SOME MINOR STAINS OF SOUTHERN PINE AND HARDWOOD LUMBER AND LOGS

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INTRODUCTION

In the course of experimental work on the control of sapwood stain and mold in southern pine and hardwood lumber and logs, various stains other than those of the ordinary blue-stain type were encountered frequently. Most of these ranged in color from bright yellow to deep red or purple, and under certain conditions were of sufficient intensity and prevalence to assume practical importance. In addition, certain common green surface molds were found to be capable of penetrating into pine lumber and producing a more or less shallow discoloration. Fresh pine sapwood stored under moist conditions was especially susceptible to stains and molds of this type. Such hardwoods as red gum, yellow poplar, and sweet bay were generally free from them; but cultural tests in the laboratory showed a few of the organisms involved to be capable of staining sap gum, at least to a slight degree.

These stains appeared to be associated with and possibly stimulated by certain chemical solutions with which the lumber and logs had been treated for the purpose of preventing blue stain. Thus, the yellow and red discolorations were common on wood that had been immersed in formaldehyde, silicofluoride solutions, benzoic acid and its salts, arsenious oxide, or boric acid; a blue-green mold was prevalent on lumber treated with ethyl mercury compounds; while several green superficial molds were commonly associated with the use of sodium bisulphite, sodium silicate, ammonium fluoride, formaldehyde, and arsenious oxide. Although such relationships between treatments and organisms seemed to exist, they were not specific, as each of the stains was later produced on fresh untreated pine sapwood under proper conditions of moisture.

Stains of a similar nature have been described by Hedgcock in his study of chromogenic fungi that discolor wood. He found that certain Penicillia, principally Penicillium aureum Cda. and P. roseum Lk., commonly produce colors varying from yellow to crimson in the sapwood of pine and several hardwoods. In the case of P. aureum, the color was due to the secretion of a soluble pigment on the surface of the fungus filament. This pigment varied with the acidity or

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2 For their kindness in identifying the organisms discussed herein, thanks are due Dr. C. D. Sherbakoff, of the Department of Botany, University of Tennessee, and Dr. Charles Thom, Principal Mycologist in Charge, Division of Soil Microbiology, Bureau of Chemistry and Soils, U. S. Department of Agriculture.
3 The southern pine lumber referred to in this paper was derived from the following species: Longleaf pine (Pinus palustris Miller), shortleaf pine (P. echinata Miller), and loblolly pine (P. taeda L.).
4 The lumber known in the trade as red gum is derived from the sweetgum tree, Liquidambar styraciflua L.
5 The lumber known in the trade as yellow poplar is derived from the tuliptree, Liriodendron tulipifera L.
6 Magnolia virginiana australis Sargent.
alkalinity of the culture media, being red when alkaline and yellow when acid, and was taken up by the cell walls of the wood. A third fungus, *Fusarium roseum* Lk., was identified as causing pink, red, and violet blotches upon fresh sapwood of *Pinus resinosa* Sol., *P. strobus* L., and several of the southern pine species. Coloration resulted from the secretion of a soluble pigment that was taken up by adjacent wood cells, staining them lightly red or purple, depending upon the acidity or alkalinity of the wood. Both Gerry and Hedgcock found that certain molds which usually occurred superficially on lumber were capable of shallow penetration and often produced mild interior discoloration.

In so far as could be determined, the fungi associated with the stains herein described, with the exception of one of the surface molds, are distinct from the species mentioned previously. It is probable that a considerable number of fungi are capable of producing less common stains of this nature under favorable conditions, although their distribution may be more or less limited regionally.

**EXPERIMENTAL METHODS**

A large number of isolations were made in both the field and the laboratory by gouging slivers from the surface and interior of discolored wood and transferring them to malt-agar slants. Those organisms that were isolated repeatedly and seemed involved in the staining of the wood were selected for the purpose of this study. Duplicate agar cultures of the Fusaria were sent to Doctor Sherbakoff and duplicate agar cultures of the other organisms to Doctor Thom for identification. To determine their staining ability and characteristics, each organism was planted upon culture blocks of pine and red gum sapwood. Previous to inoculation with the several fungi, the culture blocks had been submerged in boiling water for five minutes and transferred immediately to sterile 2-quart fruit jars plugged with cotton. After an incubation period of 50 days, reisolations were made from the resultant stains, and the gross cultural characteristics of the organisms on agar were compared with those of the original cultures. Field observations were correlated with cultural results wherever possible.

**RESULTS**

Under the almost ideal conditions for growth presented in the laboratory, all the organisms covered the blocks of both pine (*Pinus palustris* and *P. taeda*) and gum with a superficial growth within 7 to 10 days. Those capable of staining produced definite discoloration in the interior of the blocks within 30 days after inoculation. For convenience, the stains are grouped into four classes: (1) Purple-pink stains, (2) orange stain, (3) yellow stain, and (4) superficial mold stains. The organisms involved and some of their staining characteristics and effects on wood are summarized in Table 1.

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## Table 1.—Effect of minor staining fungi on wood

<table>
<thead>
<tr>
<th>Stain and fungus</th>
<th>Wood from which fungus was isolated</th>
<th>Type of stain</th>
<th>Distribution of fungus in wood</th>
<th>Factors producing the stain</th>
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| Purple-pink stains:  
*Fusarium moniliiforme* | Sapwood of southern pine; red gum. | In field  
Purple and pink patches on pine; faint purple flecks on red gum.  
Purple patches, less intense on gum. | In culture blocks  
Purple color throughout pine; small purple patches in red gum.  
Similar to that of *F. moniliiforme*, but less intense.  
Similar to that of *F. solani* on pine; less intense on gum. | Confined largely to ray parenchyma and resin ducts of pine.  
Do.  
Ray parenchyma and resin canals.  
Vigorous surface growth; slight penetration into rays and resin ducts. | Colored hyphae and secretion of soluble pigment.  
Do.  
Do.  
Do. |
| *Fusarium solani* | do. | do. | do. | |
| *Fusarium viridell* | Southern pine. | do. | do. | |
| Orange stain:  
Unidentified fungus | do. | Small shallow orange spots. | Shallow orange spots. | |
| Yellow stain:  
Gymnoscelis-like fungus | Southern pine; red gum. | Yellow patches on pine; shallow spots on gum. | Yellow coloration throughout pine; shallow spots on gum. | |
| Superficial stains:  
*Penicillium expansum* | Southern pine. | Bluish-green surface discoloration; often general over piece.  
Green surface discoloration; often associated with blue-stain log infection. | Darkening of wood limited to intermediate region of resin ducts.  
Do. | |
| *Gliocladium* sp. and *Trichoderma* sp. | Southern pine; red gum. | do. | do. | Largely colored hyphae and spores; soluble pigment to some extent.  
Compacting of hyphae and fruiting structures in resin ducts.  
Do. | |
The purple-pink stains caused by several species of Fusarium are of minor economic importance. They occur in small patches and do not involve the entire sapwood area, as the blue stain often does. They appear on lumber and logs in the early stages of drying and are prevalent only when moisture is unusually abundant. Under favorable conditions of moisture interior discoloration may be produced in lumber within 10 to 15 days after it is sawed. No reliable distinction can be made in the field between the several organisms involved, since the color differences exhibited on wood are slight, even in fresh cultures, and tend to fade as the wood dries. Moreover, differentiation is difficult in the laboratory because the several species vary considerably in color, form, and characteristics of growth, depending on the substratum upon which they are grown. Staining is accomplished through the presence of colored hyphae and the secretion of a soluble pigment which is absorbed by adjacent wood cells. Of the three species, Fusarium moniliforme Sheld. was isolated most frequently and produced the most intense discoloration both in the field and in the laboratory. F. solani (Mart.) Sacc. was often associated with purplish discolored areas in stored red gum logs, and is possibly the principal cause of such stains. The third species, provisionally identified as F. viride (L.) Wr., produced a heavy superficial growth of mycelium on culture blocks, but proved less capable of staining the wood than either of the other organisms.

The orange stain is produced in pine lumber and culture blocks by a fungus which could not be identified because of its failure to fruit. On Difco malt agar the mycelium is cream to buff-orange and semi-appressed; it secretes a pigment that gives the agar a color varying from orange to coffee. This stain was found infrequently in the field and rarely assumed dimensions greater than small shallow spots or patches. It is probable that in many instances it was overlooked because of its inconspicuousness.

Under certain conditions, the yellow stain is common on pine lumber and occurs to some extent on red gum also. This stain appears on lumber in the early stages of drying and is prevalent only when there is an exceptional quantity of moisture present. The yellow color, although bright at first, tends to fade as the wood dries. Numerous isolations from such stained areas yielded only one type of organism, which was associated frequently with Gliocladium or Trichoderma mold. This organism produces asci abundantly. These show the characteristic shape of certain species of Aspergillus, but there are no Aspergillus heads on the colony. According to Thom, the general character of the colony is that of Gymnoascus, corresponding closely in form to Penicillium luteum Zuk. and its allies, but having an entirely different form of ascospore. On Difco malt agar, the mycelium and spores are from the first a decided lemon yellow, and in older cultures the agar may be changed to a definite brown. Hedgcock 10 describes Penicillium aureum as creating a lemon-yellow stain in pine wood or in acid media. This organism was not obtained in any of the isolations made in this study.

Superficial mold stains of several different colors occur on moist surfaces of pine lumber and logs and to some extent on gum, within as short a period as 36 to 48 hours after they are sawed. The stains

appear first as white superficial growths and later assume their characteristic colorations on the surface of the wood. In the case of pine, discoloration is limited to a darkening of the wood in the immediate region of the resin ducts where the fungus filaments and spores are compacted. Of these molds, *Penicillium expansum* (Lk.) Thom showed a definite preference for both pine and gum lumber that had been treated with organic mercury salts, such as ethyl mercury phosphate and ethyl mercury chloride. *Gliocladium* sp. and *Trichoderma* sp. were encountered wherever lumber was stored under moist conditions. They seemed especially prevalent on lumber cut from infected logs, where they were usually associated with areas of blue stain. Several dipping treatments for lumber, containing fluoride salts, sodium bisulphite, formaldehyde, or arsenious oxide, seemed to encourage the development of molds of this type. The treatments giving the most satisfactory control were those with sodium carbonate and bicarbonate, sodium dinitrophenolate, sodium orthophenyl phenolate, or lime sulphur. The genus *Gliocladium* is regarded by Hedgcock as one of minor importance in the staining of lumber.

**SUMMARY**

A number of stains other than those of the ordinary blue-stain type were found on lumber and logs stored under exceptionally moist conditions. The staining capacity of the fungi that were isolated repeatedly from such discolored wood was determined by inoculating culture blocks of sap pine and gum. Most of them proved to be superficial molds, but several produced stains, including purple-pink, yellow, and orange, throughout the blocks. Most of these stains belonged to the *Fusarium* and *Penicillium* groups. The more common superficial molds were found to produce either uniform shallow discolorations or discolorations limited to the immediate region of the resin ducts. Among the most common genera represented were *Penicillium*, *Trichoderma*, and *Gliocladium*.

These stain fungi were somewhat similar to the blue-stain type in that the mycelium was concentrated in the resin ducts and parenchyma cells of the wood rays but occurred to a limited extent in the wood and ray tracheids. Coloration was due either to the color of the mycelium alone or to the combined color of the mycelium and a soluble pigment that was absorbed by the adjacent wood cells.

Certain chemical solutions with which the lumber had been treated in order to prevent stain appeared to stimulate the growth of some of these organisms.

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