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HYGROSCOPIC PROPERTIES FOLLOWING DRYING AFFECTS WOOD CONSUMPTION BY *Odontotermes obesus*

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ABSTRACT

The relationship between drying and hygroscopic ability of *Crateva adansonii* and *Populus deltoides* woods to resist feeding by *Odontotermes obesus* was studied. Woods were dried under the sun and in the oven for a range of 5-25 days and then these were exposed to termites for 25 days in underground pits in Randomized Complete Block Design pattern with five replications. Results showed that lowest moisture gain was observed at a short time for drying with each method. Weight loss after termites' exposure was more in less dried sap and heartwood of either plant species. The practical implication of these results is discussed.

Keywords: *Crateva adansonii,* hygroscopicity, moisture content, *Populus deltoids,* consumption, termites, field test.

INTRODUCTION

Like many biological materials, wood being hygroscopic, absorbs moisture from the wet environment and even saturated wood loses moisture in a dry environment (Akyildiz and Ates 2008). Hygroscopic properties of wood vary according to extractives present in wood (Quartey 2015). Heat treatment is a useful method to reduce hygroscopicity, however, the effects of heating are sometimes reversible *i.e.* recoverable by mild after-treatments such as moistening and soaking in organic solvents (Obataya 2014). In addition to heat treatment, another useful method to overcome shortcomings of heating is impregnating wood with appropriate hydrophobes (Mantanis and Papadopoulos 2010). On the other hand, heat treatment of wood increases its ability to store and transport free water. Subterranean termites construct tunnels in the outer surfaces of the wood leading to an increase of its moisture content, mainly in the areas of contact with termites. Heat treatment causes wood components degradation, facilitating termite access to free sugars (Surini *et al.* 2011, Duarte *et al*. 2012, 2016).

It is generally stated that wood with less than 20% moisture content is not susceptible to termites (Clausen 2010, Sivrikaya *et al*. 2015). In most cases, heat treated wood in contact with soil resists weight loss by feeding of termites (Scouse *et al*. 2015). There are also reports where weight loss increases with time when woods were in contact with soil. The survival time of termites, *Reticulitermes flavipes*, increased with the rise in wood moisture content without soil contact in high humidity environment.

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Wood MCs below 24% were lethal to *R. flavipes,* because moisture in wood was not suitable for termites infestation with no soil contact, probably because water obtained from the wood by termite feeding does not compensate for water loss from their bodies, regardless of relative humidity in the air-space (McManamy *et al*. 2008). Wood and termite nesting materials with >16% moisture content (MC) cause the air spaces within these structures to be saturated with moisture (Sponsler and Appel 1990). This would guarantee termite survival if water loss by cuticular permeability represents the major process for desiccation.

Wood hygroscopicity may be responsible for reporting an increase in weight loss and termites' infestation when samples are in contact with the ground and thus, may counterbalance the advantage of heat treatment. Infestation of *Odontotermes obesus* (Ramb.) on heat treated wood was greater than non-heated ones (Sheikh *et al*. 2010). This may be an artifact in experiment where hygroscopicity was not considered. Thus, present studies were aimed to determine hygroscopicity of two kinds of wood after exposure to heat (drying) and then later placed in an underground pit to observe weight loss and termites' infestation and compared with non-dried / control woods.

MATERIALS AND METHODS

Logs of *Crateva adansonii* (barna) and *Populus deltoides* (poplar) woods were cut into smaller blocks of sap and heartwoods; portions of 13x5x2 cm dimension were obtained by using an electric saw. Moisture content (MC) of freshly cut blocks of both kinds of wood was measured by oven drying method until constant weight was achieved.

Heart and sap woods of both *C. adansonii* and *P. deltoides* were sun and oven dried for 5, 10, 15, 20 and 25 days at 100 ºC. In sun drying method, blocks were put on blotting paper under a glass cover and kept exposed to the sun for above said periods. At the end of each drying time, blocks were removed and put on a concrete surface in the underground pits (Fatima *et al*. 2015) to determine moisture gain. Pits were also meant to expose blocks to termites' access and *O. obesus* was termites' species in this particular site of Postgraduate Agriculture Research Station, Jhang Road, Faisalabad. The moisture gain in wooden blocks and weight loss due to termites' feeding were carried out in separate laid out experiments. The blocks remained in pits for either purpose for 25 days. Moisture gain and weight loss were calculated from following formulae (Hartley and Marchant 1995).

$$Moisture\ gain\ (\%) = \frac{W_1 - W_2}{W_2} x\ 100$$

W_1: Oven dried weight before exposure

W_2: Oven dried weight after exposure

$$Weight\ loss\ (\%) = \frac{W_1 - W_2}{W_1} x\ 100$$

W_1: weight before feeding of termites
W_2: weight after feeding of termites

All the treatments in two experiments were arranged in Randomized Complete block design with five replications. The means of significant interaction among the parameters were compared by using Tukey's Highly Significant Difference (HSD) test for paired comparisons at a probability level of 5% by Minitab 17. Pearson's linear correlation coefficient (r) was used to determine the relationship between moisture content and wood weight loss.

RESULTS AND DISCUSSION

Oven and sun drying, heart and sapwood and duration of drying had significant differences of moisture gain in *C. adansonii* at post 25 days interval. Interaction among drying methods, wood types and time for drying was non-significant (p>0,05) (Table 1). With the increase in duration for drying, moisture gain was also increased. Lowest moisture gain was observed at a short time for drying with each method. Moisture gain in either drying method was significantly different from their corresponding controls (Table 2).

Table 1. ANOVA of moisture gain in *Crateva adansonii* and *Populus deltoides* after 25 days exposure.

		C. adansonii	*P. deltoides*
SOV	DF	MS	MS
Drying Method (DM)	3	378,33*	413,51*
Wood types (WT)	1	23,18*	24,35*
Drying times (DT)	4	169,56*	241,32*
DM x WT	3	$0{,}30^{ns}$	$0{,}17^{ns}$
DM x DT	12	6,09*	2,74*
WP x DT	4	$0{,}47^{ns}$	0,36*
DM x WT x DT	12	$0{,}34^{ns}$	$0{,}10^{ns}$
Error	80	0,26	0,08
Total	119		

*significant at p<0,05; ns, non-significant

Table 2. Comparison of means for moisture gain in *Crateva adansonii* with oven and sun drying at different drying durations.

DT	Drying Methods			
	Oven drying	Control	Sun drying	Control
5	3,95±0,24f	0,26±0,06j	3,29±0,25fg	0,22±0,05j
10	6,87±0,24c	0,91±0,32ij	6,35±0,23cd	0,57±0,07j
15	10,20±0,27b	2,28±0,56gh	9,80±0,26b	1,96±0,27hi
20	10,84±0,25ab	3,25±0,58fg	10,46±0,23b	3,93±0,24f
25	11,92±0,28a	5,37±0,26de	11,69±0,26a	5,20±0,31e

Values are Means±SE. Means sharing same letters are not significantly different at p=0,05; DT, drying times (days).

Oven and sun drying, heart and sapwood and duration of drying had significant differences of moisture gain in *P. deltoides* after 25 days' time point. Interaction among drying methods, wood types and time for drying was non-significant (p.0,05) (Table 1). An increase in duration for drying resulted in higher MC than preceding time point. Initial time point for drying (i.e. 5 days) in either method recorded the lowest moisture gain, which was negligible in respective control treatment. The latter treatment at end of experiment showed significant increase in moisture gain from corresponding initial time point and was significantly different from respective drying wood at each time point (Table 3).

Table 3. Comparison of means for moisture gain in *Populus deltoides* with oven and sun drying at different drying durations.

	Drying Methods (DM)				Wood types	
DT	Oven drying	Control	Sun drying	Control	Sapwood	Heartwood
5	5,44±0,21fg	0,47±0,06j	4,88±0,23gh	0,40±0,06j	3,01±0,78h	2,50±0,66i
10	9,23±0,23d	1,39±0,15i	8,66±0,22d	1,49±0,15i	5,53±1,18f	4,85±1,09g
15	11,10±0,25c	4,70±0,28h	10,70±0,25c	4,46±0,41h	8,31±0,94d	7,17±0,97e
20	12,10±0,27b	5,92±0,24f	11,89±0,23b	5,94±0,26f	9,49±0,92c	8,42±0,91d
25	14,78±0,23a	7,06±0,28e	14,47±0,23a	7,15±0,25e	11,38±1,13a	10,35±1,14b

Values are Mean ± SE. Means sharing same letters are not significantly different at p=0,05; DT, drying times (days).

Table 4 shows the weight loss of sap and heartwoods of *C. adansonii* and *P. deltoides* after sun and oven drying at different time durations. Weight loss was more in less dried sap and heartwood of either plant species. Highest weight loss was seen in the control treatment (fresh woods) and minimum in wood dried for a longer period. A correlation between moisture content and weight loss in both types of woods of plant species also was not only positive but also highly significant ($r > 0,5$).

Table 4. Comparison of weight loss (%) in sap and heartwoods of *C. adansonii* and *P. deltoides* at different time points after sun and oven drying.

	Sun drying				Oven drying			
DT	*C. adansonii*		*P. deltoides*		*C. adansonii*		*P. deltoides*	
	Sapwood	Heartwood	Sapwood	Heartwood	Sapwood	Heartwood	Sapwood	Heartwood
25 days	40,28±0,04b	37,08±0,64b	55,84±0,23b	53,49±0,32b	36,91±0,02b	33,91±0,02b	51,32±0,01b	48,22±0,11b
20	36,34±0,02c	32,93±0,31c	52,46±0,24c	50,12±0,45c	32,14±0,01c	29,14±0,01cd	47,52±0,02bc	44,54±0,02bc
15	34,81±0,02d	31,09±0,50d	48,64±0,77de	45,98±0,77de	30,71±0,01d	27,71±0,01d	45,74±0,02cd	41,85±0,46cd
10	31,76±0,02f	28,11±0,11e	46,54±0,56ef	44,54±0,56ef	27,83±0,01e	24,83±0,58e	42,37±0,26de	39,39±0,19d
5	28,90±0,01g	24,56±0,44f	44,62±0,39f	42,29±0,58f	24,44±0,01f	21,44±0,58f	39,34±0,23ef	33,07±3,16f
Control	52,33±0,16a	48,78±0,40a	65,55±0,74a	62,55±0,74a	48,47±0,04a	45,30±0,43a	63,78±0,86a	59,77±0,96a

Values are Mean ± SE. Means sharing same letters are not significantly different at p=0,05; DT, drying times (days).

The results have revealed that wood absorbed moisture when placed in contact with soil and there was a linear relation of the increase in wood moisture content with weight loss. Woods dried by oven and sun drying lost weight after exposure to termites' workers, however, significantly less as compared to fresh wood which were control in this study. Weight loss was more in woods dried longer in oven and sun drying methods contradicts with an early report in which an inverse correlation was found between the treatment and wood consumption (Sheikh *et al*. 2010). This different can be credited to two reasons either termites species was different or method of exposing woods to termites was not in contact with soil in the field. Termites' species was same, however, the method of exposure was totally different. Placement of woods was 30 cm deep in soil and moisture gain in this fashion may have started the wetting of woods (i.e., having MC above threshold for feeding). *O. obesus* avoids wet woods, whereas in the present studies, woods were placed onto concrete surface holed for termites to reach them. Woods kept in that way also showed an increase in their moisture contents.

Subterranean termites live in the soil, or in moist wood and they need specific moisture content in woods to gain access to food. Termites favor decaying wood in moist situations within which to establish colonies as it provides them with protein and moisture (Brian 1965). *Odontotermes* spp. and *Microtermes* spp. are not restricted to wood already infected by fungi but instead can gnaw fresh wood into fragment upon which to grow fungi to feed larvae / nymphs in colony (Richardson 1993). This corroborates to present results where fresh woods were heavily attacked by termite species because fresh woods may be moist enough to allow termites' feeding freely and sufficient space in woods should be available to allow termites to reach foods which obviously not the case in wet woods. It also clearly shows that *O. obesus* requires moist wood for feeding but not wet ones. In this case, temperature or heat treated wood will not be successful to resist termites' feeding if it is in contact with soil and continue absorbing steadily the moisture from surroundings.

Heartwoods of either plant species were resilient to moisture gain as compared to sap woods, which indicates towards role of hydrophobic extractives as indicated by Quartey (2015). Difference between plant species can be attributed to the same reason. *C. adansonii* resisted the moisture gain.

CONCLUSIONS

It can be concluded that reduction of moisture contents of wood by heat treatment, i.e. sun drying/ oven drying, is not an appropriate method to reduce the *O. obesus* infestation. Woods ought to be kept in dry conditions to prevent moisture gain and ultimately termites' infestation. Further, woods should be treated with hydrophobic preservatives under high moist conditions.

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