The production level of wheat in India had a quantum jump from 6.46 million tonnes from an area of 9.75 million ha in 1950-51 to more than 99.70 million tonnes from an area of about 30 million hectares during 2017-18 (MoA and FW 2018).

Twenty-four insect pest species were documented causing damage to wheat crop (Singh 1998) and of these, termite ranks first as a pest of wheat not only in India, but in South Asia too (Geddes and Iles 1991). Of the sixteen termite species attacking wheat crop in India, *Odontotermes obesus* and *Microtermes obesi* were found dominant (Chhillar *et al.,* 2006; Ranjith *et al*., 2018) resulting in yield losses ranging from 43 to 80 per cent in wheat (Sattar and Salihah 2001; Chhillar *et al.,* 2006).

Plant-based remedies have been used against biting arthropods since times immemorial and such records can be found in every ancient civilization (Birkinshaw and Colquhoun 1998). The discovery of chemical insecticides, especially DDT by Paul Muller in 1939, probably turned the attention of scientists towards chemical alternatives for use as insecticides (Mason *et al*., 1998). As a result, a large number of chemical insecticides were formulated and the plant-based insecticides remained neglected, although some like pyrethrum and rotenone still found acceptance. However, the prolonged over-use of all such chemicals raised an alarm as they harm pests and useful species alike, coupled with the environmental problems which made the scientists look for botanical insecticides all over again (Annis 1991).

The genus *Crotalaria* has 300 species worldwide and out of these, about 18 species are reported in India. *Crotalaria burhia* of Leguminaceae family is an undershrub, fibrous plant common in the arid regions of West Pakistan, India (Punjab, Rajasthan and Gujarat) and Afghanistan.

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It is known as Shinio in Rajasthan, its Hindi name is Bhip and in Punjabi it is known as Bhata and in Gujarati as Ghugato (Kataria *et al*., 2011). The root extract of *C. burhia* was found to repel *O. obesus* when used as a bait in field conditions (Ranjith *et al*., 2015) and was also found to repel *O. obesus* under laboratory conditions (Ranjith *et al.,* 2015).

Anacardium occidentale of family Anacardiaceae commonly known as cashew is a native of Brazil and has great economic and medicinal value. Laboratory studies conducted by Ileke and Olotuah (2012) revealed that the powders and oils extracts of *A. occidentale* seeds are effective against the cowpea bruchid, *Callosobruchus maculatus* (Fab.) in cowpea seeds. Studies conducted in Nigeria revealed that cashew nut shell liquid (CNSL) and leaf extracts of *A. occidentale* effectively repelled termites (Osipitami and Oseyemi 2012). *A. occidentale* has been found effective against *O. obesus* under laboratory conditions and was found to possess secondary metabolites responsible for the mortality of termites. (Ranjith *et al*., 2017).

As a number of botanical extracts were proved effective against various pests, timely research was taken up to evaluate the termiticidal effect of *C. burhia* and *A. occidentale* against the population buildup of *O. obesus* in wheat crop for two seasons.

MATERIALS AND METHODS

Field experiments were conducted to assess the efficacy of *C. burhia* and *A. occidentale* along with indigenous technologies and chemical termiticides against *O. obesus* in wheat. An experiment was laid at the Research Farm, Institute of Pesticide Formulation Technology, Gurgaon, Haryana during two seasons, *i.e.,* November 2014-March 2015 and during December 2015-April 2016.

Plant samples collected from Moondghasoi, Nagour distircit, Rajasthan, India and Killikulam, Tuticorin district, Tamil Nadu, India were identified as *Crotalaria burhia* Buch- Ham and *Anacardium occidentale* L. respectively by Dr. M. Palaniswamy (Scientist-D) and Dr. R.K. Singh (Botanist) at Botanical Survey of India, Southern Regional Centre, Coimbatore, Tamil Nadu and the termite samples were collected from the wheat field of Institute of Pesticide Formulation Technology, Gurgaon, Haryana, India using a camel hair brush and preserved in 70 per cent alcohol. The preserved termite specimens were identified as *Odontotermes obesus* by Dr. D. Rajavel, Professor (Entomology) at the Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam, Tamil Nadu, India using taxonomical keys (Das and Bose, 1982). The termite samples were identified as *O. obesus* by the following characteristics: Mandibles short and slender with a weakly curved outer margin. Mandible index length/head length is about 0.590.68 mm and labrum is short, with anterior broadly rounded.

Formulation of botanicals

Roots of *C. burhia* collected were sun dried to remove the moisture content so as to prepare the root extract of *C. burhia*. The roots were then hammered well and the hammered roots were collected in a tray. Different concentrations of root extracts *viz*. 0.5, 1, 2.5, 5, 10 and 20 per cent were prepared by soaking 5, 10, 25, 50, 100 and 200 g of root powder in one litre of distilled water. The supernatant was filtered after 24 h and subsequently used for testing its efficacy against *O. obesus.* The various concentrations were evaluated for their efficacy against *O. obesus* under laboratory conditions using "No-choice" bioassay method developed by Kang *et al*., 1990 and ten percent (10%) root extract of *C. burhia* was found effective (Ranjith *et al.,* 2017) and further the dosage of ten per cent was fixed for field evaluation against *O. obesus*.

Cashew leaves for the preparation of *A. occidentale* leaf dust were collected from the farm in Agricultural College and Research Institute, Killikulam, Tamil Nadu and were air dried till the leaves were devoid of moisture. The dried leaves were crushed and then powdered well using mixer. The finely powdered leaf dust passing through No. 60 sieve was used further. Different concentrations of leaf dust *viz*. 0.5, 1, 2.5, 5, 7.5 and 10 per cent were prepared by mixing required amount of powdered leaf with China clay (commercial), which acts as a carrier material. Different concentrations of *A. occidentale* were evaluated for their potential against *O. obesus* under laboratory conditions following the method described by Grace and Abdally (1990). Maximum efficacy was found in five percent (5%) formulation of *A. occidentale* leaf dust (Ranjith *et al*., 2017) and hence five per cent formulation was further evaluated in wheat field against population buildup of *O. obesus.*

Experimental trials

The experiments were laid out in a randomized block design (RBD) with a plot size of 20 m^2 and the variety used was PUSA 2967 with a spacing of 30×10 cm^2. In view of developing Integrated management practices for termite control nine treatments comprising of Indigenous technologies adopted by farmers for termite management, botanical extracts, entomopathogenic fungi and proven chemicals against termites were selected as treatments and replicated thrice. The experimental details were as follows:

Treatments	Dosage ha^{-1}
Irrigating field at 15 days interval up to wetting	-
Neem oil 3000 ppm	2%
Dusting salt in wheat field	25 kg
A. occidentale leaf dust 5% dust	25 kg
C. burhia root extract 10% L	50 l
Beauveria bassiana 2×10^8 spores/ml	500 ml
Imidacloprid 17.8% SL (Confidor-Baeyer crop science Ltd.)	350 ml
Chlorpyrifos 20% EC (Lethal-Insecticide India Ltd.)	2 l
Control	-

The treatments were imposed when termite incidence was noticed and three sprayings were given at 30 days interval with 500 litres of spray fluid per hectare, using battery operated knapsack sprayer.

Observations on termite count were taken fortnightly. Quadrats of 1 m^2 were randomly thrown five times in each plot and termite count was taken by digging the soil to 15 cm depth in the quadrat-placed area using a shovel and the excavated soil was spread on a black cloth and was observed carefully for termites (workers and soldier caste).

Statistical analysis

The standard error for the mean value of three replications in bait efficacy of *C. burhia* and *A. occidentale* against *O. obesus* was calculated using descriptive statistics (Mean±SE). The per cent reduction of termites over control in the field population was analyzed using the formula mentioned below.

$$\text{Per cent reduction over control} = \frac{C - T}{C} \times 100$$

Where,

T = Number of termites in the treatment.

C = Number of termites in the untreated check.

The data on population numbers were transformed into square root values and percentages into arc sine$\sqrt{\text{per cent}}$ values before statistical analysis. The data obtained from field experiments were analyzed in randomized block design (RBD) (Gomez and Gomez, 1984). The mean values were separated using least significant difference (LSD).

RESULTS AND DISCUSSION

During the first season, the mean termite population per plot in wheat field before imposing treatments ranged from 54.33 to 69.33 numbers. Botanicals, *viz.,* aqueous root extract of *C. burhia* (10%) and powdered leaf dust of *A. occidentale* (5%) treated wheat plots recorded 46.00 and 48.00 termites $plot^{-1}$, respectively and *B. bassiana* at 500 ml ha^{-1} recorded mean termite population of 42.00 $plot^{-1}$. The second spray was taken up thirty days after first spraying and the trend in efficacy of different treatments in respect of mean termite population in wheat plots were similar to that of first spraying (Table 1). Third spraying was given thirty days after second spraying and the termite population declined drastically in all the treated plots. Based on reduction of termite numbers over untreated check, the order of efficacy of different treatments is: imidacloprid 17.8 SL at 350 ml ha^{-1} (76.65%) > chlorpyrifos 20 EC at 2 l ha^{-1} (72.47%) > *B. bassiana* 2×10^8 spores/ml at 500 ml ha^{-1} (63.33%) > aqueous root extract of *C. burhia* (10%) (57.96%) > powdered leaf dust of *A. occidentale* (5%) (54.18%) > irrigating plots (48.66%) > neem oil (2%) (42.35%) > dusting salt at 25 kg ha^{-1} (30.59%) (Table 1). The results fall in line with the studies conducted by Ranjith *et al*. (2017) which proved the effectiveness of *C. burhia* and *A. occidentale* against *O. obesus* under laboratory conditions. Mahapatro *et al*. (2013)

Table 1: Efficacy of *C. burhia* and *A. occidentale* against *O. obesus* in wheat (November to March).

Treatment	Doses	Population of termites per five quadrat $plot^{-1}$							
	HA^{-1}*	PTC	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	Pooled mean	ROC (%)
Irrigating the field at 15 days interval up to wetting	-	54.33	43.67 (6.65)^{d}	52.00 (7.25)^{de}	42.33 (6.54)^{de}	28.67 (5.40)^{c}	20.33 (4.56)^{cd}	30.00 (5.52)^{d}	36.17	48.66
Neem oil 3000 ppm	2%	69.33	48.33 (6.99)^{d}	59.33 (7.74)^{e}	48.33 (6.99)^{e}	29.00 (5.43)^{c}	23.67 (4.92)^{d}	35.00 (5.96)^{e}	40.61	42.35
Dusting salt in field	25 kg	63.00	55.00 (7.45)^{e}	61.00 (7.84)^{f}	50.67 (7.15)^{f}	38.67 (6.26)^{d}	42.67 (6.57)^{e}	45.33 (6.77)^{f}	48.89	30.59
A. occidentale leaf dust 5% D	25 kg	62.33	37.67 (6.18)^{cd}	48.00 (6.96)^{cd}	40.67 (6.42)^{d}	23.33 (4.88)^{b}	17.67 (4.26)^{bc}	26.33 (5.18)^{cd}	32.28	54.18
C. burhia root extract 10% L	50 l	63.33	35.33 (5.99)^{c}	46.00 (6.82)^{cd}	33.67 (5.85)^{c}	22.67 (4.81)^{b}	16.67 (4.14)^{bc}	23.33 (4.88)^{bc}	29.61	57.96
B. bassiana 2×10^8 spores/ml	500 ml	66.67	33.67 (5.85)^{bc}	42.00 (6.52)^{bc}	26.67 (5.21)^{b}	19.00 (4.42)^{b}	14.00 (3.81)^{b}	19.67 (4.49)^{b}	25.83	63.33
Imidacloprid 17.8 SL	350 ml	67.33	23.67 (4.92)^{a}	30.33 (5.55)^{a}	14.33 (3.85)^{a}	11.67 (3.49)^{a}	7.00 (2.74)^{a}	11.67 (3.49)^{a}	16.44	76.65
Chlorpyrifos 20 EC	2 l	67.67	28.33 (5.37)^{ab}	35.33 (5.99)^{ab}	17.33 (4.22)^{a}	13.00 (3.67)^{a}	8.67 (3.03)^{a}	13.67 (3.76)^{a}	19.39	72.47
Control	-	67.00	87.33 (9.37)^{f}	97.00 (9.87)^{g}	60.67 (7.82)^{g}	42.67 (6.57)^{e}	63.00 (7.97)^{e}	72.00 (8.51)^{g}	70.44	-

*Mean of three replications; ROC- Reduction over Control; PTC- Pretreatment count; DAT- Days after treatment.

In a column, means followed by same letter(s) are not significantly different at P=0.05 by LSD.

Values in parentheses are square root transformed values.

evaluated NemaGel® and Sristi Suraksha® herbal formulation and two chemicals (imidacloprid (Confidor ®) 17.6 SC, 2 ml l^{-1} and chlorpyrifos 20 EC, 10 ml l^{-1} as soil application) in wheat crop and the results justified the present finding on the superior efficacy of imidacloprid in controlling termites followed by chlropyriphos, botanical and nematode formulation. The present investigation was also supported by the results of Ranjith *et al*. (2015) where *C. burhia* and *A. occidentale* when used as a bait drastically reduced the termite population in the termitaria near wheat field.

During the second season, the mean termite population prior to first spraying ranged from 53.00 to 60.67 plot^{-1}. At 45 DAT, root extract of *C. burhia* (10%) and leaf dust of *A. occidentale* (5%) recorded mean termite population of 45.00 and 50.33 plot^{-1}, respectively and were on par with each other. Second spraying was imposed thirty days after first spraying and imidacloprid 17.8 SL at 350 ml ha^{-1} recorded the lowest mean termite population of 7.33 plot^{-1} which was on par with chlorpyrifos 20 EC at 2 l ha^{-1} which registered 8.33 plot^{-1} at 75 DAT. Powdered leaf dust of *A. occidentale* (5%) dusted plots registered 14.67 mean termites plot^{-1} and was statistically on par with root extracts of *C. burhia* (10%) treated plots. Seventy-five days after sowing, third spraying was taken up and the order of efficacy in terms of per cent reduction of termite population over control 105 DAT was: imidacloprid 17.8 SL at 350 ml ha^{-1} (80.15%) > chlorpyrifos 20 EC at 2 l ha^{-1} (77.23%) > *B. bassiana* 2×10^8 spores/ml at 500 ml ha^{-1} (73.48%) > *C. burhia* root extract (10%) (70.10%) > *A. occidentale* leaf dust (5%) (66.29%) > irrigating plots (60.78%) > neem oil (2%) (57.05%) > dusting salt at 25 kg ha^{-1} (37.69%) (Table 2). The investigation finds its support from the studies conducted by Asogwa *et al*. (2007) who tested effectiveness of cashew nut shell liquid (CNSL) against soldier and worker castes of termites and the results revealed that CNSL at 6, 8 and 10 per cent concentration gave 100 per cent mortality for soldiers 90 minutes after treatment and for workers 60 minutes after treatment. The credibility of the results was also justified by the studies conducted by Osipitami and Oseyemi (2012) where-in leaf extract of *A. occidentale* resulted in 83.33 per cent mortality of termites under field conditions and proved to be highly effective.

Phytochemical analysis on the aqueous extracts of roots of *C. burhia* revealed the presence of tannins, sterols, triterpenoids, mucilage and gum (Ranjith *et al*., 2017) mean while, aqueous leaf extracts of *A. occidentale* were found to possess alkaloids, carbohydrates, tannins, proteins, sterols, triterpenoids, waxes and saponins (Ranjith *et al*., 2017). The insecticidal property of *C. burhia* and *A. occidentale* against *O. obesus* against termites were already proved under laboratory conditions (Ranjith *et al*., 2017) and this might be due to the presence of secondary metabolites *viz.,* alkaloids, terpenoids, phenols and essential oils which falls in line with the findings of (Tripathi *et al.,* 2009 and Mann and Kaufman, 2012).

Table 2: Efficacy of *C. burhia* and *A. occidentale* against *O. obesus* in wheat (December-April).

Treatment	Doses ha^{-1}*	Population of termites per five quadrat plot^{-1}								
		PTC	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	Pooled mean	ROC (%)
Irrigating the field at 15 days interval up to wetting	-	57.00	35.33 (5.94)^{d}	54.67 (7.39)^{e}	22.00 (4.69)^{d}	18.33 (4.28)^{d}	11.00 (3.32)^{d}	20.00 (4.47)^{e}	26.89	60.78
Neem oil 3000 ppm	2%	59.33	39.00 (6.24)^{d}	57.00 (7.55)^{e}	23.00 (4.80)^{d}	19.67 (4.43)^{d}	13.67 (3.70)^{e}	24.33 (4.93)^{f}	29.44	57.05
Dusting salt in field	25 kg	53.00	51.00 (7.14)^{e}	61.33 (7.83)^{f}	40.67 (6.38)^{e}	34.00 (5.81)^{e}	30.67 (5.54)^{f}	38.67 (6.22)^{g}	42.72	37.69
A. occidentale leaf dust 5% D	25 kg	53.33	29.33 (5.42)^{c}	50.33 (7.09)^{d}	19.00 (4.36)^{d}	14.67 (3.83)^{c}	9.67 (3.11)^{d}	15.67 (3.96)^{cd}	23.11	66.29
C. burhia root extract 10% L	50 l	55.67	27.00 (5.20)^{bc}	45.00 (6.71)^{c}	17.00 (4.12)^{bc}	12.67 (3.56)^{bc}	7.67 (2.77)^{c}	13.67 (3.70)^{d}	20.50	70.10
B. bassiana 2×10^8 spores/ml	500 ml	56.67	25.67 (5.07)^{bc}	40.67 (6.38)^{c}	14.00 (3.74)^{ab}	10.67 (3.27)^{b}	5.67 (2.38)^{b}	12.00 (3.46)^{bc}	18.11	73.58
Imidacloprid 17.8 SL	350 ml	60.67	18.67 (4.32)^{a}	33.67 (5.80)^{a}	10.67 (3.27)^{a}	7.33 (2.71)^{a}	2.67 (1.63)^{a}	8.67 (2.94)^{a}	13.61	80.15
Chlorpyrifos 20 EC	2 l	58.00	22.33 (4.73)^{a}	37.33 (6.11)^{b}	12.33 (3.51)^{a}	8.33 (2.89)^{a}	3.00 (1.73)^{a}	10.33 (3.21)^{ab}	15.61	77.23
Untreated check	-	56.00	63.67 (7.98)^{f}	75.00 (8.66)^{g}	63.00 (7.94)^{f}	46.00 (6.78)^{f}	70.33 (8.39)^{g}	93.33 (9.66)^{h}	68.56	-

*Mean of three replications; ROC- Reduction over control; PTC- Pretreatment count; DAT- Days after treatment.
In a column, means followed by same letter(s) are not significantly different at P=0.05 by LSD.
Values in parentheses are square root transformed values.

Chemical termiticides, Imidaclorpid 17.8% SL and Chlorpyriphos 20% EC, proved highly effective against the termites in both the seasons, reducing the per cent termite population from 72-80 per cent. This falls in line with the studies conducted by (Ahmed *et al.,* 2014 and 2015, Hassan *et al.,* 2018). Due to the persistent nature of chemical pesticides, their ill effect on animals, birds, human beings and to the environment, alternatives like \bio-fungicides and botanicals like *C. burhia* and *A. occidentale* can be used as an alternative for chemical pesticides in termite management. However further in-depth studies to be done on the plant compounds responsible for its efficacy against termites.

CONCLUSION

In recent times, due to irrational usage of pesticides the soil quality, faunal and avian biodiversity has gone down significantly on the other hand air, water and soil pollution have shoot up significantly. In order to mitigate the ill effects of chemical pesticides and to replace them botanicals are finding their way in effectively reducing the pest population thereby *C. burhia* and *A. occidentale* can be used as an alternative to keep the termites away from the wheat field.

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