spring growth cycles. Therefore adverse weather conditions during these cycles may prevent the normal seasonal development of injurious mite populations. Acaricide applications sufficiently effective to protect the new growth may also prevent the development of injurious populations until the next growth cycle.

Mature (yellow) navel orange fruit is more favorable for development of citrus red mite populations than the immature (green) navel fruit. As a result, mite populations frequently increase during the winter as well as the spring and fall. Therefore, in contrast to Valencia oranges and grapefruit it is more frequently necessary to apply mite control treatments to navel oranges during the winter months. Chemical control measures at this time are often ineffective because it is more difficult to obtain spray coverage or adequate spray deposits of the acaricides on the mature fruit. Because mites are less active during the cooler weather, they are also less likely to contact toxic acaricide residues.

In obtaining green lemon fruit for use in laboratory rearing, it was found that fruit taken from the interior districts during the summer was less favorable for mite egg production than similar fruit from coastal orchards. This occurs especially during and following periods of hot, dry, windy weather. Field data indicate that not only the fruit, but also the fully developed younger leaves, were less susceptible to rapid increase in mite populations after such weather conditions have occurred. It appears, therefore, that these weather extremes not only adversely affect mite populations directly but alter the host favorability.

The citrus bud mite *Aceria sheldoni* is primarily a pest on lemons in California. These mites are occasionally found in abundance on oranges, however; the orange bud is small and therefore does not give adequate protection during the adverse hot dry weather conditions that occur occasionally in the coastal districts.

The citrus flat mite is a pest of oranges and tangerines in the San Joaquin, Coachella, and Imperial valleys of California and in Arizona. Only occasionally does severe injury occur in the San Joaquin Valley whereas serious injury to untreated oranges and tangerines usually occurs in the Coachella and Imperial valleys. Warmer weather early in the spring favors population increase when the fruit is young and readily injured by the mites whereas injurious infestations in the San Joaquin Valley are not reached until late summer when less subject to injury.

Sulfur and the dinitrocyclohexyl phenol acaricides are known to be more effective when applied under warm rather than cool weather conditions. Neotran applications resulted in relatively ineffective control when hot weather conditions occurred during and for a few days after the application. Neotran residues are short lived under these hot weather conditions and therefore are not of sufficient persistency to be toxic to the mites which hatch from eggs present at time of treatment. Aramite has notably resulted in poor mite control when applied during rainy or damp weather conditions. Either high humidities or heavy morning dews result in loss of residual toxicity. Ovex and Tedion were influenced very little by weather extremes including rains. Kelthane applications in winter result in effectively reducing mite populations on the leaves but are frequently ineffective on the fruit. Bioassay and chemical studies on residue persistence indicate that the Kelthane is readily absorbed into the oil of the citrus peel and is therefore not available to the mites.

As previously indicated, the adult and nymphal stages of citrus red mite populations are reduced by hot dry winds leaving the remaining population largely in the egg stage. Acaricidal application properly timed following these adverse weather conditions results in more effective control of this mite than is normally obtained. When such extreme conditions occur over an extended period or consecutive periods of such unfavorable weather occur, mite populations may be reduced to below economic levels for a period of several months.

The citrus bud mite remains confined under bud bracts except during its migration to new buds. Major migration periods occur under ideal weather conditions about the time new growth reaches full size. At such times residual-type acaricides applied as mist sprays result in effective control. At other times the spray must wet the buds to contact the mites in order to obtain adequate control. This requires full-coverage-type application.

This is a report of experiments and observations of acaricides used for control of citrus mites. The discussions of materials used and timing of application are not to be considered University recommended practices. For recommendations on mite control problems in citrus areas, growers should contact their local farm advisor.

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TANOAK

AND SHRINKAGE

H. RESCH • B. A. ECKLUND

ABOUT TWO BILLION board feet of tanoak (*Lithocarpus densiflorus*) saw timber is available in California. The wood of California's tanoak exhibits outstanding strength properties and pleasant appearance. However, its commercial use depends on the proper approach to seasoning. The general interest of the State's lumber industry as well as specific production problems in the manufacture of heavy industrial flooring made desirable these investigations of shrinkage and drying methods for green or partially air-seasoned 5/4-inch lumber—as well as investigating the merits of predrying as a means of accelerating the evaporation of free water from wood.

Previous studies have indicated that air seasoning of tanoak lumber to below 20% moisture content, followed by kiln drying, will give optimum results. However, observations made on the drying rate of lumber kept in air seasoning yards located in the coastal areas of California made it apparent that air seasoning during fall, winter, and early spring progressed too slowly to secure continuous production without keeping an extremely large lumber inventory. It was doubtful whether the moisture content of the stock could come even close to the fiber saturation point within an eight month period.

In the Central Valley, on the other hand, air seasoning during the summer months resulted in severe down grading from checking, splitting, and collapse. Dark colored wood, appearing in the lumber as areas of discoloration and irregular shape, was found to check and collapse much more readily than bright colored wood. Many of these defects occurred after a relatively short time of a few days to a few weeks. After taking all these observations into consideration

DRYING PROGRAM CHARACTERISTICS

• D. R. PRESTEMON

Low temperature predrying appears to be a promising method of evaporating free moisture from tanoak lumber. The most important drying defects, surface checking and collapse, have been reduced below the level encountered in kiln drying by low temperature drying. Tanoak showed considerable variation in drying characteristics particularly between bright colored and dark colored lumber. Separate drying of these two categories should improve drying time and grade recovery. The early period of drying is the most critical and it is necessary to keep the relative humidity high and temperature low. As soon as stresses in the boards become reversed, the drying rate can be increased by stepping down the humidity.

In addition to the normal shrinkage of cell walls, a study of shrinkage characteristics showed the occurrence of collapse also determined the dimensional changes of tanoak specimens dried to various moisture content levels. The change in dimensions became apparent when the wood was still above the fiber saturation point. A distinct difference in the shrinkage of bright colored sapwood and dark colored heartwood occurs. Shrinkage values measured on boards in these tests must not be considered standard information because method of sawing, amount of heartwood present, method of drying, and other variables affect the shrinkage of tanoak lumber. However, these tests offer a good indication of dimensional changes to be expected from such drying of gang sawn or slash sawn boards.

it appeared necessary to develop a drying program that would shorten the drying time without undue damage to the lumber and increased shrinkage. Because shrinkage is so important in meeting product specification a corollary study was made of this factor.

Drying study

Preliminary investigations on the drying behavior of 5/4-inch gang sawn lumber were made by drying four sets of green boards in a small experimental kiln. Each set of ten boards was dried at a different temperature level to provide a better understanding of the type of defects occurring during drying and to assist in finding the best initial drying conditions. The starting temperatures ranged from 76°F to 105°F with 3°F to 5°F wet bulb depressions. Results of this test indicated that collapse became the most severe drying defect at the high temperature level despite a relatively slow drying rate. The kiln run having the lowest humidity level produced the largest amount of checking and honeycombing of boards.

Best results were obtained when the temperature was held at or slightly below 76°F during the early stages of drying and the humidity was kept high until the closure of fine surface checks indicated stress reversal between the shell and the core of boards. The drying rate was held at a sufficiently rapid rate by lowering the relative humidity in a series of steps after this critical point was passed. The occurrence of drying defects was highly variable between boards. Defects were associated with dark colored heartwood, knots, tension wood, pith enclosure, and diagonal grain. Dark colored heartwood not only exhibited more checking but also tended to collapse more frequently than brighter colored wood. Knots and tension wood were usually associated with cracks and collapse.

The different forms of warp appeared to be caused largely by the method of sawing. Any board including the pith showed cupping of various degrees. Crook and twist prevailed where diagonal grain was pronounced. Warp was generally less severe in boards restrained by the weight of others on top of them.

The drying rate was found satisfactory at the low temperature level. Enough moisture was evaporated from the green lumber in the first phase of drying using a closed kiln ventilation system, so that the relative humidity was raised to about 86% within a few hours—without the use of steam or water spray.

TABLE 1. TENTATIVE SCHEDULE FOR PREDRYING FOLLOWED BY KILN DRYING

Hours	Temperature Dry bulb °F.	Temperature Wet bulb °F	Equilibrium moisture content %	Average moisture content %
0	74	71	18.5	78.4
49	"	"	"	65.7
73	74	69	15.2	60.6
145	"	"	"	52.0
169	73	67	13.9	50.0
217	"	"	"	44.8
313	72	65	12.6	37.4
337	100	90	11.8	36.1
361	"	"	"	33.1
385	100	85	9.2	31.0
409	"	"	"	28.6
433	105	85	7.6	26.9
481	110	85	6.3	21.7
505	120	90	5.4	19.9
529	"	"	"	17.7
553	130	90	3.8	15.7
577	140	100	4.1	13.5
649	150	143	13.7	8.9
672	"	"	"	10.6

Based on the experience gained in the preliminary test series a tentative schedule was used to dry a package of twenty 8 × 5/4 inch × 9 foot long boards in the laboratory kiln. During the first portion of the kiln run, the heating coils and steam spray were not used and the humidity was adjusted only by closing and opening ventilators. During the second half of the drying time, heat and moisture were supplied to the kiln. The air velocity through the sample was adjusted to 390 feet per minute. Although the temperature remained below 74°F during the first 14 days, the average moisture content of the load was reduced from 78% to 36% (table 1). Under the same conditions, it was thought that the drying rate of lumber would be somewhat slower in a large commercial predryer because of the size factor. The changes in kiln conditions were made according to the average moisture content of bright colored boards and resulted in some checking and collapse in dark brown colored wood. The darker type of wood also exhibited a much slower drying rate than bright wood. Results were not promising in an additional drying test investigating pretreatment of lumber with a commercial salt solution to reduce checking and permit a faster drying rate.

The next step was a kiln run on a charge of 5300 board feet of 5/4-inch lumber. It had been air seasoned for 4½ months in a yard on the California coast, but the average moisture content had dropped from about 90% to only 65%. Some of the material showed evidence of drying defects, particularly surface and end checks. The objective was to kiln dry the material in the shortest possible time while maintaining sufficient quality of the lumber so that strips, as components of "Doweloc" units (a patented product used mainly as heavy industrial flooring), could be sawn from the dried boards.

The charge was constructed of four units, 4 feet wide, with two piles side by side and ¾-inch spacers placed 2 feet apart. The air flow through the charge averaged 390 feet per minute and was reversed at three hour intervals. The schedule in table 2 was designed to provide a rapid drying rate, allowing the occurrence of some defects in dark brown wood which could be eliminated in the manufacturing process following drying. The bright wood dried readily and excessive shrinkage and checks were found only in areas around knots.

TABLE 2. LOW TEMPERATURE DRYING FOLLOWED BY KILN DRYING OF SLIGHTLY AIR SEASONED 5/4-INCH TANOAK LUMBER

Days	Temperature Dry bulb °F.	Temperature Wet bulb °F	Equilibrium moisture content %	Average moisture content %
0	56	55		65.2
1	73	69	16.7	63.1
2	76	68	12.0	61.6
3	76	63	8.8	55.1
4	75	61	8.2	50.6
5	"	"	"	47.2
6	"	"	"	44.5
7	"	"	"	42.1
8	80	66	8.6	40.1
9	"	"	"	
10	85	69	8.1	
11	"	"	"	33.0
12	85	65	6.3	32.1
13	90	68	6.1	29.5
14	95	70	5.3	27.6
15	100	70	4.2	25.6
16	110	80	4.8	23.4
17	"	"	"	19.6
18	120	95	6.6	18.1
19	140	114		15.7
20	150	125	6.9	13.8
21	160	140	7.9	12.6
22	"	"	"	
23	"	"	"	
24	160	153	13.4	10.5
25				11.3

Frequent repetitions of this schedule for full scale kiln charges of 100,000 board feet gave satisfactory results as far as the production of strips for "Doweloc" units was concerned. The method of short air seasoning followed by kiln drying, first with low temperatures (predrying), followed by more severe conditions was then adopted for commercial use by a "Doweloc" manufacturer.

Shrinkage determination

Shrinkage specimens studied were taken from light and dark colored (heartwood) areas of discs cut from green logs. Two sets of small, clear specimens were prepared. One set of 5 discs for preliminary investigations was carefully finished according to ASTM specifications to 1 × 1 × 4 inches for testing longitudinal, radial, and tangential shrinkage. Samples in the other set included 50 discs from individual green logs containing a certain amount of dark heartwood. From each disc, two specimens were taken from bright colored wood and two from dark portions. All were finished to ⅛ × 1 × 1 inch samples and tangential and radial shrinkage was measured. Samples in both sets were dried in three stages in conditioning rooms and in a drying oven to reach an equilibrium moisture content of 12%, then 6%, and finally the oven dry condition.

Specimens in the second set were steamed at 212°F for one-half hour at which time the average moisture content had reached 15%. This treatment was designed to recondition collapsed cells. In addition to the shrinkage measurements on small, clear specimens in the true radial and tangential plane, the change in thickness and width of 40 gang-sawn boards was recorded in one predetermined location on each board. The lumber was dried from green condition to an average moisture content of 10.2% under predrying schedules, followed by kiln drying (table 1). Specific gravity determinations were made on wood adjacent to the shrinkage samples in the second set.

Graph 1 shows the relationship of shrinkage to moisture content from the green to the oven-dry condition for all samples in the first set. The moisture content shrinkage curves are graphed for radial and tangential directions only. The total longitudinal shrinkage remained, in any case, below 0.3%. The moisture content shrinkage curves in graph 2 were from measurements on specimens in the second set. The specific gravity of the adjacent wood was, on an average, 0.57 for bright sapwood and 0.58 for dark colored heartwood. The average shrinkage in thickness of the forty 5/4-inch gang-sawn boards was 11.1%, with a maximum of 21.5% and minimum shrinkage of 4.5%. The average shrinkage in width was 8.8% with a maximum of 13.1% and a minimum of 4.6%.

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MOISTURE CONTENT—SHRINKAGE RELATION