WEEVIL - INDUCED RESIN CRYSTALLIZATION RELATED TO RESIN ACIDS IN EASTERN WHITE PINE

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ABSTRACT

The major resin acid in the cortex of eastern white pine (*Pinus strobus*) was strobic acid. Two horticultural cultivars of this species were found to produce no strobic acid. In the weevil larva-resin crystallization test, all resins containing strobic acid were readily crystallized while those containing no strobic acid were not crystallized, The implications of non-crystallization of cortical resins for potential weevil resistance are discussed in relation to selection and breeding of weevil-resistant trees.

The white-pine weevil (*Pissodes strobi* Peck.) is the greatest deterrent to commercial culture of eastern white pine (*Pinus strobus* L.) throughout most of the tree's natural range. Chemical sprays may be used to control the insect but, from both the ecological and economic viewpoints, the development of weevil-resistant trees offers the best long-term solution to the problem.

Over the years, many studies have attempted to relate weevil damage to geographic seed source and various morphological, physiological, and chemical characteristics of white pine. Up to the present time, however, none of these approaches has proved eminently successful. The ultimate goals of using various criteria to select parents, establish seed orchards, and produce weevil-resistant progenies have not been achieved.

The present study may be considered as a progress report on attempts to utilize chemical characteristics of white-pine resins as criteria for selecting weevil-resistant trees, A brief summary of past work is essential to put this study in proper context.

Santamour (1965) reported that the cortical oleoresins of eastern white pine (and some other species and hybrids) could be crystallized by contact with crushed heads of weevil larvae. Resins which exhibited natural crystallization were more likely to be rapidly crystallized in the weevil-larva test. Variation in both natural and insect-induced resin crystallization was demonstrated and, in some cases, the lack of crystallization appeared to be associated with weevil resistance. A further study (van Buijtenen and Santamour, 1972) indicated that selection for "0" test crystallization could result in a tree population in which roughly 85% of the trees would not be damaged by the white-pine weevil.

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Limited chemical analyses of P. strobus oleoresin components showed no significant differences in monoterpene composition between wood resin and cortical resin (Santamour, 1965), but marked differences in resin acids (Santamour, 1967). The latter paper pointed out that (1) resin crystallization was not wholly dependent on total resin acid concentration and (2) that a major resin acid of the cortical resin was an "unknown" at that time.

In 1970, we were drawn together by our mutual interest in the "unknown" resin acid. Using resin supplied by the present senior author, Zinkel and Spalding (1971) described the "unknown" as strobic acid, a new resin acid with a seven-membered ring. The complete structure of this new acid was reported by Zinkel and Spalding (1973).

This fruitful cooperation prompted a renewal of interest in determining the inter-relationships of resin acids, resin crystallization, and weevil resistance.

PROCEDURES

A survey of 25 older, cone-bearing trees of P. strobus at the U. S. National Arboretum was made in 1971. Only two trees, both of which were horticultural cultivars, were found to produce cortical oleoresin that did not crystallize during undisturbed storage following collection. Chemical analyses of the resins of these two trees showed that no strobic acid was present. These data were in marked contrast to the rapidly-crystallizing resins[2] of two other trees that contained an average of 32.2 percent strobic acid.[3]

Because the two "non-crystallizing" trees had abnormal growth habits (one weeping and one fastigiate), a further survey was made, in 1973, of 20 younger normal trees that had just reached sexual maturity. Of the second sample, the resins of two trees exhibited no natural crystallization, four showed a minor amount of crystallization, and the resins from 14 trees crystallized rapidly and completely. The cortex resins from these young trees were found to contain from 15.9 to 35.3 percent strobic acid. Thus, the presence or absence of strobic acid could not be judged by the degree of natural crystallization.

[2] The crystalline portion contains only a somewhat increased proportion of strobic acid.

[3] The cortex oleoresins were separated into neutral and acidic (resin acid) fractions by the DEAE - Sephadex procedure of Zinkel and Rowe (1964). The acidic fractions were then methylated with diazomethane and the resulting methyl esters analyzed by gas-liquid chromatography on DEGS and SE-30/EFiP Columns (Nestler and Zinkel (1967).

In 1974, weeviling leaders of naturally-infested P. *strobus* were collected in Massachusetts to provide larvae for crystallization tests. Cortical resin was collected from P. *strobus* 'Pendular' and P, *strobus* 'Fastigiate'(the two trees that contained no strobic acid) and several other P. *strobus* whose resins ranged from "0" to complete *natural* crystallization. All resins were subjected to the standard test using crushed heads of weevil larvae taken from infested leaders (Santamour, 1965). Only the resins from the two cultivars failed to cyrstallize in this test,

Chemical analyses of the resin acid components of the two "non-crystallizers" and two "crystallizers" from the Arboretum are presented in Table 1.

Table 1.--Resin acids of selected trees of *Pinus strobus*.

	Non-crystallizing		Crystallizing	
	'Pendula'	'Fastigiata'	No. 3	No. 7
Total % resin acids	51.5	51.1	57.5	48.3
Individual resin acids (as % of total)[a]				
sandaracopimaric	1.8	1.8	6.6	8.0
levopimaric/palustric	19.7	11.0	9.3	9.3
isopimaric	11.3	18.3	17.5	13.1
communic	10.3	7.0	6.1	10.8
strobic	--	--	30.4	33.9
abietic	21.4	29.2	8.2	8.5
neoabietic	34.5	32.1	21.9	19.4

[a] Identified as the methyl esters of the acids.

[4] A word of caution: although these cultivar names indicate clonal selections, all trees in nurseries or arboreta bearing the same name may not be identical, since various selections have probably been made and named at various times.

CONCLUSIONS AND DISCUSSION

It would appear that the lack of resin crystallization in the presence of crushed heads of weevil larvae is correlated with the absence of strobic acid in the resin. The correlation between lack of weevil-induced resin crystallization and non-weeviling has already been established (van Buijtenen and Santamour, 1972), Thus, the way is open for some meaningful selection studies in plantations or natural stands within the range of eastern white pine and the white-pine weevil.

There may be some question as to whether some "normal" trees of *P. strobus* may be similar to the above-mentioned cultivars in the non-production of strobic acid, Certainly, the absence of strobic acid is not correlated with any *particular* growth form, and it is our belief that trees of normal growth habit that do not produce strobic acid may be discovered.

However, in order to mass-produce weevil-resistant seedlings by means of seed orchards of selected trees, some data on the heritability of non-crystallization (or non-production of strobic acid) are necessary. A limited number of crosses to determine these inheritance patterns have already been made and the seedlings are being grown at the National Arboretum, When the seedlings are old enough (2-3 years), their resins will be tested for crystallization and analyzed for strobic acid, Hopefully, the seedlings can then be outplanted in areas of high weevil density to further test the validity of the observations and assumptions discussed above.

Foresters should not have to wait for these results, however, to begin preliminary screening of seed orchard candidates by the application of the simple weevil-crystallization test.

Insect resistance in most plants is seldom complete and is dependent on known and unknown factors of the environment and the biology of both pest and host. With extremely high insect populations and an abundance of susceptible host plants, perhaps no trees would be free from attack. Still, any possible leads should be thoroughly explored so that, at some time in the future, "natural" control may replace chemical control.

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