Pakistan J. Zool., vol. 49(4), pp 1337-1341, 2017. DOI: http://dx.doi.org/10.17582/journal.pjz/2017.49.4.1337.1341

Comparative Efficacy of Synthetic Resins on Various Woods against Subterranean Termites

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Article Information
Received 02 June 2016
Revised 25 September 2016
Accepted 27 January 2017
Available online 10 July 2017

Authors' Contributions
SA designed the study and wrote article. MA performed experiments and BH helped in writing, preparation and publication of manuscript.

Key words
Synthetic resins, Termites, Moisture content, Infestation, Temperature.

ABSTRACT

The present studies were carried out to determine efficacy of synthetic resins on woods of three tree species to ward off subterranean termites. Three resins types in three concentrations were applied by brushing and dipping on wooden stakes which were exposed to termites' for a period of 4 weeks in the field. Weight loss before and after resin treatment was indicative of effectiveness. Highest concentration of all resins significantly reduced the chances of termites' infestation as compared to other concentrations by dipping application in contrast to coating method. Drying of woods prior to resin application was also effective in resisting termites' infestation. The findings of treatment with resins are discussed with previously cited effects of resins and its implication in wood preservation.

INTRODUCTION

Resins form an important proportion of live wood mass. Being a secondary metabolite, the resin in the plant is a shield against herbivores and pathogens by physical and chemical means (Gascon-Garrido, 2015). Naturally present in softwood of most trees, but resins can move to heartwood (Walker, 1993). Resins appear to play a significant role in preventing the degradation of wood by termites. They may act as anti-feedant, toxicant, repellents, etc. (Qian and Ryu, 2006; Shanbhag and Sundararaj, 2013). Resins in nature are water insoluble but water soluble resins have also been developed (Gindl *et al*., 2003), however, water soluble extractives were designated as wood resin by Walker (1993).

Compression of wood while heating or curing with resin enhances the strength, stiffness, water repellency, and stability of wood (Rowell and Konkol, 1987; Chong *et al*., 2010; Loh *et al*., 2011; Bakar *et al*., 2013). Resin also encompasses synthetic substances of similar mechanical properties thick liquids that harden into transparent solids. Thus a number of synthetic resins are in market that has been successfully used to treat the woods against bio agents including termites and fungi (Ryu *et al*., 1991; NurIzreen *et al*., 2011). Phenol formaldehyde (PF) resin, melamine-formaldehyde resin (Gindl *et al*., 2003), polyethylene Glycol (PEG) have been mostly tried for the purpose (Gao *et al*., 2010). Natural resins are hard to isolate and are not available at the time of need based application. In order to determine usefulness of synthetic resins in this situations, this paper explains the efficacy of synthetic resins to prevent termites' infestation on woods.

MATERIALS AND METHODS

Experiments were conducted at Entomological Field Research Laboratories at Post-graduate Agriculture Research Station, University of Agriculture, Faisalabad. Wooden blocks of *Ficus religiosa* (peepal), *Pinus wallichiana* (kail) and *Populus deltoides* (poplar) were purchased from a local timber market and these were cut into small wooden stakes of size 13×5×2 cm by using an electric saw. *Odontotermes obesus* (Ramb.) was abundant termite species in the site of the experiments. Randomized Complete Block Design (RCBD) under factorial layout was used with three replications of each treatment in all experiments. Three concentrations (10, 20 and 30%) of three commercial resins *i.e.* P3118, P3109 and P3133, obtained from the Descon Chemicals, Lahore, Pakistan in acetone as a solvent were impregnated to wood at room temperature with a control where only acetone was used.

Effects of resins on termites

Different concentrations of the resins were applied on three wooden stakes by dipping and brushing. In dipping method, wooden stakes were dipped in each concentration

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0030-9923/2017/0004-1337 $ 9.00/0

of resin for 12 h. Clear plastic boxes of dimension 30×30 cm were used for this purpose. In brushing method, four coatings of each resin concentration were done to ensure equal distribution of resin on wooden stakes. These wooden stakes were weighed and then exposed to the termites in a soil arena. After 4 weeks of exposure, these were brought to the laboratory and cleaned carefully. After re-weighing by electric balance, percent weight loss was calculated using the following formula:

$$\%\text{Weight loss} = \frac{W1 - W2}{W1} \times 100 \ldots\ldots\ldots\ldots (1)$$

Where, W1 is weight of wooden stakes before exposure and W2 is weight of wooden stakes after exposure.

This experiment was helpful in choosing the best method of application and concentration of resin for further studies.

Study on drying temperatures followed by resins application

The wooden stakes were oven dried at three different temperatures *i.e.* 100, 150 and 200°C for 24 h before application of resins. Control stakes were fresh woods. All the wooden stakes were treated with 30% concentration of the resins by dipping stakes in them. All stakes were exposed to termites and weight loss was calculated after re-weighing.

Study of resins at varying moisture levels of wood

Moisture contents (MC) of the wooden stakes were decreased up to 10, 15 and 20% of the initial (MC) by oven drying the stakes. Control stakes were fresh woods. All the wooden stakes were treated with 30% concentration of the resins by dipping stakes in them. All stakes were exposed to termites and weight loss was calculated after re-weighing.

Evaluation of the various combinations of resins

In this experiment, three resins *i.e.* P3118, P3109 and P3133 were mixed with each other at various ratios making a total 5 treatments including a control treatment, T1, 50% P3118+50% P3109; T2, 50% P3109+50% P3133; T3, 50% P3118+50% P3133 and T4, 33.3%P3118+33.3% P3109+33.3% P3133. After application of resin and exposure to termites, percent weight loss was determined as described in equation 1.

Table I.- Comparison for mean weight loss (%) of kail, poplar and peepal woods following resin application after 12 h dipping and 4 coatings against *O. obesus.*

Conc.	Resin types					
	Dipping			Coatings		
	P3133	P3118	P3109	P3133	P3118	P3109
Kail wood						
10%	37.6±3.2d-k	42.5±0.6b-f	41.1±1.5b-h	32.6±1.7 f-m	50.5±0.5b	38.5±1.9c-j
20%	20.3±1.2n-u	28.6±0.6i-p	29.1±3.3 i-p	24.7±1.3 l-s	21.2±3.1g-n	27.3±0.9j-q
30%	9.5±0.2u	16.6±0.6 q-u	13.6±2.4s-u	11.3±2.5t u	30.3±2.4m-u	18.6±1.1n-u
0%	66.6±3.3a	69.0±0.9a	71.54±1.4 a	70.16±2.25 a	67.6±1.5 a	68.7±3.2 a
Poplar wood						
10%	30.9±1.1 n-s	49.9±2.5g-k	30.5±0.7 n-s	56.7±3.9e-h	59.0±2.6d-g	41.5±2.5i-o
20%	23.9±2.7 p-t	30.6±1.5n-s	20.4±0.8r-s-t	37.4±2.1k-o	43.4±2.4i-n	30.7±1.5n-s
30%	12.8±1.7t	19.6±2.8r-s-t	11.9±1.2t	20.2±0.8r-s-t	28.6±2.5o-s	19.1±4.2s-t
0%	72.3±3.3a-b-c	69.8±3.3a-d	68.7±2.1a-e	80.2±3.9a-b	76.2±4.1a-b-c	66.3±2.8c-f
Peepal wood						
10%	23.8±2.4d-k	29.5±3.1d-g	18.3±1.4h-n	28.2±1.4d-h	33.3±1.7d-e	23.0±1.1e-k
20%	16.7±0.9i-o	19.2±1.5f-n	11.0±1.1m-n-o	18.6±0.6g-n	22.6±0.4e-l	18.4±1.2g-n
30%	7.1±1.3o	10.4±1.1n-o	6.9±1.3o	12.9±0.6k-o	21.3±1.4f-n	11.8±1.4 l-o
0%	57.1±0.8c	66.6±1.7a-b- c	63.9±2.9a-b-c	59.8±1.3b-c	65.4±3.3a-b- c	72.5±2.4a

Means sharing shame letter in column and row under each application method are not significantly different from each other. Conc, concentration.

Table II.- Comparison for mean weight loss (%) of kail, poplar and peepal woods following resin application after subjected to different temperatures against *O. obesus.*

Temp.	Kail			Poplar			Peepal		
	P3133	P3118	P3109	P3133	P3118	P3109	P3133	P3118	P3109
100	25.5±0.9b	26.8±0.6b	21.9±0.5b	40.3±0.5b	35.1±0.3b	29.9±0.7b	19.8±0.4b	20.6±0.2b	20.5±0.4b
150	18.8±0.3c	20.7±0.9c	15.6±0.5c-d	32.0±0.7c	30.2±0.5c	26.1±1.0b-c	14.5±0.8c	11.9±0.2d	12.3±0.2c
200	16.3±0.6d	16.4±0.8d	13.2±0.5d	20.7±0.4d	22.7±0.5d	16.8±0.5d	12.0±0.7c-d	15.5±0.9c	10.2±0.5d
Control	35.0±1.0a	35.7±2.0a	34.2±1.1a	50.4±1.3a	54.8±1.0a	46.2±1.1a	29.9±0.3a	32.0±1.0a	29.5±0.8a

Means sharing shame letter in a column not significantly different from each other. Temp, temperature (°C).

Table III.- Mean weight loss in various woods after reduction in moisture contents and resin application.

MC	Woods			Resins		
	Kail	Poplar	Peepal	P3109	P3118	P3133
10%	20.4±0.7c	26.8±0.8b	16.0±1.0d	18.3±1.8c	22.4±1.5b	22.4±1.6b
15%	15.0±0.8d	22.4±0.8c	10.6±0.6e	13.8±1.7d	16.6±1.5c	17.5±2.1c
20%	8.1±0.8 e-f	15.2±0.8d	5.8±0.5f	7.3±1.3f	11.0±1.6e	10.7±1.4e
Control	56.5±0.8b	32.9±0.6a	20.7±0.4c	25.2±1.8 a	27.3±2.0a	26.7±1.6 a

Means sharing shame letter in wood types and resins are not significantly different from each other. MC, moisture content.

Statistical analysis

The data obtained from all these experiments were analyzed by Minitab 16 statistical software. Analysis of variance (ANOVA) was performed for testing the level of significance among weight loss in various treatments after termite infestation. Treatment means were separated using Tukey's test at $p < 0.05$ level.

RESULTS

Weight loss in different woods due to termites' infestation was significantly different and lowest at high concentration of resins, however, overlapping weight loss was observed between 20 and 30% concentration. Resin type also differed in two application method. P3133 showed lowest weight loss in dipping method for kail and poplar woods (Table I), whereas P3109 application resisted weight loss in peepal wood (Table I). Dipping of woods in three resins recorded low weight loss as compared to coatings in all three woods (Table I). Significant difference of weight loss in control treatment was also recorded when compared with treated woods.

Woods dried at 150 and 200°C before application of 30% resin solution with dipping method resisted termites' infestation to significantly large extent and weight loss was low as compared to woods dried at 100°C. Peeled wood dried at 200°C and dipped in P3109 had the lowest weight loss (10.2%) compared to other woods treated with other resins (Table II). Reduced moisture content of woods from their initial level registered significant low weight loss than corresponding control in each wood type and resins (Table III).

The treatment (T2, 50% P3109 + 50% P3133) on woods of three tree species showed significantly lowest weight loss when compared with other treatment. However, poplar and peepal treated with T1, 50% P3118 + 50% P3109; T2, 50% P3109 + 50% P3133 had non-significant weight loss indicating importance of P3109 resin as compared to other resin types (Table IV). Bringing moisture content (MC) of wood to 20-10% from initial MC value did not show difference in weight loss but P3109 treatment after reducing MC to 20%, minimum weight loss was observed in case of all woods (Table III).

Table IV.- Comparison of means for percent weight loss of kail, poplar and peepal after treating with different combinations of the resins against termites.

Treatments	Kail	Poplar	Peepal
T1	26.7±1.3i	32.6±0.6g-h	19.7± 1.1j
T2	13.0±0.8k-l	15.6±1.0j-k	8.2±0.5l
T3	36.2±0.6f-g	37.6±0.2fg	29.7±0.4 h-i
T4	45.2±1.0e	50.3±1.8d	39.3±0.8f
T5	68.5±1.4b	77.6±0.5a	60.1±0.3c

Means sharing shame letter in columns and rows are not significantly different from each other. T1, 50% P3118+50% P3109; T2, 50% P3109+50% P3133; T3, 50% P3118+50% P3133; T4, 33.3%P3118+33.3% P3109+33.3% P3133; T5, acetone only.

DISCUSSION

Wood of three trees dipped in synthetic resins were able to prevent termites' infestation for certain period of time, which can be important duration in storage where woods are kept until their utilization into products. These results are in comparison with Amiralian *et al*. (2014) who used 30% resin solution in acetone extract of *Triodia pungens* plants on the Baltic Pine (*Picea abies*) blocks using a brush. Wood blocks treated with resin were not damaged by Macrotermes darwiniensis and severe damage was observed in control after 6 months exposure. These results have been earlier supported by Bultman *et al*. (1998) in which impregnated Pine (*Pinus stobus*) sapwood with resin and rubber obtained from guayule by solvent extraction prevented attack of *Heterotermes*, *Coptotermes* and *Reticulitermes* subterranean termites for period of 67-71 months. Similar results were also found by treatment of oil palm plywood with phenolic resins (Nakayama *et al*., 2003; Loh *et al*., 2011; Bakar *et al*., 2013). This was because the resin penetrations into the cell wall of wood improve its durability, which is in agreement with the findings reported by NurIzreen *et al*. (2011). Comparable results were also described by Arango *et al*. (2006) where authors quoted that higher density of wood resulted in more resistance against *Reticulitermes flavipes* termite attack. Another explanation for such efficacy was previously suggested by Deka *et al*. (2002) after using softwood and various types of thermoset resins. Termites' resistant capacity might be due to the bulking of wood after treatment, thereby not permitting the absorption of sufficient water to support termite attack. An important finding in these studies is that moisture had little effect on efficacy of resin but temperature treatment prior to resin application showed varying weight loss. This is supported by fact that wood treated with resin prevents increase in moisture in wood.

CONCLUSION

Based on the findings, we concluded that dried woods are resistant to termites' infestation to certain period of time, application of resins retained dryness of woods and woods were little affected than untreated.

Conflict of interest statement

We declare that we have no conflict of interest.

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