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Comparative Evaluation of Bait Materials and Bait Stations for Subterranean Termites

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ABSTRACT: The baiting tactics for the management of subterranean termites had variable outcomes in the past depending on several characteristics of the bait such as moisture retention, termite attraction, durability and so on. The subterranean termites avoid tunnelling within dry bait, potentially reducing bait infestation and its consumption. Hence it is necessary to standardise the bait material which retains optimum moisture content without rendering its potential to attract the termites. The various combinations of bait materials and bait stations were evaluated based on moisture content and termite attraction, under laboratory condition. The coconut leaf bait in the plastic container retained higher moisture of 50.61%, fifteen days after placement (DAP). In field study, the attractiveness of baits were studied based on the population of termites at different intervals 3, 9, 15, 21 DAP and its feeding percent. The mean population of termites and feeding percent were higher upto 15 DAP in the order, coconut leaf bait > combination bait > paddy straw bait > cut bait. Hence coconut leaf bait in the plastic container would be further used for the field studies.

Keywords: Termite, Bait material, Bait station, Moisture content, Foraging activity.

INTRODUCTION

Termites are decomposers of dead woods and dead plant materials which contribute to the soil nutrient recycling. But their active search for the cellulose results in substantial harm to crops, perennial trees, buildings, wooden structures etc. They are found in a wide range of ecosystems, including tropical and subtropical climates, low and high altitude forests, agricultural farms, pastures, wooden structures & buildings, libraries and also in urbanised areas justifying its omnipresent nature (Rasib and Wright 2018). Approximately 3107 termite species are known world-wide, in which 80 species are considered to be serious pests (Kuswanto *et al*., 2015). The global economic impact of termites is estimated to be USD 40 billion per year, with subterranean termites accounting for over 80% of the entire economic impact (Oi, 2022) which entails to control these cryptic species in an effective and ecologically sound methods. As far as India is considered out of 337 species recorded, 92 species are wood despoilers (Shanbhag and Sundararaj 2013). Application of any management measures are restricted to a very small portion of the tunnel system that are obvious. The hidden network of the open tunnel may contain a colony with millions of termites inhabiting in it. Any ideal method of control should disseminate the active ingredient from the exposed workers to their hidden nestmates (Rust and Su 2012).

For decades, soil termiticides were the standard treatment method, but concerns about human and environmental health, less transfer efficiency between the nestmates prompted the development of alternatives. Baits are an excellent method to control, since they take advantage of their foraging habits and social interactions *viz*. trophallaxis and grooming for the horizontal transfer of residual pesticide deposits between nestmates. The horizontal spread of bait throughout the colony is facilitated due to the delayed action and non repellant qualities of the active component used in bait rather than the rapid acting chemical used as termiticides. In addition to the active ingredient, the efficacy of the bait depends on its moisture content, palatability, diet source and its

attractiveness (Rasib and Wright, 2018). Hence the following studies were conducted to evaluate and standardise the bait sources and bait stations based on the moisture content and its duration of attractiveness for termite foraging.

MATERIALS AND METHODS

The experiments were conducted at Department of Agricultural Entomology, TNAU, Coimbatore.

A. Studies on laboratory evaluation of moisture content in combinations of bait materials and bait stations

Bait preparation. Bait sources *viz*., coconut leaves, paddy straw were collected, shade dried, cut into small pieces and grinded to fine powder. The food baits were prepared by mixing the respective bait constituents as in Table 1 with 0.50 grams of dextrose (binding agent). Based on the need water was added to the ingredients and hand moulded to compact discs (Fig. 1). For cut baits, the dried coconut leaves were chopped to about 5-7 cm length, and directly used as bait without adding other ingredients.

Table 1: Termite food bait materials.

Sr. No.	Bait	Constituent	Weight (g)
1.	Coconut leaf bait- B1	Coconut leaf powder	40
2.	Paddy straw bait- B2	Paddy straw powder	40
3.	Combination bait- B3	Coconut leaf powder	20
		Paddy straw powder	20
4.	Cut bait- B4	Coconut leaf chops	95-100

Fig. 1. Prepared food baits using different bait sources.

Bait stations. To protect the food baits, suitable bait stations were selected *viz*., mud pot, plastic container, plastic sachet and 5-6 holes were made in the selected bait stations to facilitate the termite movement, foraging, tunnelling activities and for air circulation (Fig. 2).

Based on the bait and bait stations the following treatment combinations were formulated.

Treatment details:

T1	:	Coconut leaf bait in mud pot	T9	:	Combination bait in mud pot
T2	:	Coconut leaf bait in plastic container	T10	:	Combination bait in plastic container
T3	:	Coconut leaf bait in plastic sachet	T11	:	Combination bait in plastic sachet
T4	:	Direct placement of coconut bait	T12	:	Direct placement of combination bait
T5	:	Paddy straw bait in mud pot	T13	:	Cut bait in mud pot
T6	:	Paddy straw bait in plastic container	T14	:	Cut bait in plastic container
T7	:	Paddy straw bait in plastic sachet	T15	:	Cut bait in plastic sachet
T8	:	Direct placement of paddy straw bait	T16	:	Direct placement of cut bait

The experiment was completely randomised with each treatment replicated 3 times.

Fig. 2. Bait stations.

Field simulation and moisture estimation. Soil was collected from the fields before irrigation and filled in the polypropylene trays. The bait along with bait stations as per the treatment details were placed to simulate the field condition for moisture estimation. Initial weight of the bait before placement and the weight at 3rd, 5th, 7th, 9th, 11th, 15th day after placement (DAP) were measured using the analytical weighing balance. Dry weight of the baits were measured after placing the baits in the hot air oven at 105°C until the constant weight is measured for three consecutive times. The moisture content of the baits were calculated on the wet basis using the formula,

Moisture % =

$$\frac{[\text{Wet weight of the bait } (W_w) - \text{Dry weight of the bait } (WD)]}{\text{Wet weight of the bait } (W_w)} \times 100$$

B. Studies on field evaluation of bait materials

Coconut leaf bait, paddy straw bait, combination bait and cut bait were prepared as mentioned above and placed in the termite active coconut gardens which constitutes 4 treatments *viz.*, T1 – Coconut leaf bait, T2 – Paddy straw bait, T3 – Combination bait, T4 – Cut bait. Plastic containers were used as the bait station in all the treatments. Each treatment was replicated five times. The termite population was recorded on 3rd, 9th, 15th and 21st DAP. The initial weight of the bait before placement and the final weight of the bait at 21 DAP were measured for calculating the feeding percent.

Feeding percent =

$$\frac{(\text{Initial weight of the bait - final weight of the bait})}{\text{Initial weight of the bait}} \times 100$$

Statistical Analyses. Percent data and population numbers were subjected to arcsine and square root transformation respectively prior to analysis to stabilise the error variance. Complete randomised design (CRD) was used to analyse data from the lab experiment (Moisture content estimation) and randomised block design (RBD) was used to analyse data from the field experiment. The data were subjected to one way ANOVA and means were separated using Duncans Multiple Range Test (DMRT) in the SPSS Software (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

A. Studies on laboratory evaluation of moisture content in combinations of bait materials and bait stations

Among the different bait and bait station combinations, coconut leaf bait retained higher moisture content followed by paddy straw, combination and cut baits (Table 2). The coconut leaf bait placed in plastic sachet had 52.12% moisture comparatively higher than that of those placed in plastic container 50.61%.

Table 2: Laboratory evaluation of moisture content of food baits and bait stations.

	Treatment details	Moisture % at 15 DAP
1.	Coconut leaf bait in Mud pot	45.22 (42.2)^{cd}
2.	Coconut leaf bait in Plastic container	50.61 (45.29)^{b}
3.	Coconut leaf bait in Plastic sachet	52.12 (46.15)^{a}
4.	Direct placement of coconut bait	21.75 (27.76)^{j}
5.	Paddy straw bait in Mud pot	38.41 (38.25)^{i}
6.	Paddy straw bait in Plastic container	40.16 (39.27)^{h}
7.	Paddy straw bait in Plastic sachet	42.38 (40.56)e
8.	Direct placement of Paddy straw bait	15.11 (22.84)l
9.	Combination bait in mud pot	40.74(39.61)^{g}
10.	Combination bait in plastic container	44.93 (42.03)^{d}
11.	Combination bait in plastic sachet	45.58 (42.41)^{c}
12.	Direct placement of combination bait	17.41(24.63)^{k}
13.	Coconut leaf chops in Mud pot	41.87(40.26)^{f}
14.	Coconut leaf chops in Plastic container	41.98(40.33)^{ef}
15.	Coconut leaf chops in Plastic sachet	41.96(40.32)^{ef}
16.	Direct placement of coconut leaf chops	41.82(40.23)^{f}
SE(d)		0.123
CD		0.257

* Mean of 3 replications, **DAP – Days after placement

Figures in parentheses are arcsine transformed values

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

It was evident that the tunnelling activity of termites was mostly reliant on soil moisture (Kushwanto *et al*., 2015). The results from laboratory investigations of Su and Puche (2003), demonstrated that the presence of sound wood had little effect on tunnelling activity and on the other hand positive moisture gradient boosted up the tunnelling activity of the termites. Higher the moisture content, increases the foraging activity of termites.

Compactness, less aeration and more water droplets were recorded on baits placed in the plastic sachet. The water droplets in the sachet may affect the tunnelling of termites which in turn would affects its reunion with their nestmates. This concept is in line with the studies of Xie *et al.* (2019), that the tunnelling and feeding behaviours of the termites were restricted in the more water saturated condition. Hence the coconut leaf bait with plastic container retaining 50.61% moisture content used for field evaluation. Webb (2017), observed better foraging activity in field installed plastic bait stations. The plastic stations would be durable and maintains an undisturbed microenvironment for the termites (Quarles, 2003).

B. Studies on field evaluation of bait materials

Among the food baits in the plastic bait station, the highest number of termites (*Odontotermes* sp.) 843.4 were recorded in coconut leaf bait (T1) on 15th DAP followed by combination bait (T3), paddy straw bait (T2) and cut bait (T4). Feeding percentage of the baits also followed the similar trend, T1 (73.99) > T3 (68.26) > T2 (69.46) > T4 (31.37). Termite population was highest at 15 DAP, after which it started to decrease gradually (Table 3). The foraging activity of termites on coconut leaf and paddy straw bait is due to the

presence of cellulose as its main constituent. The paddy straw and coconut leaf let constitutes approximately 36 % and 45.58% cellulose respectively (Bakker *et al*., 2013; Rajendra, 2019).

The result corroborated with the findings of Lenz *et al*. (2009), wherein the presence of more cellulose supply was critical for termites to consume more matrix especially when alternative sources were available. Sandeep Singh (2020), revealed that the termite foraging activity is attributable to the presence of cellulose content. Among the wood constituents, cellulose is particularly attacked by the termites with the co-efficient of utilization ranging from 74% to 97% (Seifert and Becker, 1966). The present study also gains the support of Krishna and Weesmer (1969), who reviewed that the termites get their energy primarily from cellulose. The nutritional regime of termites has not changed significantly over time yet, it primarily constitutes the higher cellulosic materials.

Table 3: Field evaluation of foraging activity of termites.

Treatment details	Initial weight of bait (g)	No. of termites collected				Final weight of bait (g)	Feeding percent
		3 DAP	9 DAP	15 DAP	21 DAP		
Coconut leaf bait	95.2	152.4 (12.35)[a]	497.4 (22.3)[a]	843.4 (29.02)[a]	672 (25.92)[a]	24.76	73.99 (59.34)[a]
Paddy straw bait	95.04	139 (11.79)[c]	217.6 (14.75)[c]	676.8 (25.88)[c]	453 (21.28)[c]	30.16	68.26 (55.71)[c]
Combination bait	94.81	145 (12.04)[b]	343.4 (18.53)[b]	826.4 (28.77)[b]	616 (24.82)[b]	28.95	69.46 (56.45)[b]
Cut bait	95	81 (9)[d]	153.6 (12.39)[d]	415.4 (20.42)[d]	315 (17.75)[d]	65.2	31.37 (34.06)[d]
SE(d)	-	0.007	0.033	1.023	0.015	-	0.069
CD	-	0.015	0.073	2.255	0.032	-	0.151

* Mean of 5 replication, **DAP – Days after placement

Figures in parentheses are transformed values. Count data and percent data are subjected to $\sqrt{x+0.5}$ and arcsine transformation respectively.

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

CONCLUSION

From the comparative evaluation, plastic bait station with the coconut leaf bait was standardised for further field studies. The coconut leaf bait in the plastic container retained comparatively higher moisture content at 15 DAP and higher attractiveness for termites in field conditions. The high cellulose content (45.58%) and high moisture retention capacity distinguishes plastic container along with coconut leaf bait. The bait can be replaced after 15 days for long term control.

FUTURE SCOPE

The coconut leaf bait with plastic container can be further taken to the field studies with the addition of suitable active ingredients for the long term management of subterranean termites in coconut gardens, lawns, buildings etc. Further with the addition of superabsorbent polymers and preservatives, the standardised bait can be commercialised.

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Conflict of Interest. None.

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