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CHEMICAL MODIFICATION OF FARM-GROWN EUCALYPTUS WOOD TO REDUCE SEASONING DEFORMITIES

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Abstract: In an attempt to overcome seasoning defects in wood the green sawn members of *Eucalyptus camaldulensis* Dehn. were treated with different chemical solutions. To start with, the wood specimens were submerged in 35% solutions of DEG, sucrose, zinc sulfate, sodium silicate, ferrous ammonium sulfate, 5% solutions of alginate and pure diesel oil for one week. DEG and sucrose were better than other chemicals to minimize the seasoning defects. Both DEG and sucrose are easily available and have encouraging use to control shrinkage and warpage. The effect of DEG solution expressed as ASE (%) on periphery (girth), and over the total volume were 31% and 25% respectively and expressed as LRF (%) on bend, twist, and overall volume were 99%, 95%, and 93% respectively. The effects of treatment with sucrose solution on shrinkage in girth and volume expressed as ASE were 28% and 23% respectively and expressed as LRF for bend, twist and overall volume recovery were 99%, 92% and 90% respectively after treating with the sucrose. It is of practical importance that DEG and sucrose are economical and easily available chemicals.

Keywords: *Eucalyptus camaldulensis* (Dehn.), dimensional stability, seasoning, shrinkage, warp,

INTRODUCTION

In Pakistan, *Eucalyptus camaldulensis* Dehn. was introduced from Australia. Due to its faster growth rate as compared to the indigenous tree species like, Dalbergia sissoo (Shisham), Acacia nilotica (Kikar), and Pinus species, it is the most popular tree plant among the growers. However, due to seasoning defects, like twist, bend, surface cracks, and end splits, it is the least popular among users. Another seasoning defect in treated and untreated wood is the collapse of portion of tissues that result in heavy shrinkage and warping. Shrinkage differences cause strong bowing or crooking of sawn lumber [Kajita *et al.* 2000].

Drying strains start when wood dries from the green state to the oven dry state. It compresses the wood near the log surface and have tensile effect near the core [Davis *et al.* 1993]. Little work has been reported on dimensional stability of sawn Eucalyptus wood in Pakistan.

The approaches operative for dimensional stability are, -OH bonding of the cellulose and chemical molecules and secondly bulking the lumen spaces with the chemicals. Use of sucrose as stabilizing agent for small laboratory specimen as well as at large scale for making boats and ships was found to be more feasible method [Hoffmann 1996]. The wood kept

its natural colour and the dimensional stability to a reasonable extent. To produce appearance grade material it is necessary to dry the Eucalyptus wood slowly in the early stages under controlled conditions of air velocity, temperature and humidity [Glossop 1994]. Acetylation occurs in the reaction with acetic anhydride [Shiraishi *et al.* 1993]. The hydroxyl groups on cellulose, hemicelluloses, and lignin are converted into hydrophobic acetyl groups. Such treatments have improved dimensional stability with increasing weight gain. One of the factors that cause differences within treatments was the anatomical feature of the wood [Norimoto *et al*. 1992].
The results were quantified as anti-shrinkage efficiency (ASE), and lumber recovery factor (LRF%). ASE% expresses the percentage of the shrinkage, which would be suppressed by the stabilizing treatments. Warping means the deformation through bending and torsion and the combination of both. It was quantified as LRF% (the percent amount of wood recovered after removing the defect by planting). Higher the ASE, or LRF% the better is the stabilization.
The main objective of the study was to overcome such seasoning defects by modifying the wood chemically. To probe into chemicals for selecting milder, cheaper and easy to handle and apply were the other objectives of this study [Norimoto *et al*. 1992].

MATERIAL AND METHODS

Ten farm-grown-Eucalyptus trees were felled from Post Graduate Agricultural Research Station (PARS) University of Agriculture, Faisalabad, Pakistan with the tree diameter (with bark) at breast height in the range of 35 cm - 40 cm . Logs were processed and transported to Wood Testing Laboratory, Department of Forestry, Range Management and Wildlife, University of Agriculture, Faisalabad. These were rough sawn as radial strips (boards) and specimen pieces of dimension 2.5 cm radially x 5 cm tangentially x 30 cm axially (thickness x width x length) were prepared. Each of the specimen piece was planed under gauge planer to give sharp edges (at right angle to each other) and fixed dimensions. All the specimens were mixed, and ten specimens per treatment per replication were taken at random. Then all the specimens were labeled according to the treatment to be applied, and submerged in respective solution of chemical for one week. Three replications were prepared.
Seven chemical treatments namely diethylene glycol (DEG), sucrose, zinc sulfate, sodium silicate, and ferrous ammonium sulfate, (35% solution of each w/v for solid solutes and v/v for liquid solutes), alginate (5% w/v solutions) and pure diesel oil were applied. The simple diffusion was allowed for one week by submerging the wood in solutions of these chemicals. The approach was that those chemicals would penetrate into wood as bulking agent in cell lumen spaces or intercellular spaces. The range of molecular weight was between 200 and 600 that can impregnate

the wood easily. After taking out from solution, specimens were stacked on small stickers for air seasoning. Natural air seasoning under shade in the laboratory was done for 2-months at 10-30 ^{o}C. The temperature variation was due to rapid changes in the season from end of February till the end of April. The following parameters were studied.

1. Periphery shrinkage was measured as shrinkage in girth of samples after seasoning expressed as percentage of green wood girth. Anti-shrinkage efficiency of treatments was then determined by:

$$\text{ASE \%} = \frac{\text{Shrinkage in untreated specimens} - \text{shrinkage in treated specimens}}{\text{Shrinkage in untreated specimens}} \times 100$$

2. Volumetric shrinkage was measured as the difference in green and dry wood volume expressed as percentage of green wood volume. The ASE% was calculated as above [Hoffmann 1986, Hoffmann 1996, Norimoto *et al.* 1992].
3. Twist was measured by placing the samples on flat surface with three corners touching the plane and measuring the height of fourth raised end from the plane surface. The values recorded in millimetres were considered to be planed to correct the defect (twist) and the remaining thickness of sample was taken to determine the volume of sample. This volume was taken as lumber recovered, percentage of original air-dried volume called as Lumber Recovery Factor (LRF%).

- ***LRF;** Lumber recovery factor is percent volume of lumber produced / recovered per unit actual log volume after removing defects. It was calculated as
  Lumber Recovered = Actual volume of air-dried wood – (volume after cutting the depth of end splits on both directions, then planning to remove all defects like surface checks/cracks on all sides, bend, twist, and crook which so ever is the highest as other defects will automatically be removed during planning).

4. Bend was measured as depth of depression in the center of samples placed on plane surface with convex side down. The defect was quantified as lumber recovery factor (LRF), i.e. percent volume of lumber recovered after removing the defect by planting the samples equal to the depth of bend. Twist and bend are the major cause of rejection of the wood for commercial use, hence there was utmost try to reduce those defects by proper sawing technique (preferably quarter sawing).

5. LRF vol% was the percent volume recovered from dry wood after removing twist and bend or any other defect like checks etc by planting.

Statistical analysis was done using computer program SPSS for Windows (version 10.0) at 5% probability level. Multiple comparisons were employed to compare the differences among means of the treatments at 5% probability level [Zar 1996].

RESULTS

DEG and Sucrose resulted alike to overcome shrinkage but no effect was observed on warpage by any of the chemicals (Table 1). Sodium silicate was at 2nd place as stabilizing agent. Rest of the chemical was not much significantly effective in controlling the seasoning defects.

SHRINKAGE IN PERIPHERY

The effect of chemical treatments on periphery (girth) shrinkage was highly significant (p = 0.000). Sodium silicate DEG, and Sucrose were the treatments significantly different (Table 1) from all other treatments in controlling the shrinkage along girth.

Table 1: Response of Eucalyptus wood to chemical treatments for dimensional stability.

Treatments	Response Variables				
	ASE_{cs}%	ASE_{vol}%	LRF_{bend} %	LRF_{twist} %	LRF_{vol} %
Control	0a*	0a	87	70.68	68
Sod.silicate	11.83b	13.97b	96.08	86.88	69.31
DEG	31.12c	25.42c	99.01	94.68	93.07
Zinc sul.	0.61a	4.70a	89.75	78.4	70.53
Alginate	6.01a	10.90a	94.4	81.77	80.31
Diesel	7.35ac	9.05ac	86.43	76.91	74.79
Sucrose	28.07c	23.45c	99	91.99	90
Ferr.amm.sul	4.33ac	7.10ac	86.38	78.04	75.8

*The differences in mean values sharing similar letters are statistically non-significant at 5% probability level. Other values are non significant.

VOLUMETRIC SHRINKAGE

The effect of chemical treatments on mean volumetric shrinkage in Eucalyptus wood was significantly different (p=0.000). Sodium silicate, DEG, and sucrose had the significant effect.

TWIST

The difference in LRF_{twist}% in the Eucalyptus wood specimens was statistically non-significant (p = 0.786).

BEND

The statistical analyses of data showed no significant difference (p = 0.080) in effect of different chemicals in controlling bend expressed as lumber recovery factor (LRF_{bend}%).

LRF_{vol}%

The effect of selected chemical treatments on overall lumber recovery after removing all defect was also found to be statistically non-significant.

DISCUSSION

Short rotation means that proportionately greater amounts of juvenile wood and this is of increasing significance throughout the world relying on fast growing, short rotation plantations. Fundamental understanding of the structure versus property relations helps in utilizing wood to its potential. Manipulation or modification of critical properties of wood can open new product development possibilities to meet the end use requirement. There is no reason why Eucalyptus could not be developed into an important commercial species in Pakistan. The wood seasoning problems that were experienced in the present studies were no different from those that would be expected in working with any new species of wood. The study developed a system to assess the potential of Eucalyptus wood, which will allow its volume recovery to be quantified by conventional procedures. Such assessment provided an estimate of the proportion of usable wood recovery and also addressed procedures for treating and drying lumber with high percentage of sapwood.

DEG is an economical and easily available chemical in Pakistan and is safer for wood treatment for controlling dimensional instability. Its efficiency in controlling total volumetric shrinkage was 25.42%. It was more efficient than sucrose or sodium silicate in controlling shrinkage in total volume.

Polyethylene glycol is a group of widely used chemical for wood dimensional stability as reported by Haygreen and Bowyer [1989], Hoffmann [1986, 1990, 1991, 1996], Kajita *et al.* [2000], Milota [1992], Norimoto *et al.* [1992], Shiraishi *et al.* [1993] and Walker [1993]. This group can impregnate wood by simple soaking. It is available in wide range of polymers and was considered to be the best chemical for wood dimensional stability through impregnation. Norimoto *et al*. [1992] reported that the PEG 600 treatment resulted in an excellent ASE value.

Table sugar (sucrose) is also equally good for wood dimensional stabilization (ASE 23-28%) and the good alternative of other chemicals for controlling shrinkage effectively. It should, however, be applied with some toxic chemical to avoid wood decay. Hoffmann [1996] reported that the ASE values in his experiment treatment ranged from 60-100%, where values above 75% were considered acceptable. The difference between the two results is that in the present study the material used was green wood, while Hoffmann [1996] used waterlogged specimen from a ship.

Milota [1992] noted that twist in lumber having more juvenile wood was greater than in lumbers from large logs and also this difference was quite noticeable visually though not statistically significant.

All of the specimens did not bow in the same direction. In general edge nearest the pith would probably shrink longitudinally more than the other edge, causing crook. Proper technique may be the best defense against warp in lumber, regardless of the source of wood or the drying schedule [Lugo 1992].

The distribution of juvenile wood among the boards is one of the factors suspected for causing warp. Wood with more than 50% juvenile wood significantly affected warp. Lugo [1992] reported that bow crook and twist are not related to wood density, ring count or thickness of samples. One important aspect in this study was the time factor required for penetration of chemicals. Yet it has not been determined that exactly how long will it take to react with wood holocelluloses and to penetrate as a particular chemical into cell wall and cell voids. In this study sufficient time was not allowed to submerge wood in chemical solution, however the specimens size was small. While in a study by Hoffmann [1991] on conservation and dimensional stability of ship wood, it took 2-4 years for PEG impregnation.

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