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Field evaluation and economic analysis of some potential chemicals for the control of termites in tea garden of Bangladesh

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Abstract
An experiment was carried out to find out the suitable chemicals for the control of termites in tea plantations in Bangladesh. Efficacy of eight insecticides - Admire 200 SL, Direx 80 SP, Regent 50 SC, Talstar 2 WP, Nitro 505 EC, Nize 20SP, Supertrap 50 SP and Actara 25 WG were tested against termite infesting tea under field condition at the main farm of Bangladesh Tea Research Institute. All the insecticides were found to be effective with more than 80% efficiency for the control of termites. Tea yield was significantly higher in Admire 200 SL treated plots @ 1.5 L ha^{-1}. Admire 200 SL treated plots showed 85.99% efficacy against termites in the experimental stations over the control plots. The chronology of effectiveness of different termiticides was Admire 200 SL > Direx 80 SP > Regent 50 SC > Talstar 2 WP > Nitro 505 EC > Nize 20 SP > Supertrap 50 SP > Actara 25 WG. Considering economic point of view, Actara 25 WG showed highest marginal rate of return (5741.66%) followed by Admire 200SL (775.71%), Nize 20SP (709.02%), Direx 80SP (571.74%), Regent 50SC (461.04%), and Supertap 50SP (218.32%). So, Actara 25WG @ 0.2 kg ha^{-1} might be the most economically acceptable insecticide for controlling termite pests of tea garden in Bangladesh.

Keywords: Tea, termite, termiticide, economic analysis

1. Introduction
Tea is a popular health beverage produced from the evergreen shrub *Camellia sinessis* (L) Kuntze. Globally, 1031 species of arthropods are associated with the intensively managed tea [1]. Among them termite is one of the most destructive soil inhabiting pests of tea plantation. Besides tea, they invade all types of woody materials such as shade trees, cover crops, bamboos, grasses and mulches used in tea culture [2]. Many termite species are responsible for considerable damage to tea bushes and shade trees. The damage caused by the termite is permanent in nature leading to even death of the bushes due to its recurring attack [3].
According to Ali and Ahmed [4], termites that are responsible for damage to tea bushes can be classified into two groups- viz., live wood termites and scavenging termites. The five species of live wood and scavenging termites belonging two families and four genera are recorded in the tea garden of Bangladesh. Live wood termites attack living tissues of tea bushes and are considered to be primary pests of tea. They excavate galleries within the live wood of healthy tea plants. They make fine channels along with the hard wood. In young plants, the stem beneath the surface is ring barked or the entire root system may be frequently destroyed [5]. Scavenging termites generally attack dead and dying tissues and are regarded as secondary pests of tea. They are responsible for damage to bushes by continued removal of outer dead tissues and preventing the wounds from healing by callus growth [4]. Both, live-wood eating termite and scavenging termite are harmful for tea plantations [6, 7, 8, 9, 21]. During the last 162 years of tea cultivation in Bangladesh, reveals that about 60% of 134 tea estates in greater Sylhet region are invaded by pests from sporadic to epidemic level with occasional outbreak [11]. This trend of pest succession in tea valley circles is around to be from 45% to 85% [3]. Ahmed [12] reported that 22.56% of tea crop is lost annually by termites in Bangladesh. According to Das [7] at least 15% of the total crop loss in tea is due to termite attack, though Sands [13] mentions that crop losses in agricultural fields could be 50% or more over a period of 10 years. Termite infestation may be as high as 90% in old tea areas of Barak Valley [21].
Many control measures have been adopted to combat this problem. Yet chemical insecticides have remained as the most powerful tools for controlling this pest in the tea garden of Bangladesh [14].

The chemical method of pest control involves costly inputs like pesticides, labours, spraying equipments etc. It is very important to use those inputs effectively, economically and judiciously at right time and in a proper way in order to minimize production cost and maximize benefits for a particular area [14]. Reduction of cost as well as chemical volume is looking for newer generation of pesticides which have small volume of dose rate, low cost and long persistent in the tea field. For these reasons, an attempt was taken to test the efficacy of some new generation termiticides for the control of termites and to perform their economic analysis.

2. Materials and Methods

2.1 Pesticide trial and measuring their effectiveness

The experiment was carried out in the experimental fields of Bangladesh Tea Research Institute (BTRI)'s main farm of Srimangal, Moulvibazar during December, 2016 to November, 2017. Details of the trial are given in Table 1 (a & b). Tea bushes of each plot were checked thoroughly and percent of termite infestation recorded before first application. Treatments were used for the control of termites infesting tea as per BTRI recommendations [15]. Each treatment was replicated thrice. Second and third applications were done after 4 months and 8 months interval respectively. Other agronomic practices *i.e.*, plucking, pruning, weeding was done as per schedule. An acute infestation was noticed at initial stage of study. Post–treatment data on percentage (%) of bush infestation and total shoot weight were noted at monthly and weekly intervals, respectively. Thus, a total of 12 and 34 data were recorded for % of bush infestation and total shoot weight, respectively. Yield of the respective treatment plots were converted into yield per hectare.

Effectiveness of the chemical was calculated by using Henderson and Tilton's [16] formula as follows:

$$\text{Percent effectiveness} = \left(1 - \frac{cbxta}{caxtb}\right) \times 100$$

Where

cb = Number of termite population in untreated field before treatment

ca = Number of termite population in untreated field after treatment

tb = Number of termite population in treated field before treatment

ta = Number of termite population in treated field after treatment

Plate 1: Termite infested tea plant and live wood termites

Table 1a: Particulars of insecticides used in the experiment

Treatments	Insecticide used in the experiment		Dose
	Technical name	Trade name	
T1	Chlorpyrifos + Cypermethion	Nitro 505EC	@ 4.0 lit ha^{-1}
T2	Bifenthrin	Talstar 2WP	@ 10.0 kg ha^{-1}
T3	Imidachloripid	Admire 200SL	@ 1.5 lit ha^{-1}
T4	Thiamethoxam	Actara 25WG	@ 0.2 kg ha^{-1}
T5	Acetamiprid	Nize 20SP	@ 0.5 kg ha^{-1}
T6	Fipronil	Regent 50SC	@ 1.5 lit ha^{-1}
T7	Trichlorfon	Direx 80SP	@ 1.0 kg ha^{-1}
T8	Cartap	Supertap 50SP	@ 1.4 kg ha^{-1}
T9	Control		-

Note: Doses were fixed as per recommendation of Bangladesh Tea Research Institute

Table 1b: Particulars of pesticide trials

Trial initiated	02/12/2016
Plot size	5m x 5m
Replication	3
Water volume	1000 lit ha^{-1}
Date of spray: 1st spray	02/12/2016
2nd spray	07/04/2017
3rd spray	04/08/2017
Sprayed used	CP 15 Knapsack hand sprayer
Plant type	Mixed clones
Total no. of bush/plot	30
Design	Randomized Complete Block Design (RCBD)

2.2 Economic analysis

The economic analysis was carried out to determine the economically viable insecticide against termites by using partial budgeting technique [17]. Only variable costs (costs of insecticides per hectare) of different insecticides were considered for these treatments and the rest of the costs were considered to be constant. Variable costs are those cost which vary proportionately with saleable produce.

2.3 Statistical analysis

The data were statistically analyzed by Randomization Complete Block Design (RCBD) using MSTAT statistical

software. The means were separated by Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

Results showed that all tested insecticides were found effective with more than 80.00% efficiency (Table 2). The average effectiveness of two locations revealed that Admire 200SL was the most effective insecticide (85.99%) followed by Direx 80SP (84.59%), Regent 50SC (84.37%), Talstar 2WP (83.42%), Nitro 505EC (83.30%), Nize 20SP (82.74%), Supertap 50SP (82.68%) and Actara 25WG (82.06%) (Fig. 1 and Table 2).

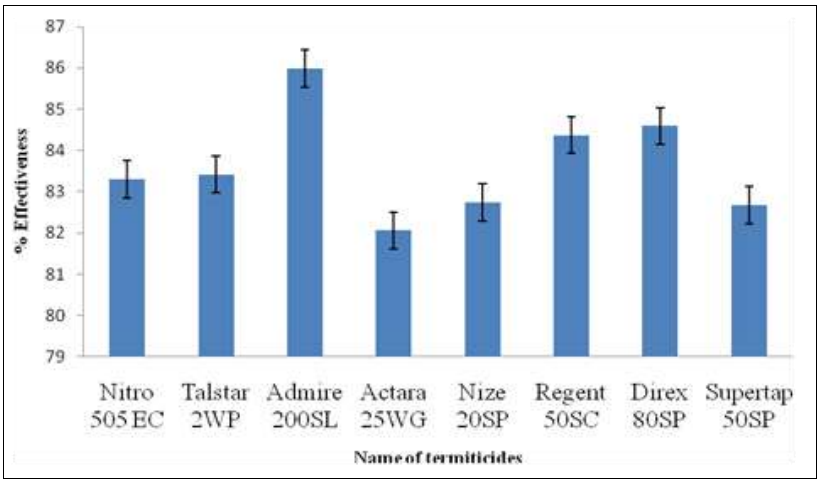

Fig 1: Effectiveness of insecticides tested against tea termites in BTRI main farm

Termites, (both live-wood eating and scavenging species) are serious pests in major parts of tea growing areas. Since both the live-wood eating and scavenging termites have their nests under the ground at depths ranging from 10 cm to 2.5 m below the soil surface [21]. In the field, the pesticides can be effective only on the section of population that remains near soil surface on the infested site of the tea bushes. They are less effective for the control of subterranean population. Perhaps irrigation following the pesticide treatments could help by increasing the rate of percolation/infiltration of the pesticide used, thus giving better efficiency for control by covering the segment of population beneath the ground level.

Choudhury *et al.* [6] performed a trial on few termiticides and reported that both the synthetic chemical and phytopesticides are effective for the control of termites. They also concluded that among the chemical pesticides, endosulphan, chlorpyrifos and phorate are equitoxic. Ahmed [18] reported that the minimum acceptable level of effectiveness of pesticide is 80%. The insecticidal treatments of the present study provided bush infestation reduction over control within the acceptable limit.

The yield of tea crop also increased significantly in all the treated plots in comparison with the untreated plots. In the insecticide treated plot, yield was reported from 1969.67 to 2075.44 kg/ha compared to 1550.78 kg/ha in untreated control plots (Table 3). The percent increase of yield due to various treatments against termites over untreated control ranged from 27.01% to 37.44% (Table 3). The present findings are mostly in line with that of Ahmed [3].

Table 2: Effectiveness of Nitro 505 EC, Talstar 2WP, Admire 200SL, Actara 25WG, Nize 20SP, Regent 50SC, Direx 80SP and Supertap 50SP against Termite control in mature tea at BTRI's main farm

Treatments & Locations	Dose/ha	Pre-treatment observ. (% bush infest.)	% effectiveness of pesticides after application												
			After 1st application				After 2nd application				After 3rd application				Overall mean
			Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	(% effectiveness)
T_1 Nitro 505 EC	4.0 lit	50	91.46	80.25	78.72	74.68	92.19	88.21	79.07	76.45	90.03	86.20	82.37	79.92	83.30[b]
T_2 Talstar 2WP	10.0 kg	47	91.25	85.85	81.84	75.81	87.21	81.89	78.57	74.55	91.07	88.23	84.21	80.52	83.42[b]
T_3 Admire 200SL	1.5 lit	43	92.82	88.42	84.22	78.77	90.94	88.32	86.20	78.63	91.36	88.14	85.00	79.09	85.99[a]
T_4 Actara 25WG	0.2 kg	45	85.71	81.13	77.97	70.97	88.06	83.10	80.00	76.25	91.67	87.91	82.11	79.80	82.06[c]
T_5 Nize 20SP	0.5 kg	46	86.02	81.54	76.79	71.60	85.32	82.84	81.74	79.21	91.85	89.25	84.55	82.21	82.74[c]
T_6 Regent 50SC	1.5 lit	49	90.63	84.41	79.76	76.30	90.41	85.77	81.63	79.34	91.25	87.89	84.53	80.52	84.37[b]
T_7 Direx 80SP	1.0 kg	42	88.23	84.55	81.77	76.84	90.43	87.86	84.68	79.65	93.16	87.37	81.86	78.72	84.59[b]
T_8 Supertap 50SP	1.4 kg	44	91.65	80.70	77.47	73.61	92.37	82.71	78.18	74.43	90.26	87.64	83.85	79.34	82.68[c]
T_9 Control (% bush infestation)	-	45	49.00	53.00	59.00	62.00	67.00	71.00	75.00	80.00	84.00	91.00	95.00	99.00	-

Mean of 3 replications in a column having the same letter did not differ significantly by DMRT ($p>0.05$)

Table 3: Yield of tea and partial budget of different insecticidal treatments applied for controlling termites in tea at BTRI's main farm

Insecticides and their dosage used	Mean yield (kg/ha)	Increase of yield over control (%)	Variable cost (Tk/ha)	Gross return[1] (Tk/ha)	Net return[2] (Tk/ha)
Nitro 505EC @ 4.0 lit/ha	2010.13b	29.62b	14640	412076.65	397436.65[c]
Talstar 2WP @ 10.0 kg/ha	2025.45b	30.61b	25500	415217.25	389717.25[d]
Admire 200SL @ 1.5 lit/ha	2131.34a	37.44a	7470	436924.70	429454.70[a]
Actara 25WG @ 0.2 kg/ha	1969.67c	27.01c	1470	403782.35	402312.35[c]
Nize 20SP @ 0.5 kg/ha	2005.78c	29.34c	2469	411184.90	408715.90[c]
Regent 50SC @ 1.5 lit/ha	2034.27b	31.18b	3510	417025.35	413515.35[b]
Direx 80SP @ 1.0 kg/ha	2075.44b	33.83b	6161	425465.20	419303.80[b]
Supertap 50SP @ 1.4 kg/ha	1985.89c	28.06c	1965	407107.45	405142.45[c]
Control	1550.78d	-	-	317909.90	317909.90[e]

Mean of 3 replications in a column having the same letter did not differ significantly by DMRT ($p>0.05$)

Cost of insecticides: Nitro 505EC @ Tk 1220/lit, Talatar 2WP @ Tk 850/kg, Admire 200SL @ Tk 1660/lit, Actara 25WG @ Tk 2450/kg, Nize 20SP @ Tk 1646/kg, Regent 50SC @ Tk 780/lit, Direx 80SP @ Tk 655/kg and Supertap 50SP @ Tk 1467/kg

Auction price of made tea in 2015 @ 205.00 Tk/kg

[1]Gross return: Yield x price of a particular product

[2]Net return: Gross return - total variable cost

The parameters of partial budgeting technique *i.e*., average yield, variable cost, gross return and net return of different insecticides were calculated. In BTRI main farm, the highest net return of Tk. 429454.70/ha was obtained in Admire 200SL treated plots followed by Direx 80SP (419303.80 Tk/ha), Regent 50SC (413515.35 Tk/ha), Nize 20SP (408715.90 Tk/ha), Supertap 50SP (405142.45 Tk/ha), Actara 25WG (402312.35 Tk/ha), Nitro 505EC (397436.65 Tk/ha) and Talstar 2WP (389717.25 Tk/ha) (Table 4). The results obtained by Ahmed *et al*. [19] and Mamun *et al.* [20] in case of *Helopeltis* and red spider mite, respectively somewhat supports present findings.

According to Perrin *et al.* [17], a treatment is said to be dominated when there is at least one option that offers a greater net return at an equal or lesser cost and a treatment is un-dominated when no other options exist offering a greater net return at an equal or lesser cost. The treatments of Nitro 505EC and Talstar 2WP with variable cost of Tk 14640/ha and Tk 25500/ha respectively, were cost dominated due to its higher cost compared to lower net return (Table. 4). So these two treatments were eliminated for further analysis.

The performances of cost-un-dominated treatments have been shown through marginal analysis in Table 4. The purpose of marginal analysis was to reveal how the net return from investment increased as the amount of investment increased [17]. It was observed that Actara 25WG showed the highest marginal rate of return (5741.66%) followed by Admire 200SL (775.71%), Nize 20SP (709.02%), Supertap 50SP (571.74%), Regent 50SC (461.04%), and Direx 80SP (218.32%). It indicated that if the planters would spend an additional one hundred taka more by applying Actara 25WG, they could get an extra income of Tk. 5741.66 over the control.

Table 4: Marginal analysis of different insecticidal treatments applied for controlling termite in mature tea

Insecticides	Net return (Tk/ha)	Variable cost (Tk/ha)	[1]Marginal net return (Tk/ha) (a)	[2]Marginal variable cost (Tk/ha) (b)	Marginal rate of return (%) (a/b x 100)
Admire 200SL	429454.70	7470.00	10150.90	1308.60	775.71b
Supertap 50SP	419303.80	6161.40	5788.45	2651.40	218.32c
Regent 50SC	413515.35	3510.00	4799.45	1041.00	461.04b
Nize 20SP	408715.90	2469.00	3573.45	504.00	709.02b
Direx 80SP	405142.45	1965.00	2830.10	495.00	571.74b
Actara 25WG	402312.35	1470.00	84402.45	1470.00	5741.66a
Control	317909.90	0.0	0.0	0.0	0.0

[1]Marginal Net Return: The increase in revenue of a farm caused by increasing one extra unit of inputs

[2]Marginal Variable Cost: The increase in the variable cost of farm caused by increased output by one extra unit

4. Conclusion

At present, chemical control is one of the important management strategies for the control of termites. It is quick and popular control method in most of the tea gardens. Judicious and timely use of effective termiticides may reduce termite infestation in an effective way. Efficacy of eight termiticides were observed in Bangladesh Tea Research Institute experimental farm. Among the eight termiticides used in the experiment, the highest performance was recorded in Admire 200 SL (Imidacloprid) for the control of termites. Effectiveness and tea yield were significantly higher in Admire 200 SL (Imidacloprid) treated plots @ 1.5 lit/ha. From the economic point of view, Actara 25WG (Thiamethoxam) showed the highest marginal rate of return compared to all other insecticides. So, Actara 25 WG @ 0.2 kg/ha is the most economically acceptable insecticide for controlling termite in tea. This chemical can be used as one of the important tool for the management of termites in tea plantation in Bangladesh.

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6. Conflict of Interest

The authors have declared that there is no conflict of interest.

7. Source/S of Funding
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8. References

1. Hazarika LK, Bhuyan M, Hazarika BN. Insect pests of tea and their management, Ann. Rev. Entomol 2009;54(1):267-84. https://doi.org/10.1146/annurev.ento.53.103106.093359
2. Ahmed M. Use of food traps for monitoring termite population in tea. Tea J Bangladesh 2014;43:10-14.
3. Ahmed M. Incidence of termites on different tea agrotypes and plantation sites in Bangladesh. Tea J Bangladesh 2010;39:7-12.
4. Ali MA, Ahmed M. Termites in tea, BTRI Pamphlet No. 11, 1990, 1-18.
5. Ahmed M, Das SC, Alam AFMB, Wazihullah AKM, Akhter S. Termites resistant plant varieties of tea in Bangladesh. Tea J Bangladesh 1994;30(1&2):29-38.
6. Chouchury P, Dutta BK, Bhattacharjee PC. Control of termites in tea (*Camellia sinensis*) plantations of Barak valley, Assam (India). Int. J Tea Sci 2005;4(1&2):2005.
7. Das GM. Termites in tea, termites in humid tropics. Humid Tropics Research UNESCO. In: Proc. of New Delhi Symposium 1962, 229-231.
8. Das SC, Mukherjee S, Gope C, Satyanarayana G. Termites in Cachar - an ecological study. Two & a bud 1982;29(1):3-4.
9. Chakravartee J. The pest management: present status and research needs. Two & a bud 1996;43(1):23-32.
10. Christopher Nyarukowa, Mari van Reenen, Robert Koech, Samson Kamunya, Richard Mose, Zeno Apostolides. Multivariate models for identification of elite mother bushes with high commercial potential for black tea from mature seedling fields of Camellia sinensis. Int. J Res. Agron. 2020;3(2):09-21.
11. Sana DL. Tea Science. Ashrafia Boi Ghar, Dhaka 1989, 224-226.
12. Ahmed M. Tea Pest Management. Dhaka, Evergreen Printing and Packaging 2005, 101.
13. Sands WA. The role of termites in tropical agriculture. Outlook on Agriculture. In: Termites and Soils (ed. Lee and Wood, 1971), Academic Press, London and New York 1977;9(3):136-143. https://doi.org/10.1177/003072707700900307
14. Ahmed M. Bio-ecology and pest status of tea termites in Bangladesh and its management. BTRI, Srimangal, Moulvibazar. Contract Research Project. BARC 2000, 1-81.
15. Ali M, Mamun MSA, Paul SK, Alam MJ. Approved insecticides, miticides and nematicides for tea (Revised & Updated). BTRI Circular no. 142, Bangladesh Tea Research Institute, Srimangal, Moulvibazar 2017, 40.
16. Henderson CF, Tilton EW. Tests with acaricides against brown wheat mite. J Econ. Entomol 1955;48:157-161. https://doi.org/10.1093/jee/48.2.157
17. Perrin RK, Winkelman DL, Moscardi ER, Anderson JR. From agronomic data to farmer recommendations: An economic training manual. International Maize and Wheat Improvement center (CIMMYT), Mexico 1988.
18. Ahmed M. Observation on swarming patterns of the reproductive caste of *Odontotermes feae* (Wasmann) in tea fields at Srimangal, Bangladesh J Zool 1996;24(2):189-190.
19. Ahmed M, Paul SK, Mamun MSA. Field performance and economic analysis of some commonly used insecticides against tea mosquito bug (*Helopeltis theivora* Waterhouse). Bangladesh J Agril. Res 2011;36(3):449-454. DOI: 10.3329/bjar.v36i3.9273
20. Mamun MSA, Hoque MM, Ahmed M, Akandha MYH, Paul SK. Evaluation of some potential miticides against red spider mite infesting tea in Bangladesh. Tea J Bangladesh 2016;45:52-64.
21. Choudhury P. Studies on the pests of *Camellia sinensis* L. Kuntze and their control in the tea agro-ecosystem in Barak Valley, Assam. Ph.D thesis, Gauhati University, India 1999, 65.