CONTROL OF STAIN AND DECAY IN UNSEASONED DOUGLAS FIR

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ABSTRACT

Green Douglas fir sawn timber was dipped in an aqueous solution containing 0.6% sodium pentachlorophenate and 1.8% borax pentahydrate, within 48 hours of conversion. Almost complete control of decay and partial control of sapstain over a storage period of one year was obtained. Packets tightly wired for export and dipped for 30 seconds in this solution were protected from fungal attack equally with those where the individual pieces were momentarily dipped before before block-stacking and wiring.

INTRODUCTION

Until November 1970, it was not customary in New Zealand to dip green (unseasoned) Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) sawn timber in an antisapstain solution, as it was generally considered to be of low risk for attack by mould, stain or decay fungi. During 1970, however, there were several instances of green Douglas fir being rejected as unsuitable for export because of a high incidence of fungal attack. This had developed during protracted storage in block-stack prior to export. The timber was badly sapstained and many pieces within packets were covered with mycelial wefts, or sheets, of decay fungi. The timber was of poor appearance. Microscopic examination of many samples infected with decay fungi showed this infection to be largely superficial and not associated with wood breakdown. Isolated reports of decay in New Zealand-grown Douglas fir exported to Australia suggested that continued development of decay fungi may lead to advanced decomposition of the wood if it is improperly stored by the importer, i.e., held in block-stack for several months before use, instead of being placed in filleted stacks.

In view of the potential seriousness of the problem, the New Zealand Sawmillers' Federation, acting on the advice of the Forest Research Institute and the Utilisation Development Division of the New Zealand Forest Service, passed a resolution making it mandatory that all green Douglas fir intended for export must be dipped in an approved antisapstain solution, within 48 hours of sawing. The antisapstain solution had to contain a minimum of 0.5% sodium pentachlorophenate (NaPCP) + 1.5% borax pentahydrate (recommended solution: 0.6% NaPCP + 1.8% borax).

On the basis of cost, an antisapstain, or prophylactic, dip treatment was preferred to kiln drying, air-seasoning in filleted stacks, or boron treatment. Dipping in the solution as specified would not exceed a cost of 50c/m^3 (12c/100 bd ft) inclusive of labour, whereas none of the alternatives would cost less than \$2.00-\$2.50/m^3 (50c-60c/100 bd ft).

Sodium pentachlorophenate was recommended as the active ingredient of the antisapstain solution because of its wide acceptance in New Zealand for the control of stain and decay in exotic softwoods, notably radiata pine (*Pinus radiata* D. Don). Also, Roff and Cserjesi (1965) in British Columbia had shown sodium pentachlorophenate + borax consistently to prevent decay in green, block-stacked Douglas fir and to give an acceptable level of sapstain control, although it failed to control the brown mould *Cephaloascus fragrans* Hanawa (which has not been recorded on sawn timber in New Zealand). Cserjesi and Roff suggested in 1966 that storage of up to 15 months may be feasible in block-stacked Douglas fir.

The present study was undertaken to substantiate the mandatory requirements of the New Zealand Sawmillers' Federation, to compare different methods of dip treatment and to ascertain the storage periods feasible for unseasoned Douglas fir held in block-stack.

MATERIALS AND METHODS

Rough-sawn Douglas fir was taken from the green chain of the Waipa State Mill, Rotorua, immediately after sawing. Sufficient timber was obtained to provide two block-stacks (approximately 330 cm long by 105 cm wide by 65 cm high) containing, on average, 100 pieces of 10 cm × 5 cm export grade Douglas fir for each of the following treatments:

1. Block-stacked, wired and dipped.
2. Dipped, block-stacked and wired.
3. Dipped, block-stacked, wired and wrapped in black polyethylene sheeting (this was to prevent the timber from drying and consequently to maintain conditions suitable for fungal growth).
4. Block-stacked and wired (untreated controls).

The antisapstain, or prophylactic, solution contained 0.6% NaPCP + 1.8% borax pentahydrate. Dipping of wired block-stacks (Treatment 1) was done by immersion of the entire packet for 30 seconds in a dip tank. Individual pieces (Treatments 2 and 3) were momentarily immersed in the same tank prior to assembly into block-stacks (or packets). Timber was dipped within 48 hours of sawing.

All packets were artificially inoculated with a mixed mycelial and spore suspension of sapstain and decay fungi. The upper surfaces of alternate layers of the 10 cm × 5 cm pieces were sprayed with the fungal suspension. Packets dipped as a block-stack (Treatment 1) were inoculated before dipping; packets of all other treatments (2, 3 and 4) were inoculated after dipping and during assembly into block-stacks.

The fungal suspension used for inoculation contained the following four fungi:

1. *Ceratocystis piceae* (Münch) Bakshi, a major sapstain fungus of Douglas fir.
2. *Alternaria tenuis* Nees, a commonly isolated sapstain fungus of Douglas fir.
3. *Peniophora gigantea* (Fr.) Massee, the principal decay fungus of exotic softwoods.
4. The basidiomycetous fungus, as yet unidentified, which produces the characteristic mycelial strands on Douglas fir (*see* Fig. 1).

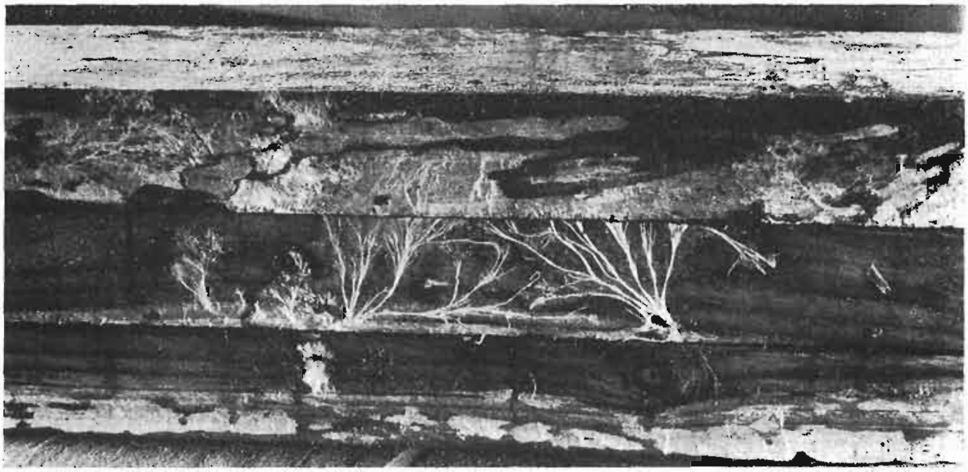

FIG. 1—Untreated, green Douglas fir sawn timber after prolonged storage, showing sapstain, mycelial strands of decay fungi and patches of decay.

During the first week of September 1970, December 1970, March 1971 and June 1971, two replicate packets of each treatment were placed out under test. Packets which were wrapped in polyethylene after dipping (Treatment 3) were placed out on only the first two of these occasions, because they tended to dry out, which cannot be readily explained.

The treated packets and their controls were placed in the export storage yard of the Waipa State Mill and inspected at 3-monthly intervals for one year. For inspection, each packet was broken down and each piece classified according to type and extent of fungal attack. After inspection, packets were re-assembled so that all pieces were in their previous positions. The packets were then rewired and storage continued.

Three categories were used to classify type of fungal attack. They were sapstain, presence of mycelia of decay fungi, and presence of decay. Mould fungi were of no significance and were consequently not recorded. The extent of fungal attack was judged by using the following arbitrary visual scale:

0	=	No attack	=	0%	surface area infected
1	=	Slight attack	=	1- 10%	surface area infected
2	=	Light attack	=	11- 25%	surface area infected
3	=	Medium attack	=	26- 50%	surface area infected
4	=	Heavy attack	=	51- 75%	surface area infected
5	=	Very heavy attack	=	76-100%	surface area infected

For the estimation of sapstain the recorded figures refer to sapwood, and not to the total surface area of each piece. All pieces with sapwood contained considerable heartwood; many pieces comprised heartwood entirely.

RESULTS AND DISCUSSION

The development of sapstain in dip treated and untreated packets of Douglas fir throughout the various storage periods is shown in Table 1. Two figures (each based on the mean values of two packets) are shown for each treatment at each inspection.

TABLE 1—Development of sapstain in dip treated and untreated Douglas fir sawn timber.

Month stack erected	Treat-ment	3 MONTHS		6 MONTHS		9 MONTHS		12 MONTHS	
		% badly stained	Total % stained	% badly stained	Total % stained	% badly stained	Total % stained	% badly stained	Total % stained
9/70	1	0.0	1.5	3.2	20.8	5.1	13.8	8.2	29.7
	2	0.0	0.0	3.5	30.5	5.5	20.7	6.1	17.4
	3	3.5	7.5	4.1	11.4	2.9	7.4	6.5	21.6
	4	24.0	49.0	33.8	73.9	37.1	55.6	27.7	37.1
12/70	1	2.1	39.3	11.2	20.6	14.7	23.5	7.4	19.0
	2	0.0	18.9	6.8	24.1	10.3	20.9	2.0	5.1
	3	0.0	20.2	5.5	21.1	8.0	16.0	2.2	21.0
	4	34.0	69.5	34.5	44.3	34.7	51.4	27.0	31.5
3/71	1	0.0	18.6	1.9	13.7	1.7	21.5	4.5	36.2
	2	0.0	11.9	1.9	17.3	1.9	13.6	4.5	28.4
	3	-	-	-	-	-	-	-	-
	4	14.6	34.2	29.7	45.1	23.9	42.9	28.6	50.4
6/71	1	1.9	47.9	6.0	23.2	16.4	46.5	3.4	20.4
	2	2.5	10.1	7.2	30.1	17.6	51.7	14.0	35.2
	3	-	-	-	-	-	-	-	-
	4	12.0	59.7	47.1	75.8	58.1	84.6	66.0	78.4

The first records the mean percentage of pieces "badly" stained (medium to very heavy sapstain attack) and the second records the mean number of pieces containing any stain, whether it be the result of slight or very heavy attack. It was established by observation during the 3-monthly inspections that only pieces "badly" stained need be taken into account when considering visual degrade of the timber.

Table 1 shows that infection of dipped timber by sapstain fungi was much reduced when compared with the infection of undipped control packets (Treatment 4). The rate of sapstain development was much slower and a minority of infected pieces was assigned to the "badly" stained category. In contrast, many (often the majority) of the infected pieces in the control packets were heavily stained. This was particularly noticeable after 9 months or more of storage.

Often a lower incidence of sapstain was recorded after 9 or 12 months storage than during previous examinations. This was a general trend observed for packets in all treatments placed out on each of the four occasions during this study. Although moisture content determinations were not carried out it was obvious that with prolonged storage the timber tended to dry out. Sapstain is most noticeable in wet timber. Also, the slight darkening of dipped timber and the higher incidence of decay fungi on undipped timber would have obscured some sapstain.

In Fig. 2 the mean percentage of pieces "badly" stained in a packet has been plotted against time of storage, regardless of the time of year in which packets were originally placed out for storage. No distinction has been made between the various dip treatments (Treatments 1-3 inclusive). Consequently, mean values for dip treatments are based on 20 packets and mean values for the controls are based on eight packets. The range in the incidence of "badly" stained pieces in both dipped and undipped packets stored for the same periods of time is also shown. In only one case (after 9 months of storage) was a dipped packet more heavily stained than an undipped one, and then only by a small margin. Mean values indicate that even after 12 months of storage dipped material is less stained than undipped timber stored for 3 months. However, dip treatment was

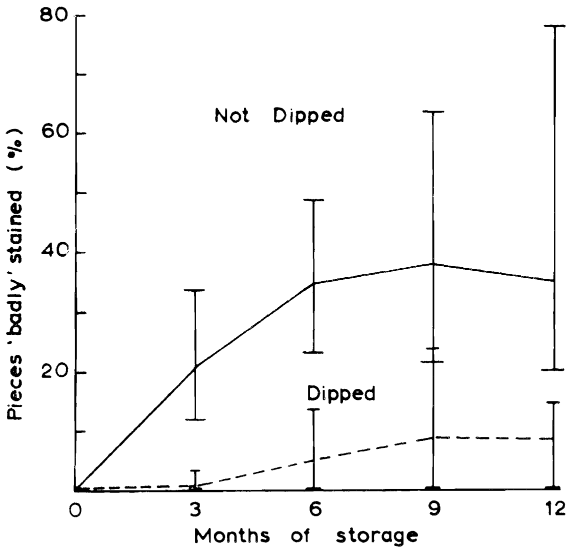

FIG. 2—Occurrence of disfiguring sapstain in dipped and undipped packets of Douglas fir sawn timber over 12 months storage. Mean values and range of data shown for each storage period.

effective in controlling sapstain for only the first 3 to 6 months of storage, after which about 10% of pieces was sufficiently stained to downgrade appearance.

The high incidence of basidiomycetous fungi and associated decay in untreated packets of green Douglas fir is the most serious fungal degrade of this material (Fig. 1). It renders the timber unsightly and ultimately causes loss in mechanical strength. The development of this degrade on dipped and undipped Douglas fir during the experimental period is shown in Table 2. Both the mean percentage of pieces in a packet with surface mycelial growths of decay fungi and the mean percentage with detectable decay are recorded. Each figure is the mean of two packets and is based on the number of pieces in a packet with infection, regardless of the severity of attack. Dip treatment kept infection by decay fungi at a very low level throughout the various storage periods. At no time was more than 10% of the surface area of any dipped piece of timber covered by mycelia of decay fungi (i.e., level of infection never exceeded that of slight attack). In contrast, at least one third of infected pieces in control packets had more than 25% of their surfaces covered by mycelia of decay fungi. After 9 or 12 months storage a majority of infected pieces were in this or a higher category. Whereas decay was detected on only two occasions in dipped packets, it was recorded on all but one occasion for the untreated controls.

In Fig. 3 the mean percentage of pieces infected with mycelia of decay fungi has been plotted against storage time for both untreated and dipped packets. No distinction has been made between the various dip treatments. In addition, the mean percentage of pieces with decay in untreated packets has been plotted against storage time. The very high level of protection against attack by decay fungi afforded by dip treatment

TABLE 2—Development of surface mycelial growth of basidiomycetous fungi and associated decay.

Month stack erected	Treat-ment	3 MONTHS % with mycelium	3 MONTHS % with decay	6 MONTHS % with mycelium	6 MONTHS % with decay	9 MONTHS % with mycelium	9 MONTHS % with decay	12 MONTHS % with mycelium	12 MONTHS % with decay
9/70	1	0.0	0.0	0.5	0.5	3.7	0.0	0.0	0.0
	2	0.0	0.0	3.2	0 0	3.2	0.0	3.9	0.0
	3	1.5	0.0	1.4	0.0	0.5	0.0	0.0	0.0
	4	11.0	4.0	25.3	23.5	41.6	28.0	42.5	34.9
12/70	1	1.0	0.0	0.0	0.0	2.1	0.0	0.9	2.3
	2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	1.0	0.0	0.0	0.0	2.9	0.0
	4	17.0	16.0	40.7	27.5	53.8	32.0	42.5	30.0
3/71	1	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	-	-	-	-	-	-	-	-
	4	5.1	3.4	23.6	14.2	56.9	27.5	29.3	18.6
6/71	1	0.0	0.0	0. 0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.0
	3	-	-	-	-	-	-	-	-
	4	0.0	0.0	22.9	7.6	19.1	10.3	69.0	41.6

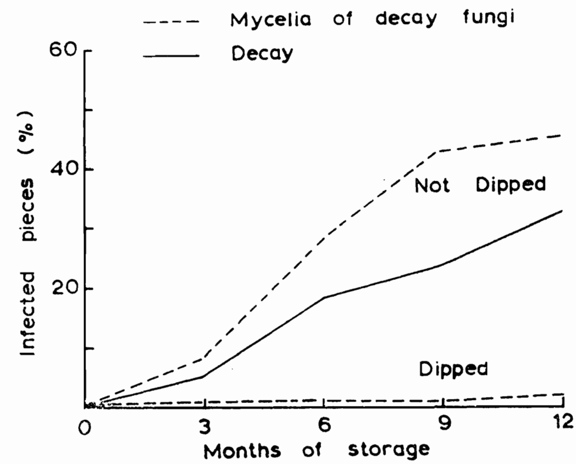

FIG. 3—Occurrence of mycelia of decay fungi in dipped and undipped packets of Douglas fir sawn timber over 12 months storage. Occurrence of decay is also shown for undipped packets.

is clearly shown. Fig. 4 shows part of the mid-section of an untreated packet and Fig 5 part of the mid-section of a dipped packet after 9 months of storage.

GENERAL DISCUSSION

This work confirms the earlier findings of Eades (1956), Roff and Cserjesi (1965) and Cserjesi and Roff (1966) that sodium pentachlorophenate + borax is an effective prophylactic for the control of stain and decay in Douglas fir. It was shown conclusively that this dip treatment will protect sawn timber of Douglas fir for at least 12 months, whereas McQuire and Hutchinson (1958) showed that a dip in 0.5% NaPCP + 1.5%

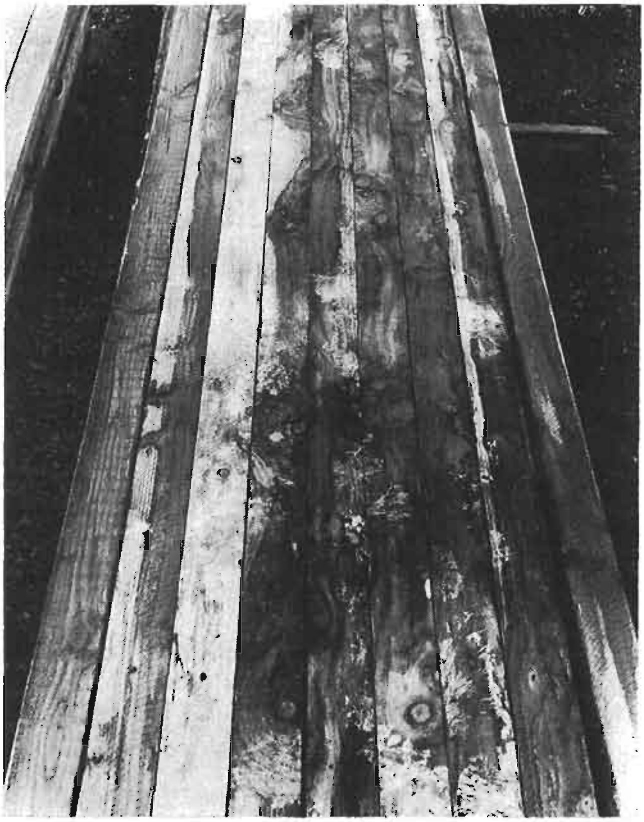

FIG. 4—Mid-section of an untreated packet of green Douglas fir sawn timber after 9 months of storage.

borax will protect radiata pine in block-stack only for shorter periods (e.g., 3 months). Radiata pine is regarded as more susceptible than Douglas fir to fungal attack.

The similar protection given to timber by dipping as a packet wired for export compared with dipping it as individual pieces is noteworthy. It means that timber may be re-dipped with ease, either to prolong the storage period or to give additional protection during export.

To ensure effective prophylactic treatment it is essential that there be minimum delays between felling, sawing and dip treatment. It is also essential that the recommended solution strength of the prophylactic be achieved and maintained. Cummins (1971) examined the stability of sodium pentachlorophenate solutions in various buffer systems. His findings showed that sodium pentachlorophenate-borax pentahydrate solutions (pH 9.05) are of acceptable stability, but that problems could arise when mixing solutions because of the low solubility of the borax pentahydrate (1.6% at 10°C). He also showed that to maintain sodium pentachlorophenate in solution at recommended concentrations the pH must not be lower than 9.0. Alternative buffer systems to borax pentahydrate were 0.75% sodium carbonate plus 0.75% sodium bicarbonate (pH 9.64) and 0.75% sodium carbonate plus 0.75% "Timbor" (pH 9.25). Both of the alternative buffer systems were easier to prepare and were of improved stability.

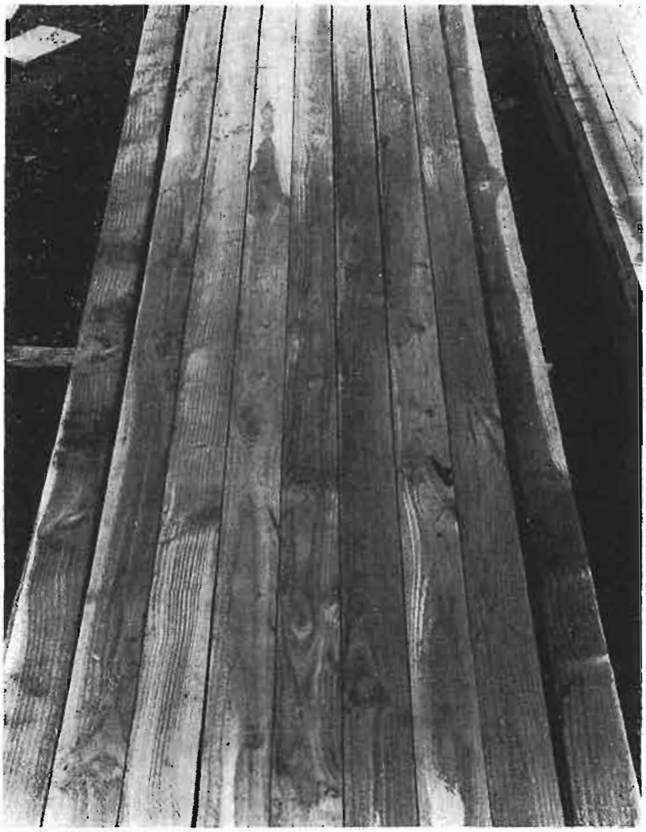

FIG. 5—Mid-section of a dipped packet of green Douglas fir *sawn timber after 9 months of storage.*

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