STUDIES OF VARIATION IN WOOD-DECAY ABILITY AMONG ISOLATES OF *SERPULA LACRIMANS* (WULF EX FRIES) SCHRÖT

A Thesis submitted to the University of Glasgow for the Degree of Doctor of Philosophy in the Faculty of Science

by

ABDULLAH NASSER ABU-HEILAH

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SUMMARY

1. (a) Great variations in wood-decaying ability were observed among the tested strains; some of them were significantly more active than the standard test strain, while others were significantly less active. There is close correlation between measurement of loss in dry weight and measurement of loss in breaking strength.

   (b) The activity of the strains so far collected from the Clyde Valley area is generally lower than that of most of the others. The survey is being continued with a long term objective of looking for patterns in the geographical distribution of differences in wood-decaying ability.

2. (a) No correlation has been found between the differences of wood-decaying ability of a variety of dikaryotic and of monokaryotic cultures and their rate of increase of colony diameter on malt agar at 21°C.

   (b) Monokaryotic cultures, all of which were isolated from basidiospores of a single fruit body showed much less variation in their rate of increase in colony diameter than that found in the dikaryotic cultures.

   (c) The greater number of dikaryons showed a relatively faster growth than that demonstrated by monokaryons.

3. A close and consistent correlation has been found between wood decaying ability and the enzyme activity of 6 strains, as measured by rate of hydrolysis of sodium carboxymethyle cellulose by cell-free medium from liquid cultures. Monokaryotic cultures generally had greater enzyme activity and wood decay ability than the dikaryotic

cultures tested.

4. The fungus has been shown to have a tetrapolar mating system by multiple pairing of two separate populations of monokaryons. The decay ability of the two populations has been found to range within similar limits to those of the dikaryons. The greater number of monokaryons had a higher decay ability than a dikaryotic culture isolated from tissues of the parent sporophore. The decay ability of fifty-seven dikaryons formed from monokaryons of different decay ability is consistently less than that of the most active partner.

5. A long term experiment carried out to examine any differences in wood-decaying ability resulting from storing the cultures on 2% malt agar and on wood pieces at each of three temperatures, has shown that at 20°C wood-decaying ability is significantly greater in cultures which have been held on wood pieces than those held on agar. The effects of storage at 15°C and at 24°C are generally similar, but the differences are not statistically significant.

6. We have confirmed earlier results obtained by Findlay (1932) and other workers that basidiospores germinated within 7-10 days after they were planted on 2% malt agar + 1% phosphoric acid at 21°C. The chances of germination were, however, increased by picking up the spores directly from the hymenium of fresh sporophore by use of sterile needle and spreading them on the surface of 2% malt agar medium which was sprayed by 8% phosphoric acid.

7. The mycelium of colonies of Strain 8 on 2% malt agar was killed by exposure to 40°C for 20 minutes. Slow growing and fast growing

sectors developed on colonies held at 40° for 15 minutes. The permanence of these changes of habit are being investigated.

Other strains reacted differently; some were killed off more quickly and some less quickly than strain 8.

8. In tests using five common building timbers, strains showing differences in decay ability on Scots Pine show similar differences on other common building timbers.

9. Experimental observations with different lengths of hyphal tips inoculae revealed that pieces which are less than 100 μ long do not survive. A fluorescent technique was used to determine the nuclear distribution within each of these apical cells. This has shown that nuclei tended to lie in the centres of the cells.

GENERAL INTRODUCTION

GENERAL INTRODUCTION

Serpula lacrimans (Wulf ex Fries) Schröt* is common and widely distributed throughout Britain and North of Europe, and it has also been reported as a cause of extensive damage to house timber in Russia (Rodigin, 1946; Bondartzev, 1948; and Demikhovs'ka, 1959).

The fungus generally occurs in buildings where the timbers have been allowed to remain in damp conditions. It has been found on external walls of infected houses in Britain, but only when local environment leads to high relative humidity and low temperature range (Hutchinson, personal communication).

There is also a single report of sporophores being formed on the external wall of an infected house in Norway (Danielsen, 1959).

In Britain, the fungus has not been reported in the field (Findlay, 1967), but very rare cases of its occurrence in the field have been reported in some other countries. Bagchee (1955) has reported the occurrence of the fungus on spruce logs in the temperate regions of the inner Himalayan forests, and Guzman (1963) found the fruiting bodies of the fungus together with some other wood-rotting fungi attacking the dead native trees in Mexico.

S. lacrimans, as far as is known, has never been reported in any tropical countries, and it is less common in U.S.A. and Mediterranean climate countries. It seems likely that this can be explained by the higher summer temperatures and perhaps also by more heating in the buildings during winter (Burt, 1917; Richards, 1933; Silverborg, 1953; and Verral, 1954).

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* In view of the extensive nomenclature of the fungus, the synopsis of information prepared by Segmüller and Walchli which appeared in the International Research Group on Wood Preservation, Document IRG/WP/108, 12 October, 1972, was discussed with Dr R. Watling, Mycologist, The Royal Botanic Garden, Edinburgh. We accepted his advice that the name shown above is the correct name of the fungus.

Cartwright and Findlay (1934) were of the opinion that the sensitivity of S. lacrimans towards temperatures higher than 25°C is probably one of the reasons why the fungus is rarely found on felled timber in the field; under normal temperate summer conditions the timber may become heated by the sunlight to beyond this tolerable limit.

Occurrence of the fungus, however, fits the hypothesis that it is closely correlated with the need for abundant water, high relative humidity, and optimal growth at cool temperature range (20-22°C) (Theden, 1941; Cartwright and Findlay, 1934; and Brown et al., 1968).

The economic and social importance of the decay has resulted in research being strongly concentrated towards direct field control measures. There has been little general investigation of either the differences in the degree to which separate strains of the fungus can decay wood in standard conditions or of the characters which lead to any such differences. In this thesis this property will be referred to as "decay potential". It has obvious similarity to that of virulence in pathological interactions.

Decay of wood was studied first primarily by forest pathologists interested mainly in the diseases of growing trees. The association between fungi and decay of wood was not established until the middle of the last century when Robert Hartig (1874, 1878) published the results of his research. His investigations are classic today, for he was the first investigator to diagnose properly the relationship between fungal hyphae and the decay of wood. His work covered such a wide field and was so well done that it has influenced workers in this subject to the present time (Cartwright and Findlay, 1958).

Amongst the early studies on the fungi which cause dry rot in

buildings is that of Falck (1909, 1912) who studied in some detail the various varieties of Serpula lacrimans and other related species. He found that Merulius himantioides Fr. (Syn: M. Silvester), which is sometimes found growing on coniferous trees and closely resembling S. lacrimans, could be readily distinguished from S. lacrimans by its ability to grow at temperatures above 30°C. His results were confirmed later by Cartwright and Findlay (1934), Cooke (1957) and Harmsen et al. (1958). Falck also carried out a number of physiological experiments and studied in some detail the germination of the spores of S. lacrimans.

There are several recent reviews of literature dealing with the variation in wood-decaying ability among various isolates of the same species of the most important wood rotting fungi. These reviews have indicated that considerable variation could exist within each of several species of these fungi.

Schmitz (1924) found differences in wood-decaying ability of different isolates of Fomes pinicola (Schw.) Karst. and concluded that there may be some physiological variation within the species, but he was not certain whether this variation was the result of host influence.

Mounce (1929) worked with the same species and concluded that the difference was the result of variation of the fungus rather than host influence. Owens (1936), Childs (1937), Hilborn (1942) and Aoshima (1954) arrived at a similar conclusion for various species of Fomes and Polyporous. Their conclusions were, however, not supported by any statistical analysis.

Relatively little rigorous work has been reported on the variation in decay abilities among various strains of Serpula lacrimans. Theden and Schulze (1942) showed that different strains of S. lacrimans may differ substantially in the rate at which they were able to decay pine sapwood. Gersonde (1958) found differences in the decay potential of

four strains of this fungus; the range of weight loss of Pinus sapwood in these strains varied from 20-40% over a period of sixteen weeks.

Harmsen (1960) reported that he had found differences between the rates at which a number of different isolates of S. lacrimans and of a related species, could decay wood.

Suvorov (1970) showed that the decay potential caused by S. lacrimans was similar to that caused by Coniophora cerebella on different building timbers, although the growth rate of C. cerebella was considerably faster than that of S. lacrimans on malt agar medium. Similar results have also been obtained by Wazny (1963) and Rennerfelt (1963).

It is, however, important to note that the above mentioned studies include few details of the experimental design used, and no statistical analysis was done to determine the degree of significance of their results. Further, these studies do not include any analysis of the factors contributing to differences in the decay ability. No geographical survey of the distribution of different strains was performed.

Other studies related to the methods of measurement of decay, sexuality, and the relationship between enzyme activity, growth rates, and decay ability of the fungus etc. will be reviewed later on under the appropriate sections.

The present work has, therefore, been carried out on the following lines:

(1) Isolation and measurement of "decay potential" of different strains. The short term objective has been to obtain examples of strains with different degrees of potential for further examination. The longer term objective is to look for any

possible patterns in the geographical distribution of any differences in "potential" which may be found.

(2) Identification of the physiological factors which contribute to any differences which are found. This comprises examination of response and tolerance to obvious physical and chemical factors in the environment, of variability of each strain in standard conditions, and of the relationship between "decay potential" and production of extra-cellular wood attacking metabolites.

(3) Analysis of the genetic factors affecting wood decay ability and of the relationship of this to inheritance in culture and field conditions.

(4) Some other investigations which developed from observations during this programme are also reported.

PART 1

GENERAL METHODS

GENERAL METHODS

This section of the thesis describes the methods used generally in many parts of the work. Those used specifically for particular investigations are described separately in the relevant parts.

(1) Source of Cultures

The sources of the 36 strains examined so far are given in Appendix 1. Most of them have been isolated by the author from infected houses in the Clyde Valley. Some strains from culture collections have been included for reference and comparison.

(2) Techniques used for Isolation of Strains in Culture

All isolates of the fungus made by the author were obtained from three different sources, pieces of sporophores, pieces of infected wood, and basidiospores.

(a) Pieces of sporophores

Pieces of mycelium were cut from fruit bodies under sterile conditions, and incubated in large dishes at 21°C under high relative humidity. A mass of new mycelium normally appeared on the surface within 7 to 10 days of the start of the incubations period; pieces of this mycelium were transferred to agar slants and incubated under the same conditions.

(b) Pieces of infected wood

Mycelium was obtained from wood by scraping infected samples to remove gross surface contamination, immersing the scraped samples for 30 seconds in 0.1% aqueous mercuric chloride solution, washing them several times with sterilized distilled water, and incubating them as above under high

relative humidity. In the course of one week, white mycelium bearing clamp connections grew out and pieces of this mycelium were transferred by normal sterile technique as indicated above.

(c) Basidiospore isolates

Germination and isolation of single basidiospore cultures is discussed in a separate section below.

Throughout this work, cultures obtained from sporophores or infected wood and containing clamp connections are termed "dikaryons". Cultures obtained from single basidiospores are termed "monokaryons".

(3) Culture Media, and Maintenance of Cultures

Unless otherwise stated, all cultures used for this work were grown on 2% malt extract agar. [Oxoid malt extract 20 g, Oxoid Agar 20 g, Deionized water 1000 ml. Autoclaved at 15 lb steam pressure for 20 minutes.] Stock cultures were maintained on this medium in test tube slopes. They were subcultured every three months; sub-cultures were incubated for ten days at 21°C, until vigorous growth was established. They were then stored at 5-10°C in a refrigerator. Inocula for experiments were prepared by subculturing stock cultures into 9 cm glass petri dishes. The dishes were incubated at 21°C for 14 days and the mycelium produced was used as inoculum for the experimental vessels.

(4) Design of method of measurement

(i) Previous work

Various methods of measuring the wood-decaying ability of fungi have been described and discussed by different investigators.

The earliest test to determine loss in mechanical properties due to decay appears to be that of Von Schrenk (1899) who measured the loss in strength of a few pieces of pecky cypress wood (Taxodium distichum) due to "peckiness". His tests were rather crude and the number of tests made was too small to determine whether any relation exists between weight losses and the breaking strength.

A more extensive but also rather crude investigation was reported in 1926 by Longyear, on the breaking strength of a number of woods representing different degrees of durability, after burial of the specimens for varying periods in unsterilized sand or soil in the laboratory. No clue was given as to the type of decay or the fungi that were responsible for it. His results showed that considerable loss in strength occurred before any significant loss in weight became apparent.

In other early studies, workers attempted to correlate the loss in strength with changes in the chemical and/or physical properties as decay proceeds. Cartwright et al. (1931) using the brown rot fungus Poria monticola (syn: Trametes serialis) to decay Sitka spruce, reported a reduction of over 15% in mechanical strength before any weight loss became apparent. They concluded that loss in strength would appear to be due to a chemical action on the cell wall substance rather than to a physical breaking down of the walls by hyphal penetration.

Liese and Stamer (1934) studied the influence of S. lacrimans, Coniophora cerebella, and other related fungi on the compressive strength of Pinus sylvestris sapwood (0.5 x 0.5 x 5 cm). From their table and graphs it is seen that S. lacrimans at all incubation periods from 1 to 6 months, caused roughly four times as much rot as calculated by both the weight and strength criteria, as its forest

relative, Merulius sylvester. Poria vaporaria Fr. and C. cerebella were intermediate in their effects. Percent of strength loss through the first three months was between 3 and 5 times the percent of weight loss. In computations based on Liese's and Stamer's table, differences in loss between duplicates expressed as percentages of the mean loss averaged 1.6 times as great for strength as for weight; this indicated that weight loss, though much less in value, had been definitely the more sensitive measure of decay in this investigation.

Armstrong (1935) investigated the effect of Poria monticola Murr. on the compressive and bending strength of samples of Sitka spruce. He pointed out that the reduction in impact bending strength (toughness) proceeds more rapidly than does the reduction in compressive strength.

Wazny (1958, 1959) carried out crushing and breaking tests on various timbers such as Pine (sap and hardwood), Spruce, Beech and Oak after six months exposure to S. lacrimans and Coniophora cerebella. He showed that impact bending strength decreased most of all, followed by bending strength, crushing strength and hardness.

Pechman and Shaile (1951) studied the influence of several brown rot fungi, including S. lacrimans, and the white rot fungus, Polyporus versicolor, on the impact bending strength of wood. They found that brown rots generally caused a greater reduction in strength of wood than did the white rots. They also concluded that the decrease in impact bending strength caused by both types of organisms was generally much more rapid than the loss in dry weight.

Similar results have also been obtained by Hinningsson (1967) who worked with various brown and white rot fungi.

Kennedy (1958) comparing the effects of brown and white rot fungi on the strength of a number of wood species, found that decay caused

by the brown rot organism, Poria monticola Murr., generally induced higher levels of strength loss than that caused by the white rot fungus Polyporus versicolor. Richards (1954), however, found no consistent difference in the ability of brown and white rotting fungi to reduce toughness at the same weight loss levels.

After considering this information and doing a little preliminary work, it was decided to start on the survey by recording loss of dry weight as one measure of chemical change, and a direct measure of change in a strength property.

(ii) Choice of the property to be measured

This was discussed in detail with the Department of Mechanical Engineering of Glasgow University. After careful reflection and consideration of the apparatus available we decided to measure the ability to cause loss of breaking strength across the grain of standard pieces of sapwood of Pinus sylvestris. The possibility of measuring loss of compression or tension strength was rejected as it was thought that would be more likely to be affected by minor differences in fibre arrangement etc. in the wood samples.

(iii) Choice of testing apparatus

A Hounsfield tensometer (Plate 1) was used as it was available in the Department of Mechanical Engineering. It was found to be convenient in preliminary tests, and a new one was subsequently purchased for use in the mycology laboratory.

(iv) Choice and sorting of wood samples

Pinus sylvestris sapwood was chosen as a common and conveniently

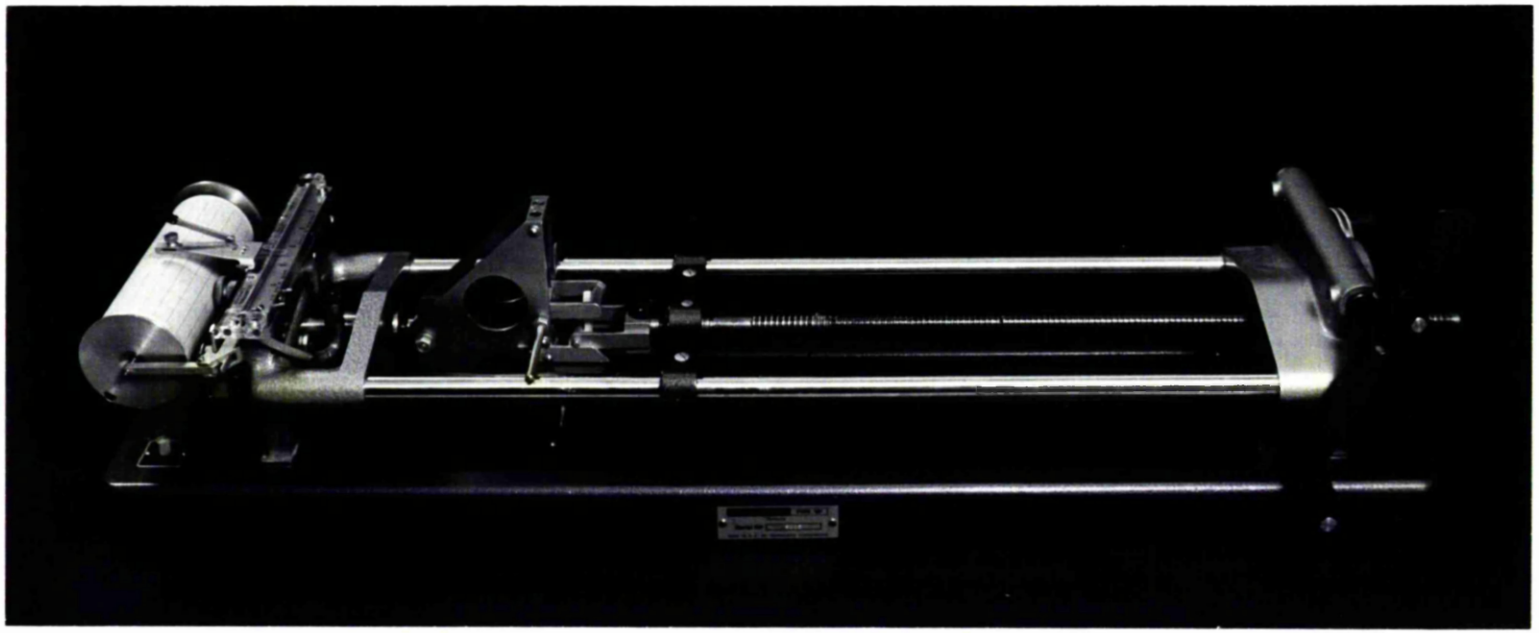


Plate 1. A Hounsfield Tensometer machine used for determining the breaking strength of the test wood samples.

available building timber which would be likely to decay reasonably rapidly. It was appreciated that differences in the structure of the wood in the different samples would probably be responsible for a great part of the experimental errors which were to be expected.

Separate preliminary investigations, reported in Appendices 2 and 3, were set up to determine the degree to which certain possible sorting by grain angle, and control of water content during the strength test, could lead to useful reduction in this error.

(v) Preparation of wood samples

Test pieces 60 mm x 10 mm x 5 mm were cut from a single batch of Pinus sylvestris sapwood kindly given to the Department by Robinson, Dunn & Co. in 1971. It was found that this particular size of test piece was convenient for use in the tensometer, and was a suitable size to permit five replicate pieces to be placed in each experimental bottle. Before cutting, planks were tested chemically with Benzidene to eliminate heartwood (Lominski & Hutchinson, 1949; and Phillips & Savory, 1958). This test requires two reagents, which may be prepared as follows:

(A)	Benzidene	0.5 g
	Conc. HCl	5.0 ml
	Distilled H_2O	100 ml
(B)	Sodium Nitrite ($NaNO_2$)	10 g
	Distilled H_2O	100 ml

Equal volumes of the two reagents are mixed just prior to testing. The mixed solution is brushed on to the end of each plank. After 3-5 min. heartwood stained with a bright red colour, while sapwood stained with yellow or

yellowish-brown colour.

Conversion was arranged so that the annual rings were approximately (± 45°) parallel to the narrow longitudinal axis; more rigorous sorting was not carried out in view of the findings of the preliminary investigation (Appendix 2).

(vi) Preparation of decay bottles

All decay experiments have been done using Roux bottles (one litre) fitted with cotton wool plugs as shown in Plate 2. Approximately 200 ml of 2% malt extract agar medium were poured into each bottle. They were autoclaved at 15 lb pressure for thirty minutes. The bottles were then removed and the medium allowed to solidify in a horizontal position. Each bottle was inoculated aseptically with discs of inoculum (approx. 10 mm in diameter) in six places with one of the isolates used in the test.

All cultures were incubated in the dark at 21°C in a thermostatically controlled chamber for two weeks, or until the mycelium had grown well over the surface of the medium.

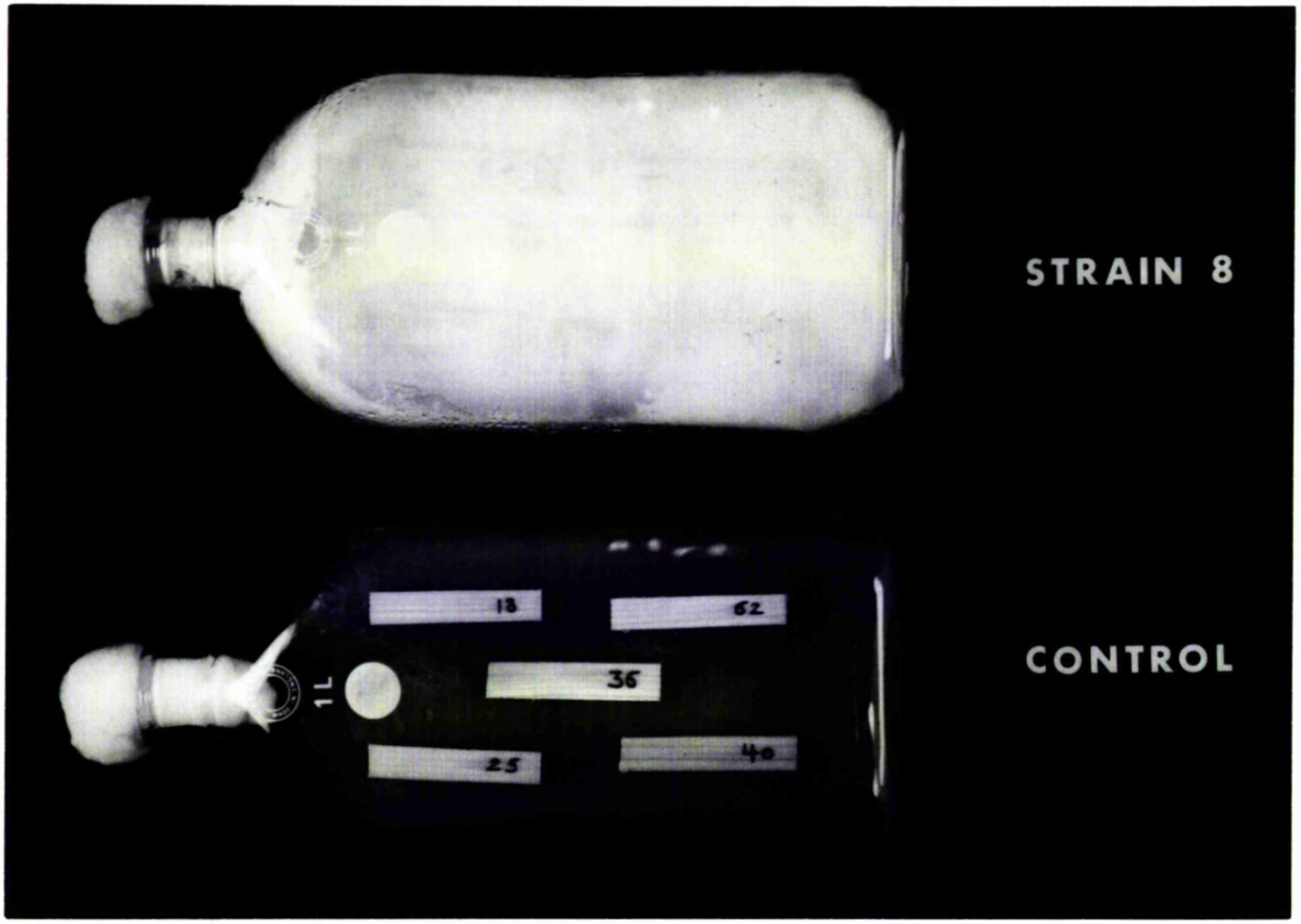
This survey forms part of a longer term survey to be carried out in these laboratories. The various tests are set up in batches as cultures become available. To facilitate comparison of strains examined in different batches a "standard strain" (isolate 5) is included in each batch of tests.

PLATE 2

Roux bottles used as decay chambers.

(A) Standard culture bottle at the end of incubation period.

(B) Control bottle with five standard test pieces of wood placed in standard pattern.


A
STRAIN 8
B
CONTROL
18
62
1L
36
25
40

PART 2

SURVEY OF OCCURRENCE OF DIFFERENCES OF WOOD DECAY ABILITY

VARIATIONS IN WOOD DECAY ABILITY AMONG VARIOUS STRAINS OF THE FUNGUS

Materials and Methods

Appendix 4 describes a preliminary investigation to determine the amount of replication etc. which would be appropriate. From this investigation the following experimental design was adopted. Test pieces of Pinus sylvestris sapwood were taken at random from sorted stock and dried in an oven at 105°C for 48 hours to constant dry weights. They were then placed in desiccators at room temperature before their oven-dry weights were determined. Weights were recorded up to 0.001 gm.

Pieces were then soaked with distilled water for 15 minutes by which time their moisture contents were of the order of 25-40% of their dry weights. This was not recorded more precisely at this stage, as it was appreciated that it would change rapidly while in contact with the agar cultures during the experiment.

All pieces of wood were autoclaved at 15 lb. steam pressure for 30 minutes.

For each experiment five cultures of each test strain were set up on 2% malt extract agar, and five sterile test pieces were placed in standard pattern on the surface of each culture (see Plate 2).

After ten weeks incubation, all pieces were removed from each culture, the surface mycelium was lightly scraped off, and the pieces of wood were brought to constant oven dry weight at 105°C. Their dry weight was recorded, and their breaking strength (Newtons) was measured using a Hounsfield Tensometer. The results were compared with those of control pieces incubated in similar assemblies on uninoculated 2% malt agar.

Results and Discussion

The results of the three batches of tests are given in Appendix 5, Tables 14a, 14b and summarised in text figure 1.

The differences between the effects of the standard test strain 5 in the three batches are slight. For the purposes of this general survey this justifies the direct comparison of the activity of the other strains in the three batches without further calculation.

The results have therefore been consolidated in three sections.

(1) The general range of activity of the isolates

Figures 1 and 2 show that there is a great variation in the activity of the tested strains; 7 strains were significantly more active than the standard test strain ($P = 0.05$) and 4 were less active.

(2) Comparison of informativeness of measurements by loss of dry weight and by loss of breaking strength

Figure 2 shows that there is a close correlation between the two methods of measurements ($r$batch 1 = -0.315; batch 2 = -0.283; batch 3 =-0.396 ($P = 0.05$)).

The overall pattern shows that the measurement by loss of breaking strength is less sensitive than that by loss of dry weight. Figure 2 shows that there is little appreciable difference between the results from Strain 16 to Strain 5 inclusive.

(3) Geographical distribution

The strains are grouped by origins in text figure 3. The number of strains tested is too small to justify extensive analysis. Y_et, the following possible patterns appear, which may be worth further

exploration as more results become available.

(a) The activity of the strains so far collected from the Clyde Valley area is generally lower than that of most of the others.

(b) The cultures obtained from the Netherlands (received from the C.B.S.), were more active than those from the Clyde and they included one of the most active strains (Strain 16).

(c) The strains which are known to have been in culture for more than 10 years are intermediate in their decay ability.

The data concerning the other strains shown in Figure 3 are insufficient to warrant further discussion.

FIGURE 1

Histograms showing effects of different strains of S. lacrimans on wood pieces in three experiments. (Each column in these histograms represents the means of the measurements of five test pieces in each of five culture bottles.)

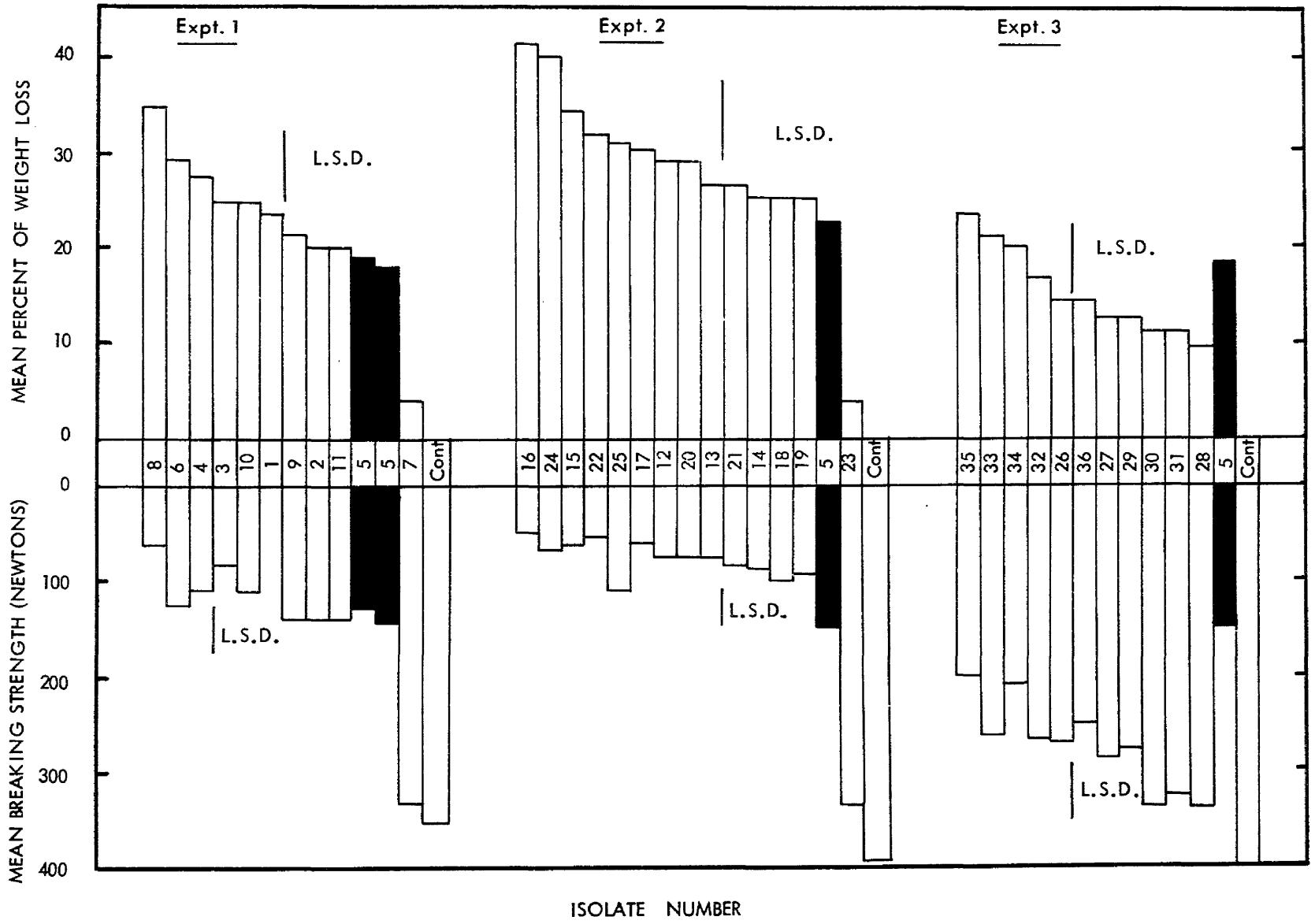

Expt. 1
Expt. 2
Expt. 3
L.S.D.
L.S.D.
L.S.D.
L.S.D.
L.S.D.
L.S.D.
MEAN PERCENT OF WEIGHT LOSS
MEAN BREAKING STRENGTH (NEWTONS)
40
30
20
10
0
0
100
200
300
400
8 6 4 3 10 1 9 2 11 5 5 7 Cont
16 24 15 22 25 17 12 20 13 21 14 18 19 5 23 Cont
35 33 34 32 26 36 27 29 30 31 28 5 Cont
ISOLATE NUMBER

FIGURE 2

Histogram showing the mean percent of weight losses and reduction in breaking strength of test pieces of P. sylvestris sapwood decayed by 36 dikaryotic isolates of S. lacrimans at 10 weeks incubation. (Each column in this figure represents the mean of the measurements of five test pieces in each of five culture bottles.)

(This Figure is a summary of consolidation of results recorded in Appendix Table 14.)

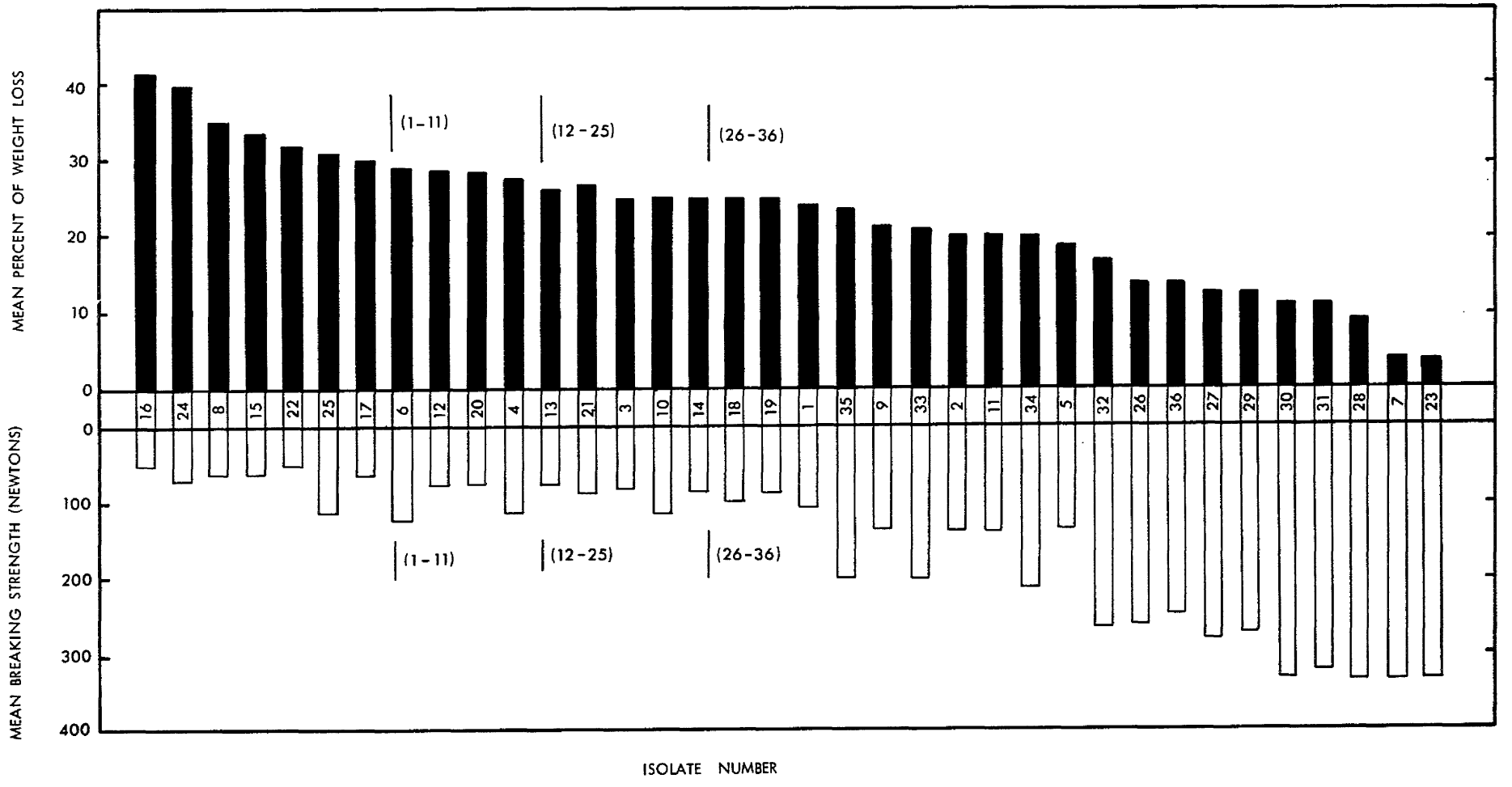

MEAN PERCENT OF WEIGHT LOSS
MEAN BREAKING STRENGTH (NEWTONS)
40
30
20
10
0
0
100
200
300
400
(1-11)
(12-25)
(26-36)
(1-11)
(12-25)
(26-36)
16
24
8
15
22
25
17
6
12
20
4
13
21
3
10
14
18
19
1
35
9
33
2
11
34
5
32
26
36
27
29
30
31
28
7
23
ISOLATE NUMBER

FIGURE 3

Dikaryotic cultures of S. lacrimans arranged in groups according to location from which they were isolated.

Group A = Strains collected from Clyde Valley area in Glasgow.

" B = " obtained " Netherlands.

" C = " " " Sweden.

" D = " " " F.P.R.L. (England).

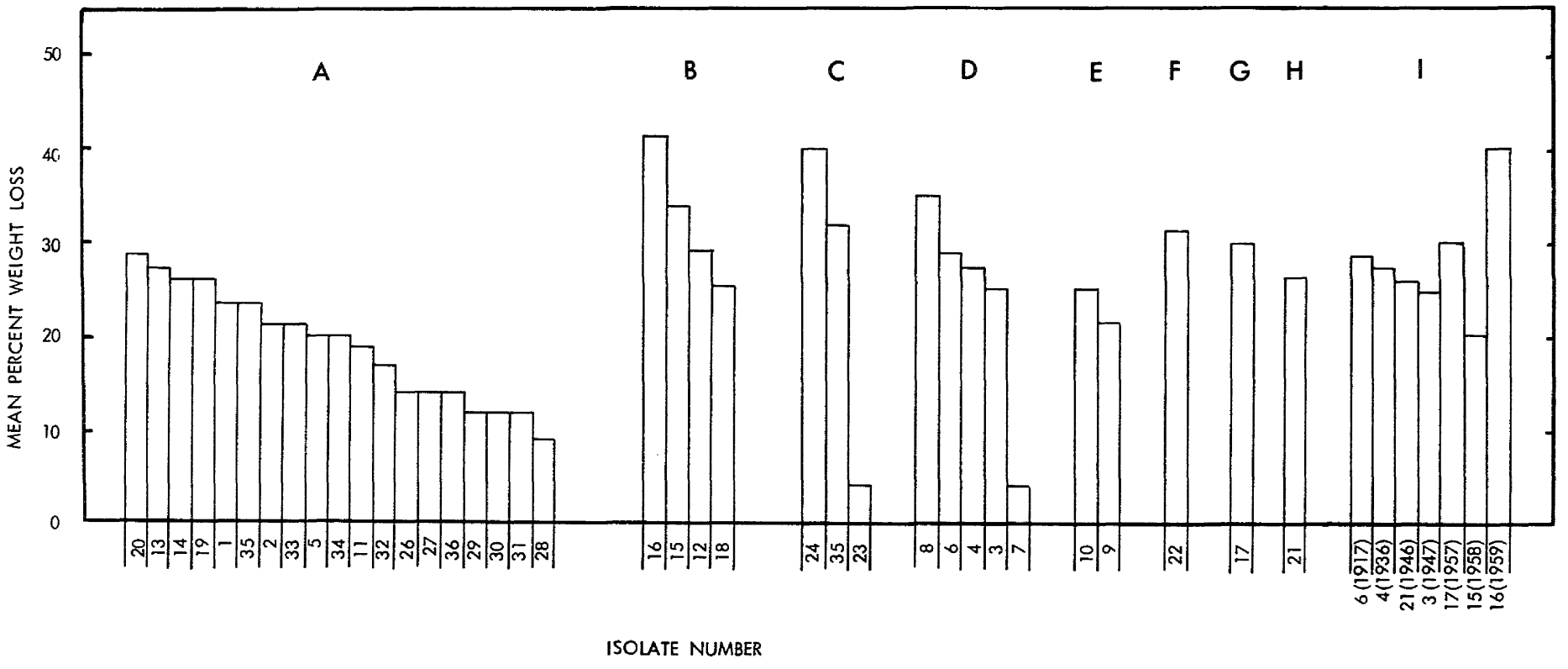
" E = " " " Liverpool.

" F = " " " Cambridge.

" G = " " " Canada.

" H = " " " U.S.A.

" I = Strains from culture collections isolated in the year indicated in the figure.


MEAN PERCENT WEIGHT LOSS
50
40
30
20
10
0
A
B
C
D
E
F
G
H
I
20
13
14
19
1
35
2
33
5
34
11
32
26
27
36
29
30
31
28
16
15
12
18
24
35
23
8
6
4
3
7
10
9
22
17
21
6 (1917)
4 (1936)
21 (1946)
3 (1947)
17 (1957)
15 (1958)
16 (1959)
ISOLATE NUMBER

PART 3

ANALYSIS OF THE FACTORS CONTRIBUTING TO THE DIFFERENCES IN DECAY ABILITY

SECTION 1

EXTRACELLULAR ENZYME ACTIVITY

Introduction and Previous Work

In the early years of the present century two types of wood-decaying fungi were distinguished, brown rots and white rots. Another type of decay caused by microfungi of the classes of Ascomycetes and Fungi Imperfecti is generally termed "soft rot". Decay of this nature usually occurs in timber immersed in sea water (Barghoorn and Linder, 1944) or in contact with soil (Savory, 1954).

The classification of fungi and the type of decay caused has been reviewed by Cartwright and Findlay (1958).

The white rot fungi, e.g. Armillaria mellea and Fomes annosus, are able to attack both cellulose and lignin, whereas the brown rot fungi, e.g. Serpula lacrimans and Coniophora cerebella, attack only cellulose leaving the lignin unattacked. Soft rot fungi are similar to brown rot fungi in that they preferentially attack the cellulose in the cell wall. Wood attacked by soft rot fungi does not undergo a rapid increase in alkaline solubility which is characteristic of brown rot fungi, and in this respect is similar to white rots (Savory and Pinion, 1958; Levy, 1964; Henningsson, 1967).

A classical test to distinguish white rot and brown rot fungi - the Bavendamm reaction (1928) is based on the presence or absence of phenol oxidases. Many authors (Macdonald, 1937; Campbell, 1932; Davidson et al., 1938; Law, 1950 and Nobles, 1958) have shown that the white rot fungi, when cultivated on 2% agar medium containing 0.2% tannic acid, produce a dark coloured ring around the culture, whereas brown rot fungi do not form this coloured ring.

The enzymes of wood-decaying fungi have received relatively little systematic investigation in comparison with those of many

other classes of organisms, although these fungi are principally responsible for attacking living trees and building timbers. Most of the information about the enzymes of these fungi is of a rather general nature. Relatively little is known about their chemistry or their precise mode of activity. Work in connection with their presence in wood-decaying fungi started in 1895 when Bourquelot and Herissey investigated the enzymes present in the juice of young sporophore of Polyporus sulphureus which attacks a number of broad-leaved trees and conifers. They found evidence for the presence of the following enzymes: Emulsin, Cellulase, Maltase and Tanninase, but did not themselves consider this list to be exhaustive.

Later, other workers, such as Kohnstamm (1901) made some attempts to determine the enzymes present in Serpula lacrimans, Armillaria mellea, and Polyporus squamosus at different stages of growth. Kohnstamm's results were inconclusive as the technique of enzyme chemistry was not then fully developed.

In the recent years, the cellulolytic enzymes produced by certain basidiomycetes have been characterised by various workers (Sison et al., 1958; Ahlgren & Eriksson, 1967; and Eriksson & Rzedowski, 1969).

Differences between cellulase activities produced by different strains of wood-decaying fungi have been studied by some other workers. Aschan and Norkrans (1953), working with various isolates of the white rot fungus Collybia velutipes (Curt) Fr., found that synthesized dikaryons gave a higher cellulolytic activity than either of their component monokaryons.

Cowling and Kelman (1963) stated that dikaryotic isolates of Fomes annosus showed relatively higher cellulase activity than the monokaryotic isolates. Bell and Burnett (1966) investigated the cellulase activity of different strains of Polyporus betulinus.

They found that the cellulase activity of these strains is not correlated with their growth rates in the presence or absence of cellulose.

The object of this study was to investigate the cellulase activity of some strains of S. lacrimans and to relate this activity to the decay ability and growth rate produced by these strains.

Materials and Methods

Four dikaryons (8, 4, 2, 7) and three monokaryons (AS9, AS15, AS7) were chosen to study the extracellular enzyme activity. These strains gave a comprehensive range of variety of decay ability.

The strains were grown in a chemically defined liquid medium; this medium was similar to that described by Pattersson et al.(1963), except that 10 g/litre cellulose (Whatman cellulose powder) acted as carbon source. It contained 10 g Whatman powdered cellulose, 2.0 g $NH_4H_2PO_4$, 0.6 g KH_2PO_4, 0.4 g K_2HPO_4, 0.5 g $MgSO_4 7H_2O$, 10 mg $FeCl_3$, 4.4 mg $ZnSO_4 7H_2O$, 5 mg $MnSO_4 4H_2O$, 55 mg $CaCl_2$, 1.0 mg $CoCl_2.6H_2O$, 100 µg thiamine hydrochloride and distilled water to make one litre. The initial pH after autoclaving was 5.2.

Narrow mouth, 250 ml, Erlenmeyer flasks, containing 25 ml of liquid medium were used in these tests. All flasks, with their media, were autoclaved for 20 minutes at 15 lbs, steam pressure. Thiamine hydrochloride was then added to each flask. Each flask was then inoculated with three week old mycelial discs, (10 mm in diameter). Flasks were then incubated at 21°C for 30 days.

Extract of cellulase from cultures:

After the inoculated cultures had been incubated at 21°C for 30 days, the contents of the culture vessels were filtered through a filter paper. The residual cellulose powder and mycelium were washed

with a few mls of distilled water. The washings were added to the original filtrate and the whole made up to 30 ml in standard centrifuge tubes.

The culture filtrate was then centrifuged at 3000 r.p.m. for ten minutes, the supernatant decanted and its enzyme activity measured.

Before filtering, the filter papers had been oven-dried at 80°C until they reached their constant dry weight. After obtaining the mycelial mat on the filter paper, they were dried to constant weight and the dry weight of the mycelium produced by each isolate was calculated.

Enzyme assays:

Gascoigne and Gascoigne (1960) and Eriksson (1969) have reviewed the different methods used for measuring the cellulolytic activity of cellulase preparations. These assay methods have been based on the following procedures:

(a) Increase in reducing sugar value.

(b) Change in turbidity of cellulose suspensions.

(c) Decrease in viscosity of cellulose derivatives.

(d) Loss in weight of insoluble substrates.

(e) Decrease in mechanical properties of fibre and films.

(f) Measurements of clearance zones in cellulose agar.

(g) Colorimetric determination of dissolved decomposed products of cellulose.

In this work the method (a) has been used.

Measurement of increase in reducing sugars:

Cellulase activity was determined by the amount of soluble reducing sugars formed when the enzyme was incubated with carboxymethyl cellulose (CMC).

A 1 ml portion of the enzyme filtrate and 9 ml of a 1% (w/v)

aqueous solution of carboxymethyl cellulose of degree of substitution 0.52 (Gascoigne & Gascoigne, 1960, p. 108) were added to 2 ml of McIlvaine buffer (citric acid - sodium phosphate) solution at pH 5.0; the mixture was incubated in a water bath at 40°C for one hour. After incubation, a 1 ml aliquot of the assay mixture was withdrawn, 1 ml of distilled water added to it and then the solution was added to 1 ml of dinitro-salicylic acid reagent (DNS). The samples were incubated in a boiling water bath for 10 minutes followed by rapid cooling to room temperature.

A zero incubation time controls were made for every sample by adding 1 ml of reagent to 1 ml of substrate before the 1 ml of enzyme solution. The controls were immediately boiled and treated as the test samples.

The reducing sugars present in 1 ml of the enzyme incubation mixture were determined spectrophotometrically by measuring the absorbancy of the final solution at 540 mμ against a control prepared at zero time. This difference in reducing power (expressed as mg/ml glucose) at zero time and at one hour incubation gave a relative estimate of cellulase activity.

A calibration curve determined with an aqueous solution of glucose (0.05 to 1 mg per 1 ml of water) is used to convert the optical density readings into milligrams of glucose.

Results

The results are summarised in text Table 1 and shown in Figure 4.

Cellulase activity and decay ability

Figure 4 shows that monokaryotic cultures with high decay ability had a relatively high enzyme activity whereas cultures with low decay ability had a relatively low enzyme activity.

A similar pattern of differences in cellulase activity was also

observed by the dikaryotic isolates.

Strain 2, which was isolated from sporophore from which the above monokaryons were isolated, showed a lower enzyme activity and a lower decay ability than any of these monokaryons.

On the basis of these results, it was suggested that monokaryotic isolates of S. lacrimans generally had a greater enzyme activity and a higher decay ability than the dikaryotic isolates.

Cellulase activity and growth rate

Growth rate as determined by (a) dry weight of mycelium after 30 days in defined liquid medium, and (b) growth represented by increase in colony diameter (mm) on 2% malt agar in petri dishes was compared with cellulase activity. No direct correlation between growth rate and cellulase activity was found, whether growth rate was measured in liquid culture during cellulase production or on malt agar.

Conclusion

From the foregoing results, it may be concluded that there is a close correlation between enzyme activity of these isolates and their decay abilities. However, cellulase activity and decay ability seemed to be independent of growth rate, both when cellulose is present in the medium or when it is absent.

There is no evidence on which to judge which difference in activity of the culture filtrates is due to differences in the amount of enzyme produced, or to differences in the activity of the enzymes due to culture conditions etc.

Table 1. Relationship between cellulase activity, dry weight of mycelium and wood decaying ability of isolates of S. lacrimans.

No. of isolates	Incubation period (days)	Dry weight** of mycelium (mg)	CX activity* mg/ml/hr.	Decay ability	
				Mean weight loss %	Mean breaking strength (Newtons)
AS9	30	29	0.24	42	50
AS15	=	21	0.20	34	70
AS7	=	28	0.13	17	130
8	=	39	0.12	35	60
4	=	22	0.05	27	105
2	=	36	0.04	20	140
7	=	17	0.03	3	330

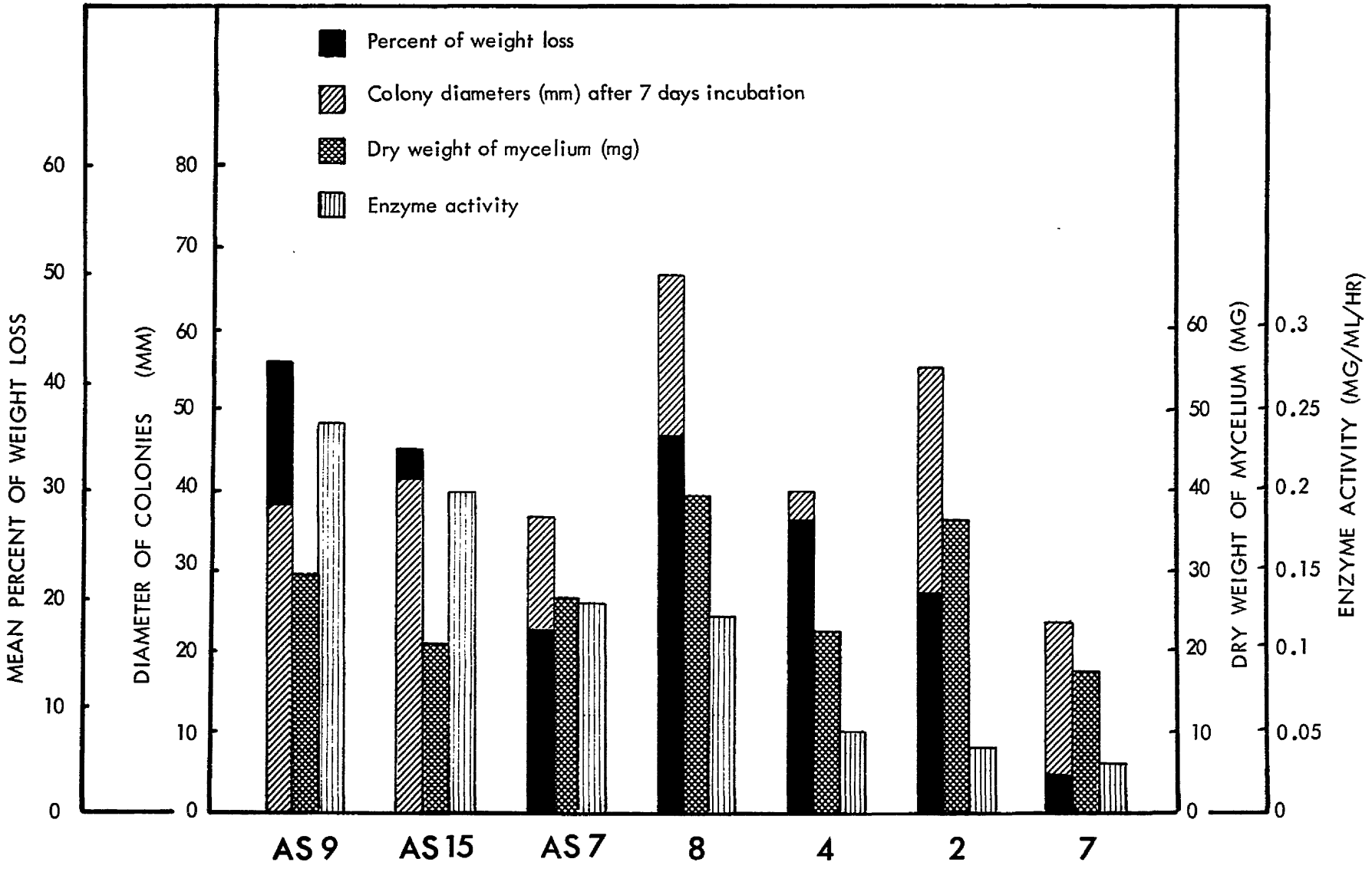
* Results expressed as reducing sugar in terms of glucose in mg/ml of mixture/hour. (Each figure is a mean of readings of ten replicates.)

** Each figure is a mean of measurements of ten replicates.

For illustration see text figure 4.

FIGURE 4

Comparison of wood decay ability with enzyme activity and increase in colony diameters (mm) of four dikaryotic (8, 4, 2, 7) and three monokaryotic (AS9, AS15, AS7) isolates of *S. lacrimans*.


Percent of weight loss
Colony diameters (mm) after 7 days incubation
Dry weight of mycelium (mg)
Enzyme activity
MEAN PERCENT OF WEIGHT LOSS
DIAMETER OF COLONIES (MM)
DRY WEIGHT OF MYCELIUM (MG)
ENZYME ACTIVITY (MG/ML/HR)
0
10
20
30
40
50
60
70
80
0.05
0.1
0.15
0.2
0.25
0.3
AS 9
AS 15
AS 7
8
4
2
7

SECTION 2

GROWTH RATE STUDIES

Introduction and Previous Work

There has been much previous work on saprophytic growth in a variety of cultural conditions. This has shown that the optimum temperature for vegetative growth of various strains of S. lacrimans is generally about 20-22°C. Maximum temperature for growth seemed to be about 26-28°C (Humphrey & Siggers, 1933; Jahn, 1941; Harmsen, 1960 and Langvad & Goksøyer, 1967).

Cartwright and Findlay (1934), in an extensive investigation of the effects of different temperatures on common wood-decaying fungi, found that the difference between maximum and optimum temperature was much smaller in S. lacrimans than in any other species tested. They agreed with Falck's (1909) earlier suggestion that this low temperature range of growth may distinguish S. lacrimans from the other species which they tested.

Davidson and Lombard (1953) have also pointed out that this fungus could be easily distinguished from cultures of other wood-decaying fungi by differences in growth rate and mycelial mat characteristics when grown on 2% malt agar medium.

Harmsen (1960) carried out some cultural and taxonomic studies of several species of the genus Merulius. He pointed out the importance of various cultural criteria (e.g. growth characters and mat colour) for separating closely related species.

It has been demonstrated by several investigators (Mounce, 1929; Herrick, 1939; Hilborn, 1942 and Hwang, 1955) that various strains of the same species of the most important wood-decaying fungi, and some other fungi, may, and often do, vary somewhat in their growth and cultural characteristics.

Variation in growth among both monokaryotic and dikaryotic isolates of these fungi have also been reported by many other investigators, such as Kaufert (1936) who reported that monokaryotic isolates of Pleurotus corticatus fr. grew only about half as fast as dikaryotic isolates. Verral (1936) found that dikaryotic isolates of Fomes igniarius (L.) Gill mostly grew faster than their monokaryotic components. Similar results have also been obtained by Hwang (1955) who worked with various strains of Merulius americanus.

Lindgren (1933) compared the rate of growth on agar at various temperatures of several species with the rate of decay of wood by these fungi at the same temperatures and concluded that in some fungi these might differ, but his data were not statistically analysed.

The only previous comparison of culture growth rates of different strains of S. lacrimans and decay ability seems to be the brief report by Harmsen (1960). He found that dikaryons mostly grew faster than monokaryons on malt agar, but that these growth rate differences were not correlated with differences in decay ability. He unfortunately gives little detail of this work and he does not support his deductions by statistical analysis.

Similar observations have also been found by Amburgey (1967, 1970) who worked with different isolates of Lenzites trabea.

This work, therefore, was carried out in order to determine whether or not growth (represented by the increase in diameter of colonies in mm) on 2% malt agar at the optimum temperature can be correlated with the "decay potential" of each isolate of S. lacrimans.

Materials and Methods

10 discs (10 mm in diameter) were cut from the edge of a 14 day old culture of each strain growing on 2% malt agar. One of these

discs was placed centrally on the surface of 20 ml aliquots of 2% malt agar in each of ten Petri dishes.

All cultures were incubated in the dark for seven days in a constant temperature incubator maintained at 21°C.

Two previously marked arbitrary diameters, at right angles to each other, were measured at the end of incubation period to the nearest millimetre.

The mean increase in diameter of colonies at the end of incubation period was based on the average of the ten measurements taken for each strain.

Results and Conclusion

The results are given in Appendix 5, Tables 15, 20a, and summarised in text Figure 5.

The variances between rates of increase in colony diameter were analysed and they are given in Appendix 5, Tables 15, 16 and 17. Plates 3, 4 and 5 illustrate the growth of some of these isolates on 2% malt agar medium.

Figure 5 shows clearly that the strains varied widely in their rate of growth on malt agar, as well as in their decay potential. There is no consistent relationship between the two; e.g.

Strains 8, 15 and 22 were fast growing with high decay potential.
Strains 31, 28 and 23 were fast growing with low decay potential.
Strains 16, and 24 were slow growing with high decay potential.
Strains 21, 14 and 4 had moderate growth rate and decay potential.

Further confirmation was made by using monokaryotic isolates as shown in text figures 6 and 7. Monokaryotic isolates, collected from

each of two separate sporophores, showed a pattern of differences in growth rates and decay ability* similar to that shown by dikaryotic isolates discussed above. However, the monokaryotic isolates of each of the two sporophores showed generally less variation in the rate of increase in colony diameters than that shown by the dikaryotic isolates.

These results agreed fairly well with those obtained by Harmsen (1960) who worked with various strains of the same fungus, and Amburgey (1970) who worked with different strains of Lenzites trabea.

From the results discussed above, the following conclusions may therefore be stated:

(1) No consistent correlation could be demonstrated between rate of increase in colony diameter on malt agar of a variety of dikaryotic and monokaryotic isolates, and their decay potential.

(2) Monokaryotic cultures, all of which were isolated from basidiospores of a single fruit body, showed much less variation in their rate of increase of colony diameter than the dikaryotic cultures isolated either from sporophores or from decayed wood.

(3) The growth rate of dikaryotic isolates tends to be faster than that of monokaryotic isolates.

---

* Wood-decaying ability of monokaryotic cultures isolated from sporophores A and B is discussed in detail in Part 4.

FIGURE 5

Comparison of wood-decay ability of 36 strains with their rate of increase of colony diameters on malt agar at 21°C. Each column in this figure represents the mean of the measurements of five test pieces in each of five culture bottles, or the mean of seven days measurements of colony diameters in ten replicates taken for each strain.

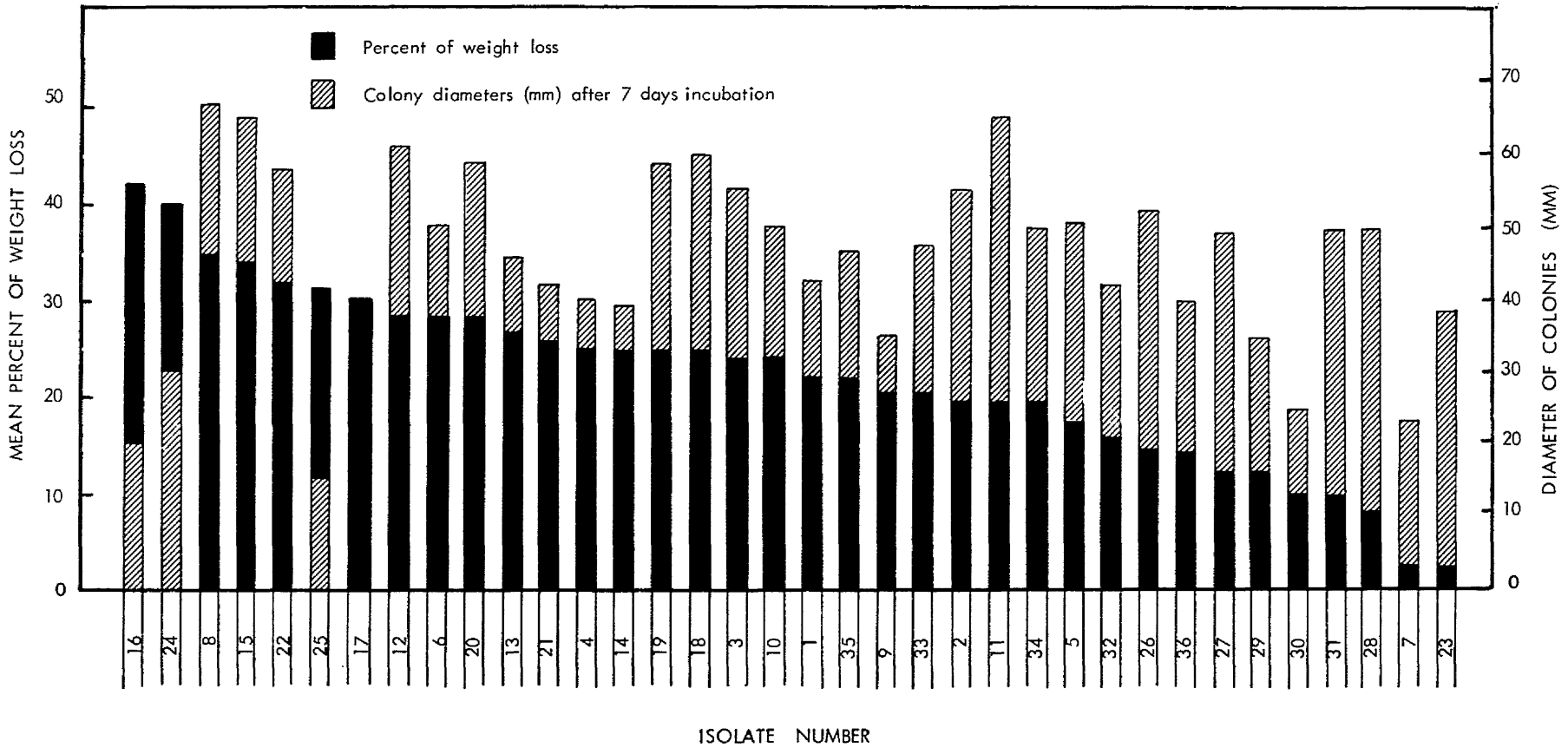

Percent of weight loss
Colony diameters (mm) after 7 days incubation
MEAN PERCENT OF WEIGHT LOSS
DIAMETER OF COLONIES (MM)
0
10
20
30
40
50
60
70
16
24
8
15
22
25
17
12
6
20
13
21
4
14
19
18
3
10
1
35
9
33
2
11
34
5
32
26
36
27
29
30
31
28
7
23
ISOLATE NUMBER

FIGURE 6

Comparison of wood-decay ability of 25 monokaryotic cultures (isolated from sporophore A) with their rate of increase of colony diameter on malt agar at 21°C. Each column in this figure represents the mean of the measurements of five test pieces in each of five culture bottles, or the mean of seven days measurements of colony diameter in ten replicates taken for each isolate.

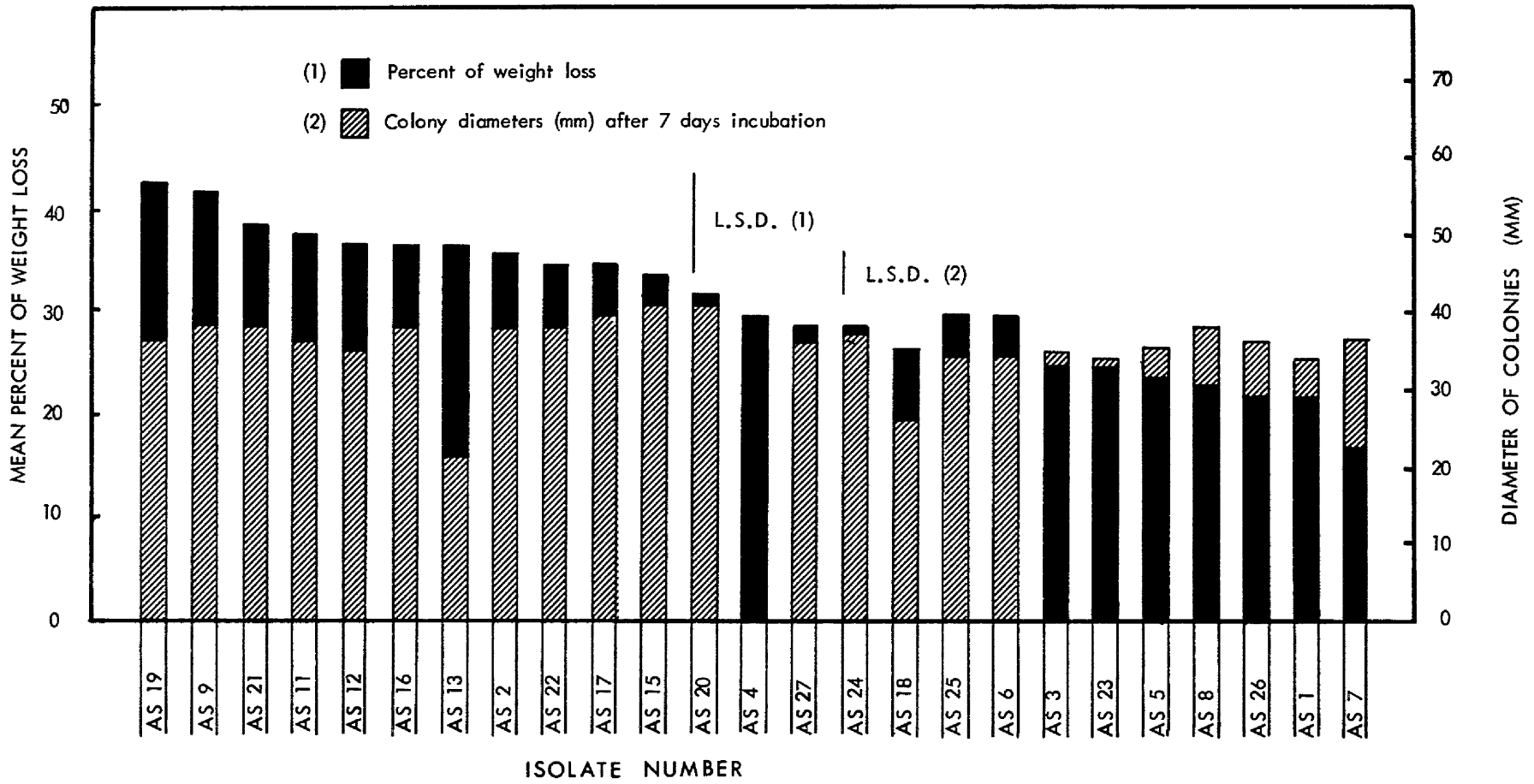

(1) Percent of weight loss
(2) Colony diameters (mm) after 7 days incubation
L.S.D. (1)
L.S.D. (2)
MEAN PERCENT OF WEIGHT LOSS
DIAMETER OF COLONIES (MM)
0
10
20
30
40
50
60
70
AS 19
AS 9
AS 21
AS 11
AS 12
AS 16
AS 13
AS 2
AS 22
AS 17
AS 15
AS 20
AS 4
AS 27
AS 24
AS 18
AS 25
AS 6
AS 3
AS 23
AS 5
AS 8
AS 26
AS 1
AS 7
ISOLATE NUMBER

FIGURE 7

Comparison of wood-decay ability of 42 monokaryotic cultures (isolated from sporophore B) with their rate of increase of colony diameter on malt agar at 21°C. Each column in this figure represents the mean of the measurements of five test pieces in each of five culture bottles, or the mean of seven days measurements of colony diameter in ten replicates taken for each isolate.

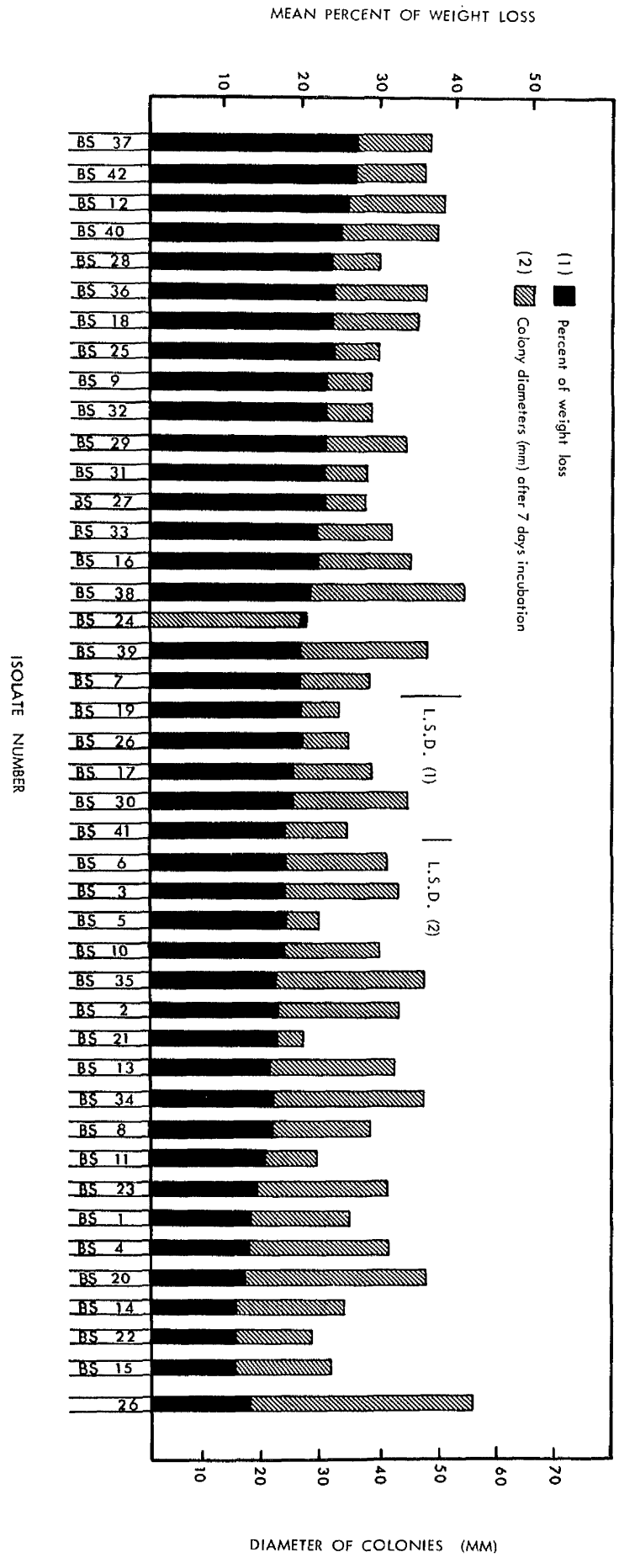

MEAN PERCENT OF WEIGHT LOSS
10
20
30
40
50
(1) Percent of weight loss
(2) Colony diameters (mm) after 7 days incubation
BS 37
BS 42
BS 12
BS 40
BS 28
BS 36
BS 18
BS 25
BS 9
BS 32
BS 29
BS 31
BS 27
BS 33
BS 16
BS 38
BS 24
BS 39
BS 7
BS 19
BS 26
BS 17
BS 30
BS 41
BS 6
BS 3
BS 5
BS 10
BS 35
BS 2
BS 21
BS 13
BS 34
BS 8
BS 11
BS 23
BS 1
BS 4
BS 20
BS 14
BS 22
BS 15
26
L.S.D. (1)
L.S.D. (2)
ISOLATE NUMBER
10
20
30
40
50
60
70
DIAMETER OF COLONIES (MM)

PLATE 3

One week old cultures of different growing isolates of S. lacrimans with different degrees of saprophytic ability.

Strain 8 High in its decay ability with fast growth rate.

Strain 2 Low " " " " " " " "

Strain 16 High " " " " " slow " "

Strain 7 Low " " " " " " " "

Strain 4 Moderate in its decay ability with moderate growth rate.

Strain 21 " " " " " " " " "

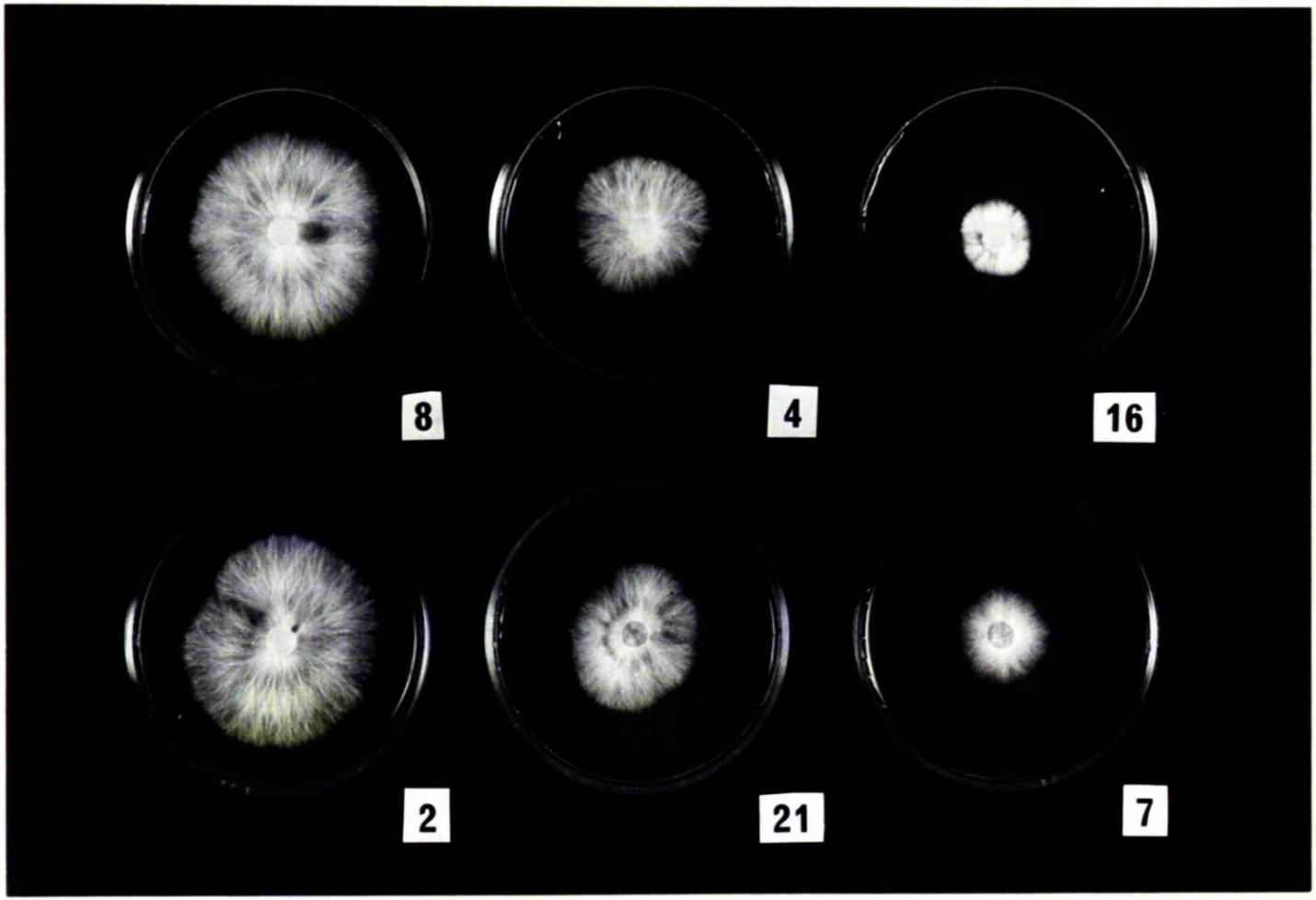

8
4
16
2
21
7

PLATE 4

One week old monosporous cultures (isolated from sporophore A) of S. lacrimans with different degrees of saprophytic ability.

AS9 High in its decay ability with fast growth rate.

AS8 Low " " " " " " " "

AS13 High " " " " " slow " "

AS7 Low " " " " " " " "

AS15 Moderate in its decay ability with moderate growth rate.

AS20 " " " " " " " " "

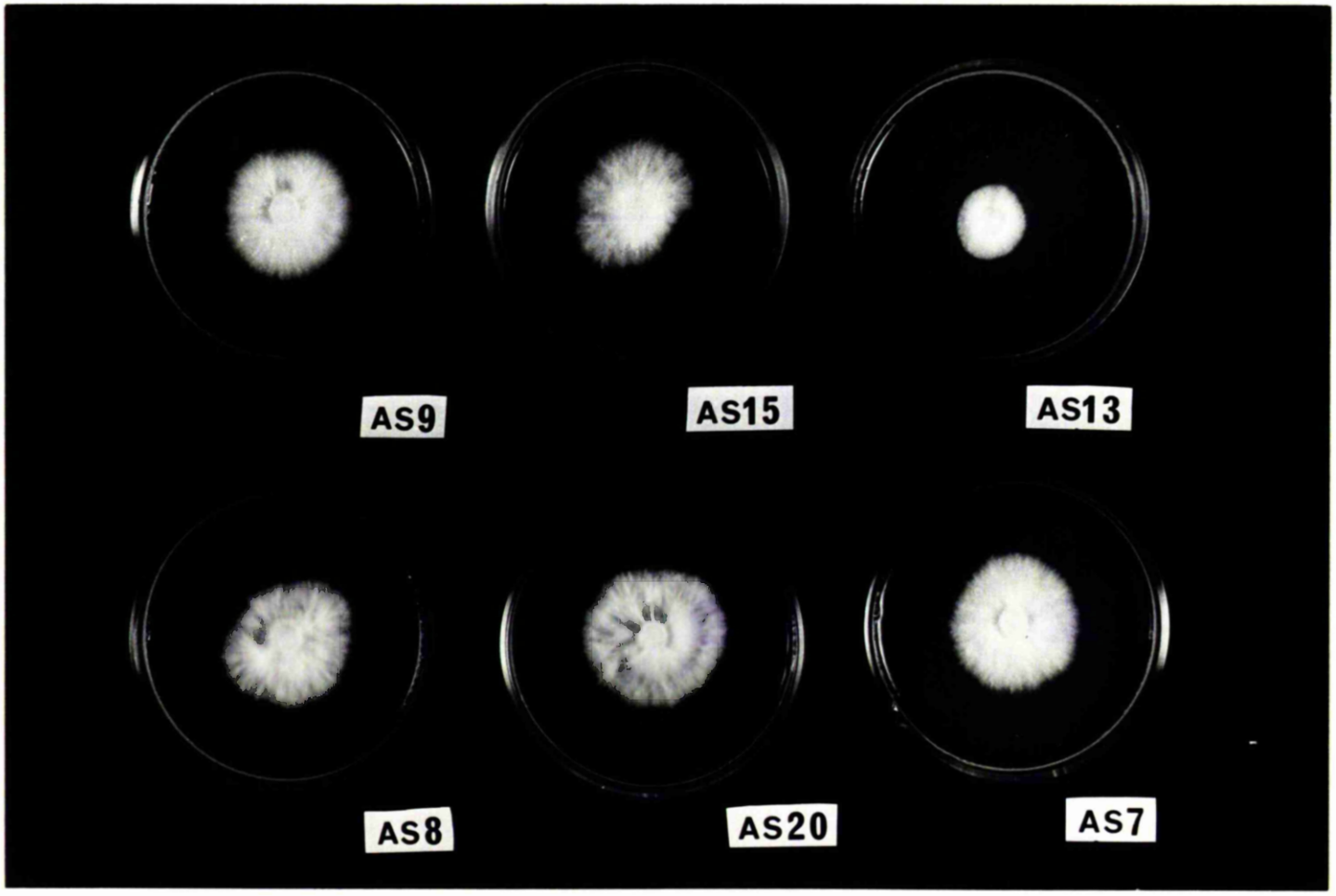

AS9
AS15
AS13
AS8
AS20
AS7

PLATE 5

One week old monosporous cultures (isolated from sporophore B) of *S. lacrimans* with different degrees of saprophytic ability.

BS12 High in its decay ability with fast growth rate.

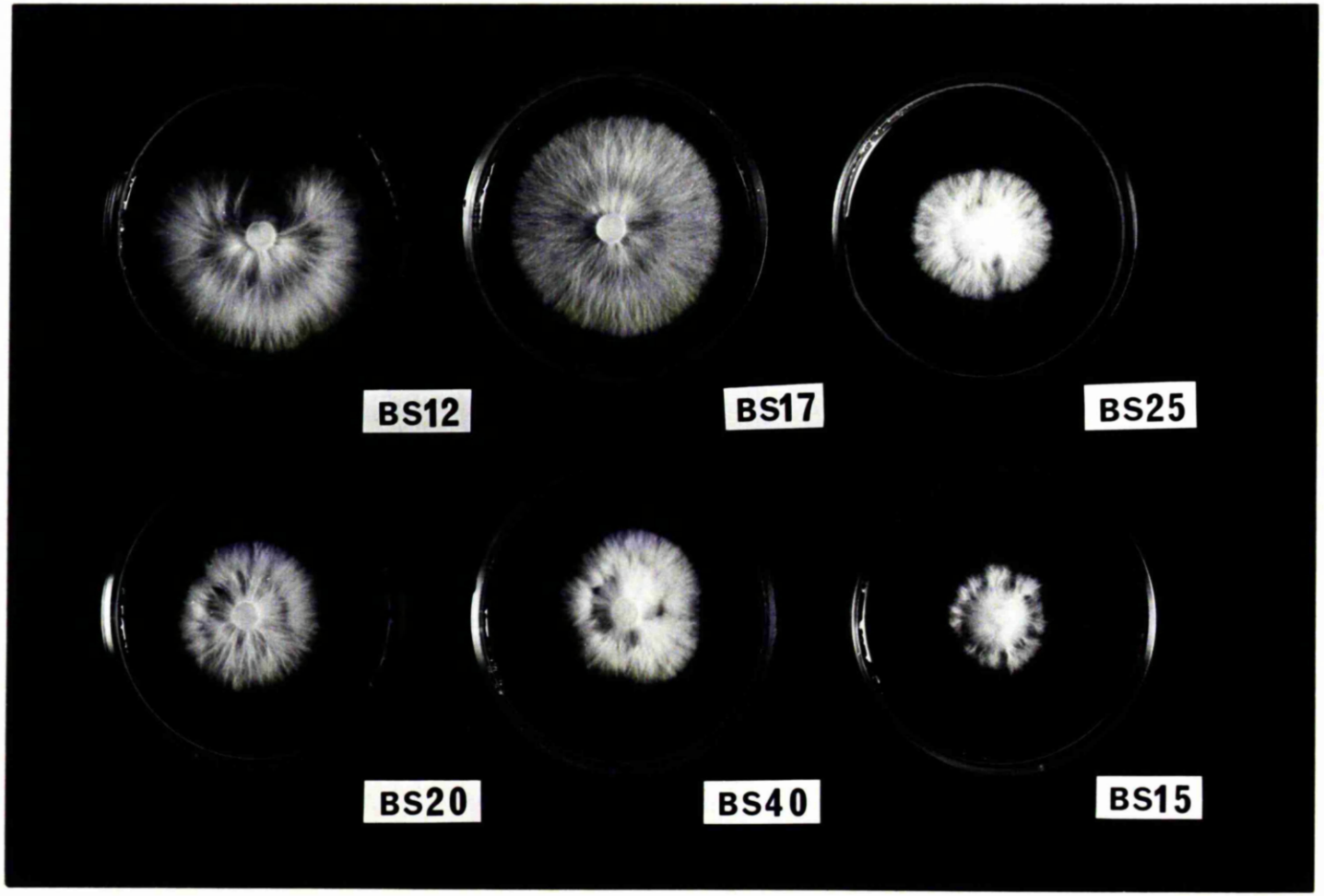
BS17 Low " " " " " " " "

BS25 High " " " " " slow " "

BS15 Low " " " " " " " "

BS20 Moderate in its decay ability with moderate growth rate.

BS40 " " " " " " " " "


BS12
BS17
BS25
BS20
BS40
BS15

PART 4

Genetics and inheritance of factors affecting wood-decay ability

SECTION 1 GENETICS

Introduction

It has been well established by several investigators that there is a variation in the ability to cause decay of wood among various monokaryotic and dikaryotic isolates of some important wood-decaying fungi. Among these, Verral (1936) working with isolates of Fomes igniarus (L.) Gill and Kaufert (1936) working with Pleurotus corticatus Fr. both reported that monokaryotic isolates of these organisms decayed wood less rapidly than either of the dikaryotic cultures from which they were derived or the synthetic dikaryons formed by pairing them.

Da Costa and Kerruish (1965), indicated that monokaryotic cultures of Poria vaillentii (DC ex Fr.) Cke. were generally more destructive than related dikaryons, whereas dikaryotic cultures of Lenzites trabea (Pers.) Fr. tended to be slightly more destructive than related monokaryons.

Aoshima (1954) on the wood-decaying abilities of monokaryotic isolates of Elfvingia applanata (Pers.) Karst., and of the dikaryons formed by pairing them, indicate that more decay was caused by the monokaryons. He tentatively suggested that the results might be due to the denser aerial mycelium formed by the dikaryons on the wood pieces leading to a relatively poorer supply of oxygen within the pieces and hence less decay.

Similar results have also been obtained by Amburgey (1967, 1970) who worked with isolates of Lenzites trabea.

The only previous work on monokaryotic cultures of S. lacrimans which has been traced is the brief report made by Harmsen (1960). He reported that single spore cultures obtained from a single fruit body of S. lacrimans were found to have a somewhat greater decay ability and a somewhat lower growth rate than that in dikaryotic cultures isolated

from tissues of the same fruit body. His work was, however, inconclusive as he gives few details of the experimental design used, and he also gives no estimate of the degree of statistical significance of any differences in his results.

This part of the thesis is, therefore, concerned with examining the variability in wood decaying ability among different monokaryotic cultures derived from single spores from each of two sporophores, and a comparison of their ability with that of the dikaryotic cultures which were isolated from the tissues of the parent sporophores. It also reports on an examination of the mating type system, and of the relationship in decaying ability between compatible monokaryons and their synthesized dikaryons.

(1) Measurement of range of variation in decay ability among monokaryotic isolates.

Materials and Methods

a. Isolation of single spores.

In early work, spore deposits were collected by holding each fresh sporophore, pore surface downwards, above sterile coverslips in a humid container at about 21°C for 24 hours. The whole assembly was sterilised before the sporophore was introduced.

Deposited spores were suspended in sterile 1% phosphoric acid (Findlay 1932) and 5 ml samples of the suspension were then spread on the surface of 2% malt agar medium. About 30% to 50% germination occurred during 7-10 days subsequent incubation.

In later work, spores were removed directly from the hymenium of fresh sporophores by use of a sterile needle. These spores were spread into 2% malt agar on which a few drops of sterile 8% phosphoric acid had been sprayed after autoclaving and cooling. About 50% to 70%

germination was recorded after 7-10 days full incubation.

Pieces of agar each containing single germinating basidiospores were transferred to agar slopes in test tubes and incubated in the standard conditions.

[Note: The better germination in acidic conditions is well known (Falck 1912; Findlay 1932; Girzitska 1933; Czaja and Pommer 1959). The technique by spraying the surface of agar plates permits a change of pH without affecting the setting of the agar. The possibilities that the better germination in these conditions is due to the high local acidity or to the difference in the treatment of the spores, has not been examined.]

b.Measurement of decay

A total of sixty-seven monokaryotic cultures have been obtained from two sporophores which grew in different localities in Clyde Valley.

25 monokaryotic cultures were isolated from sporophore A (from which dikaryotic strain No. 2 was isolated) and 42 monokaryotic cultures were isolated from sporophore B (from which dikaryotic strain No. 26 was isolated).

The method of determining the decay ability of these cultures and the period of incubation of this experiment were the same as described in the preceding experiments.

Results

The results are recorded in Appendix Tables 18 and 19 and summarized in text figures 8 and 9.

Conclusion

The recorded amount of decay caused by the monokaryotic cultures is regularly higher than that caused by the parent dikaryons. The differences were statistically significant ($P = 0.05$) for 15 of the

FIGURE 8

Histograms showing the mean percent of weight losses and reduction in breaking strength of test pieces of P. sylvestris sapwood decayed by 25 monokaryotic cultures (isolated from sporophore A) at 10 weeks incubation. (Each column in this Figure represents the means of the measurements of five test pieces in each of five culture bottles.)

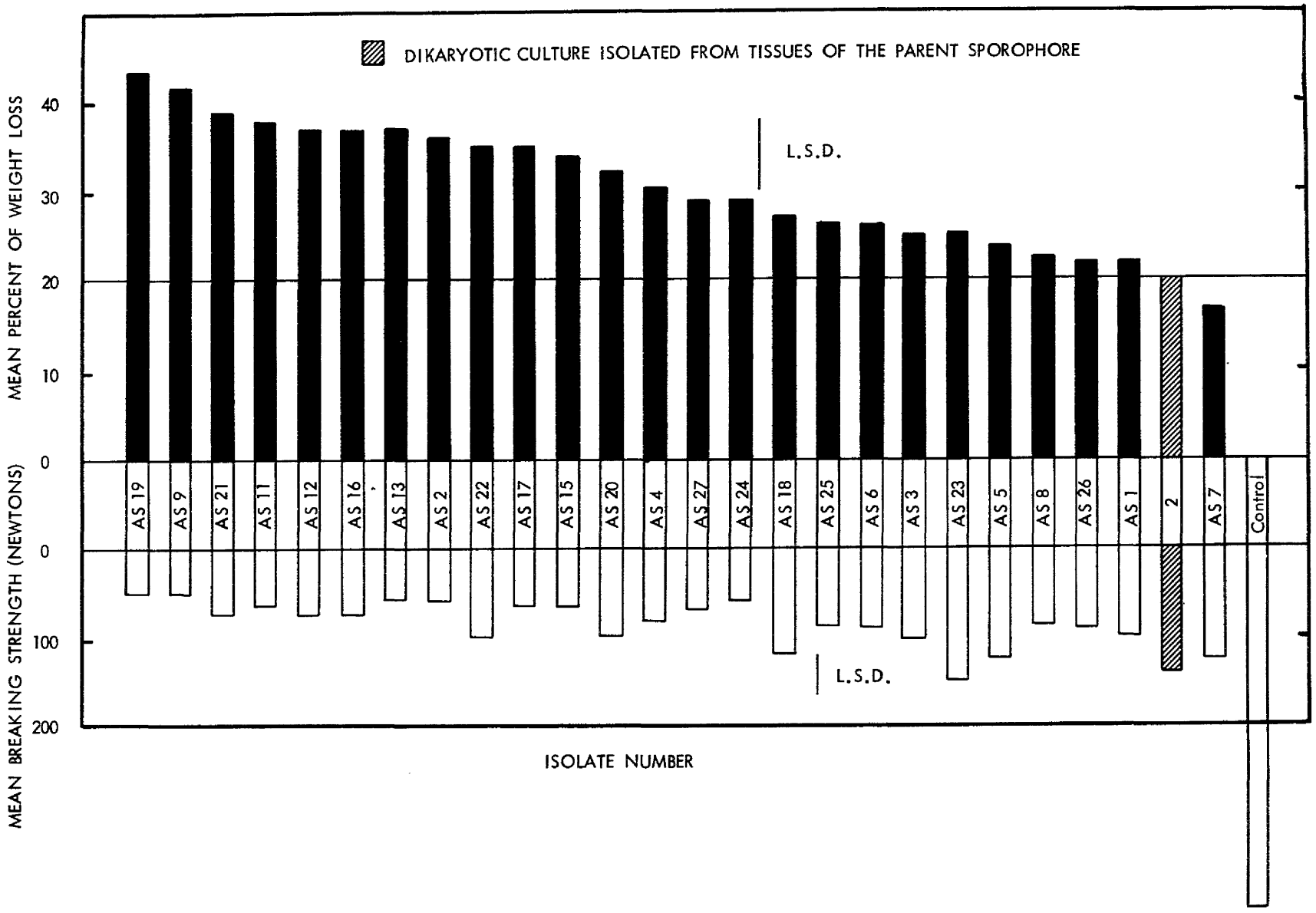
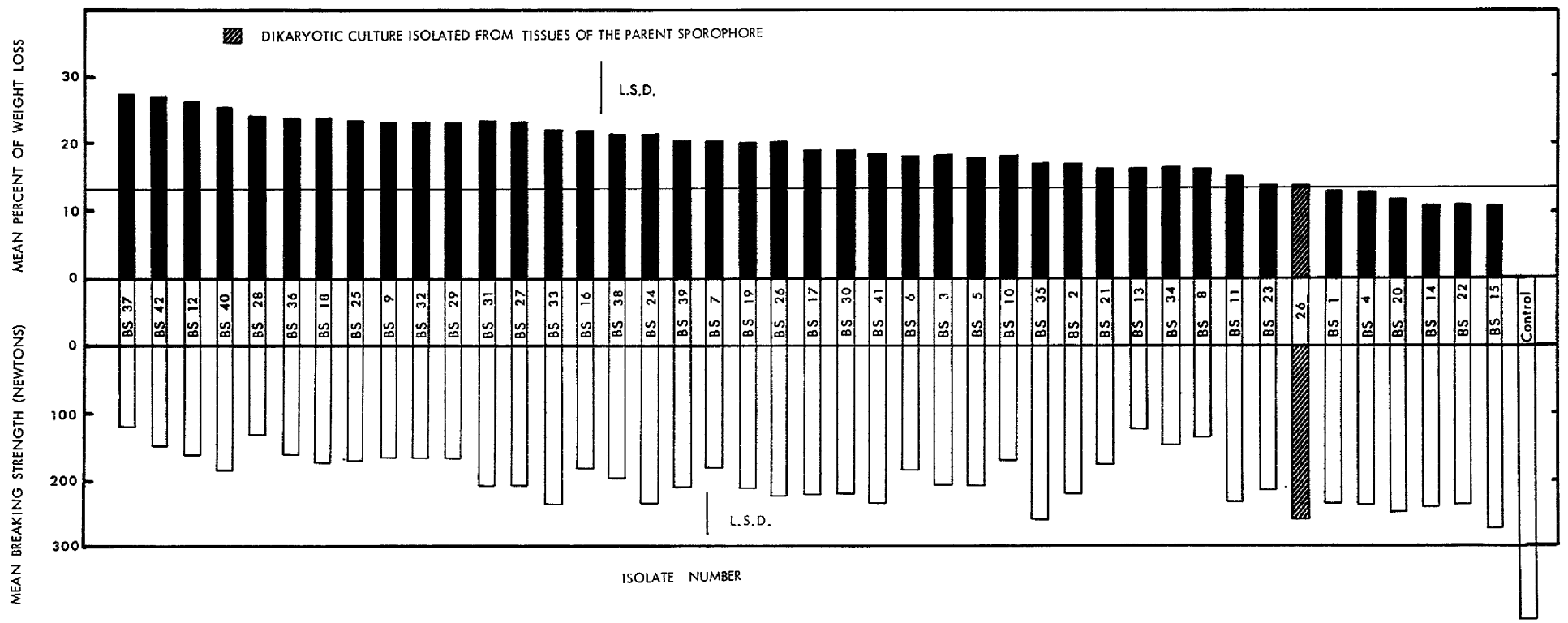

DIKARYOTIC CULTURE ISOLATED FROM TISSUES OF THE PARENT SPOROPHORE
MEAN PERCENT OF WEIGHT LOSS
40
30
20
10
0
L.S.D.
MEAN BREAKING STRENGTH (NEWTONS)
0
100
200
L.S.D.
AS 19
AS 9
AS 21
AS 11
AS 12
AS 16
AS 13
AS 2
AS 22
AS 17
AS 15
AS 20
AS 4
AS 27
AS 24
AS 18
AS 25
AS 6
AS 3
AS 23
AS 5
AS 8
AS 26
AS 1
2
AS 7
Control
ISOLATE NUMBER

FIGURE 9

Histogram showing the mean percent of weight losses and reduction in breaking strength of test pieces of P. sylvestris sapwood decayed by 42 monokaryotic cultures (isolated from sporophore B) at 10 weeks incubation.


DIKARYOTIC CULTURE ISOLATED FROM TISSUES OF THE PARENT SPOROPHORE
L.S.D.
L.S.D.
MEAN BREAKING STRENGTH (NEWTONS)
MEAN PERCENT OF WEIGHT LOSS
30
20
10
0
0
100
200
300
BS 37
BS 42
BS 12
BS 40
BS 28
BS 36
BS 18
BS 25
BS 9
BS 32
BS 29
BS 31
BS 27
BS 33
BS 16
BS 38
BS 24
BS 39
BS 7
BS 19
BS 26
BS 17
BS 30
BS 41
BS 6
BS 3
BS 5
BS 10
BS 35
BS 2
BS 21
BS 13
BS 34
BS 8
BS 11
BS 23
26
BS 1
BS 4
BS 20
BS 14
BS 22
BS 15
Control
ISOLATE NUMBER

monokaryons from sporophore A, and for 15 of those from sporophore B. Only 8 monokaryotic cultures gave lower figures than the dikaryons.

The recorded amount of decay by all cultures from sporophore B was consistently less than that recorded for cultures from sporophore A. This conforms with the differences between those strains found in the general survey.

(2) Investigation of mating types

Methods

In order to determine the mating type system of isolates, monokaryotic mycelia of each sporophore were crossed in all possible combinations.

The crossings were usually made on malt agar slants in test tubes. When necessary, pairings on malt agar in petri dishes were also done. Small discs of inoculum (6 mm in diameter) taken from 2 weeks old malt agar cultures of each of two monokaryon mycelia (from the same sporophore) were placed on opposite sides of malt agar slants in a 15 cm test tube. The cultures were allowed to grow for at least two weeks, the paired and unpaired mycelia were then examined microscopically for the presence or absence of clamp connections. Those showing the presence of clamps or the compatible matings, were marked + and assumed to be dikaryons, and those showing only simple septa were marked with - and assumed to be monokaryons or incompatible matings.

Results

The results are shown in Figures 10 and 11.

Conclusion

The results of crosses of monokaryons from the two sporophores indicate clearly that all are heterothallic and possess the tetrapolar type of sexuality. This confirms earlier reports concerning the

FIGURE 10

Tetrapolar pattern of mating type obtained by rearrangement into groups of 23 monokaryotic cultures of S, lacrimans obtained from sporophore A.

The sign (+) indicates the presence of clamp connections.

" " (-) " " absence " " "

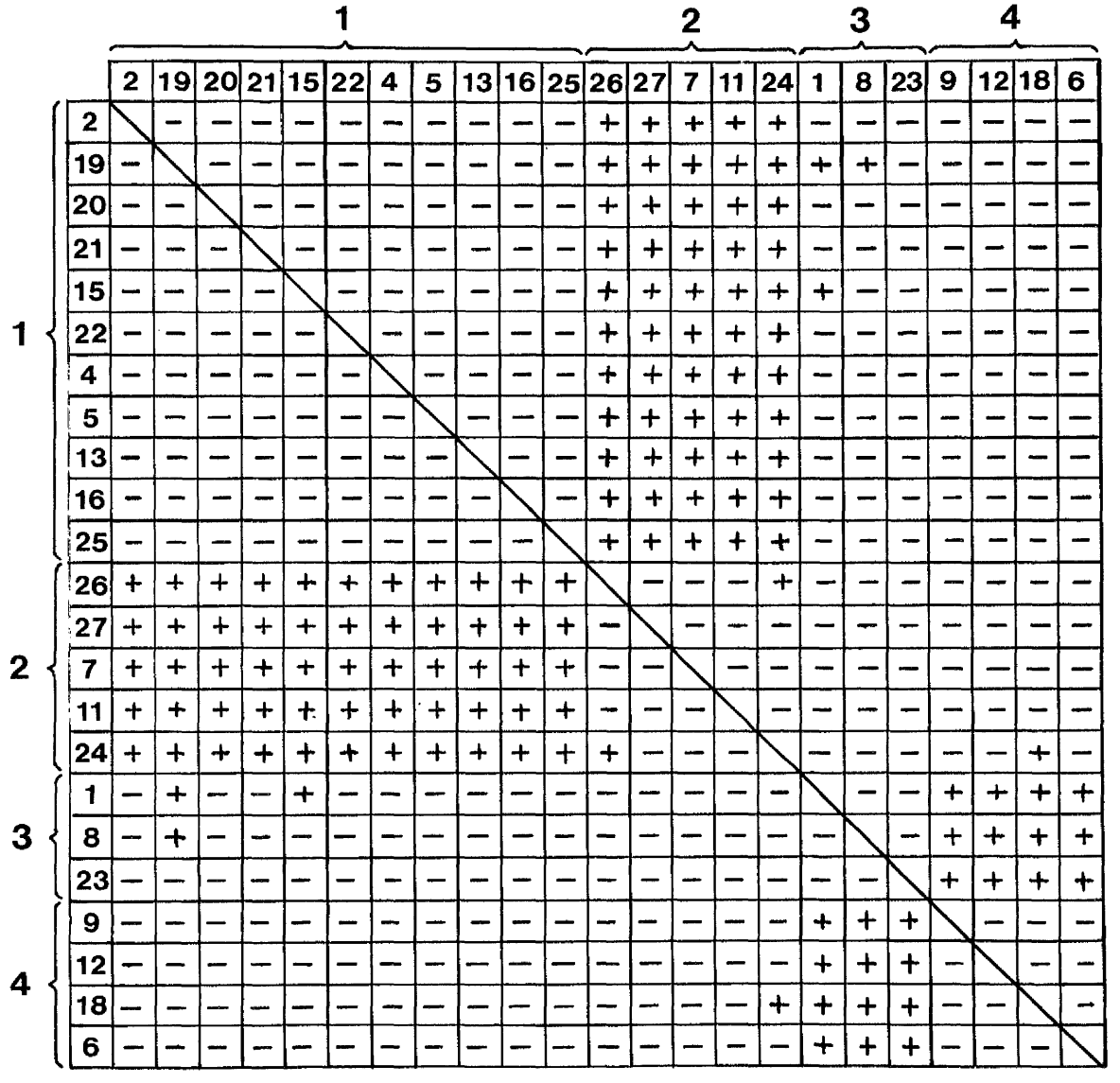
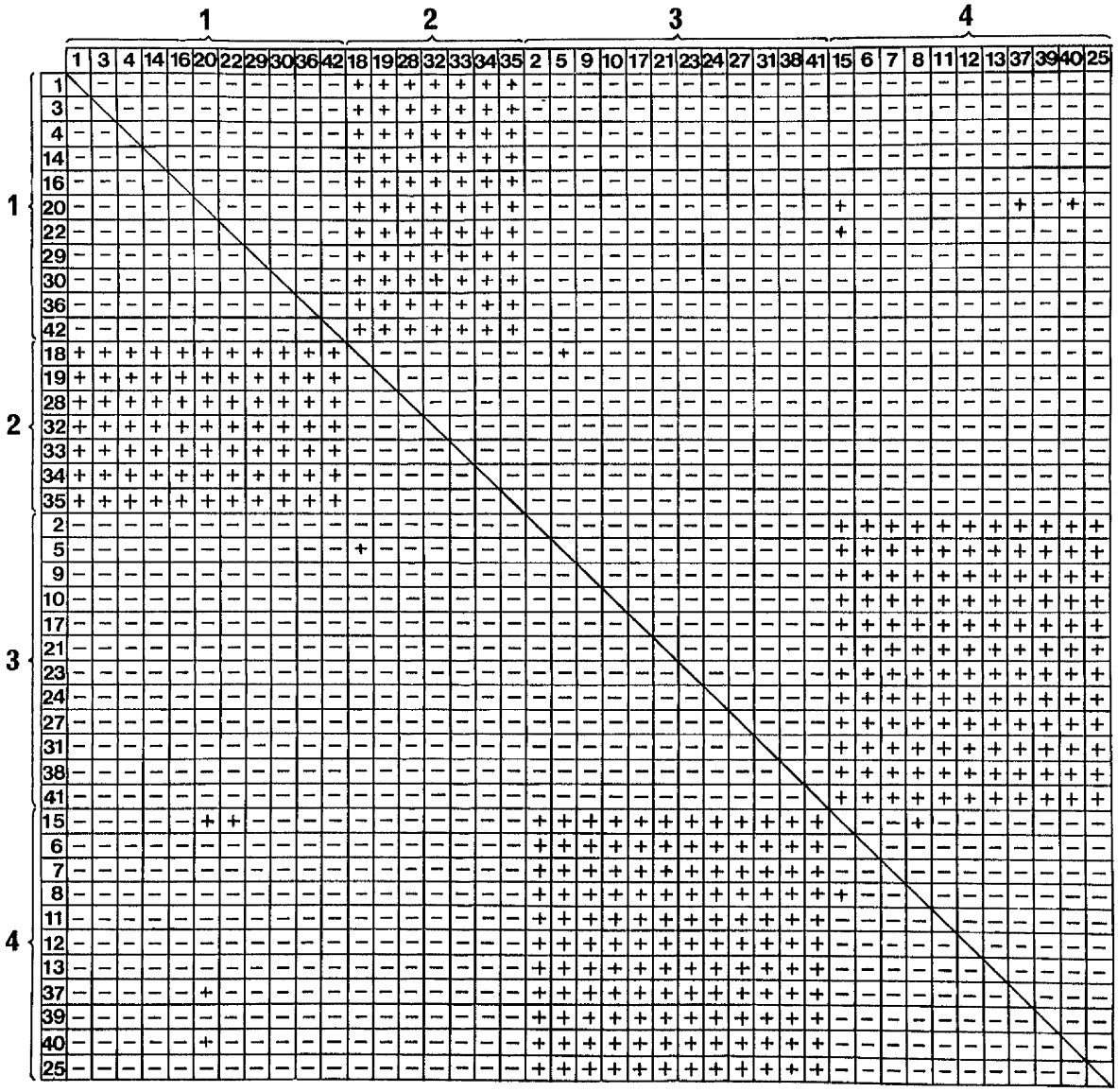

1
2
3
4
2 19 20 21 15 22 4 5 13 16 25 26 27 7 11 24 1 8 23 9 12 18 6
1
2
3
4

FIGURE 11

Tetrapolar pattern of mating type obtained by rearrangement into groups of 41 monokaryotic cultures of S. lacrimans obtained from sporophore B.

The sign (+) indicates the presence of clamp connections.

" " (-) " " absence " " "


1
2
3
4
1 3 4 14 16 20 22 29 30 36 42 18 19 28 32 33 34 35 2 5 9 10 17 21 23 24 27 31 38 41 15 6 7 8 11 12 13 37 39 40 25
1 3 4 14 16 20 22 29 30 36 42 18 19 28 32 33 34 35 2 5 9 10 17 21 23 24 27 31 38 41 15 6 7 8 11 12 13 37 39 40 25

tetrapolarity of S. lacrimans (Harmsen et al. 1958 and Harmsen 1960).

(3) Comparison of monokaryons and the dikaryons synthesized from them

Methods

In this section, a comparison was made of the wood-decaying ability of selected monokaryons from sporophores A and B and the dikaryons synthesized from them.

For each sporophore, the incompatibility reactions of its progeny were determined by mating each monokaryon to select representatives of each of the four incompatibility groups or mating types.

Five cultures of one mating type were chosen from the monokaryons from sporophore A, and mated in all possible combinations with five other cultures of compatible mating type from the same sporophore. A similar set of 6 x 6 matings were made with the monokaryons from sporophore B.

The decay abilities of the dikaryons have been tested and compared with the decay ability of their component monokaryons.

Results

Results are recorded in Appendix Tables 20, 21 and illustrated in text figures 12 and 13.

Discussion

Figure 12 shows that most of the dikaryotic cultures, obtained by pairing of compatible monokaryons from sporophore A, had a lower decay ability than either of their component monokaryons. Of the 25 dikaryotic cultures, only (AS5 x 7) and AS13 x 7) had a slightly higher amount of decay than either of their component monokaryons.

Text figure 13 summarizes the results of variation in wood-decay

ability of dikaryotic cultures obtained by pairing of compatible monokaryons from basidiospores of sporophore B. In this experiment, similar differences in decay ability were observed. From figure 13, it can be seen that most of the dikaryons had a lower decay ability than either of their component monokaryons. In most cases monokaryons with low decay abilities produced a dikaryon with low decay ability. If a synthesized dikaryon is formed by mating a monokaryon with a low decay ability and one with an intermediate or high decay ability, the decay ability of the produced dikaryon will usually be equal to or lower than that of the monokaryon with the higher decay ability. Only two of the 36 dikaryotic cultures (BS34 x 42 and BS35 x 20), produced a slightly higher amount of decay than either of their component monokaryons.

Aoshima (1954) pointed out that dikaryotic isolates of Fomes applanatus (Pers.) Karst obtained from two monokaryotic mycelia both with high decay ability, do not always have a great ability to cause decay of wood. Similarly, dikaryotic mycelia synthesized from the monokaryotic ones, both with weak decaying ability do not always have weak ability to cause decay of wood. He concluded that the differences in ability to cause decay of wood existing among the dikaryotic mycelia cannot be explained on the basis of the decay ability of the monokaryons from which they were derived.

Amburgey (1967) indicated that dikaryotic isolates of Lenzites trabea (Pers) Fr. usually have a lower ability to cause decay of wood than their component monokaryons.

The results indicated by Amburgey are rather similar to that obtained by the present investigations in which it is indicated that the wood-decaying ability of dikaryotic isolates of S. lacrimans formed from monokaryons of different activities is consistently less than that of the most active partner, and in some cases less than the

FIGURE 12

Comparison of wood-decay ability of monokaryons (isolated from sporophore A) and their synthesized dikaryons formed by mating the monokaryons in all possible combinations.

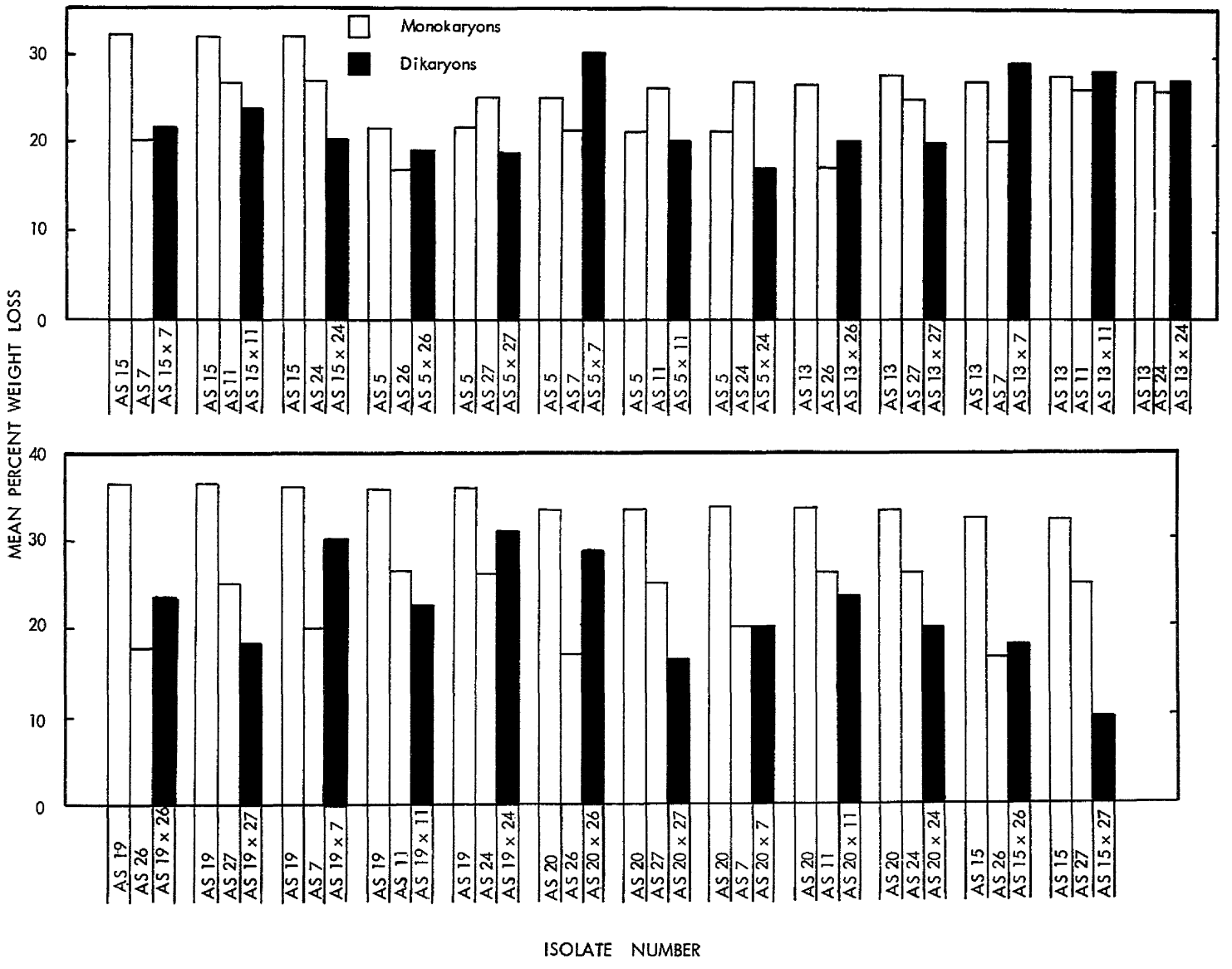
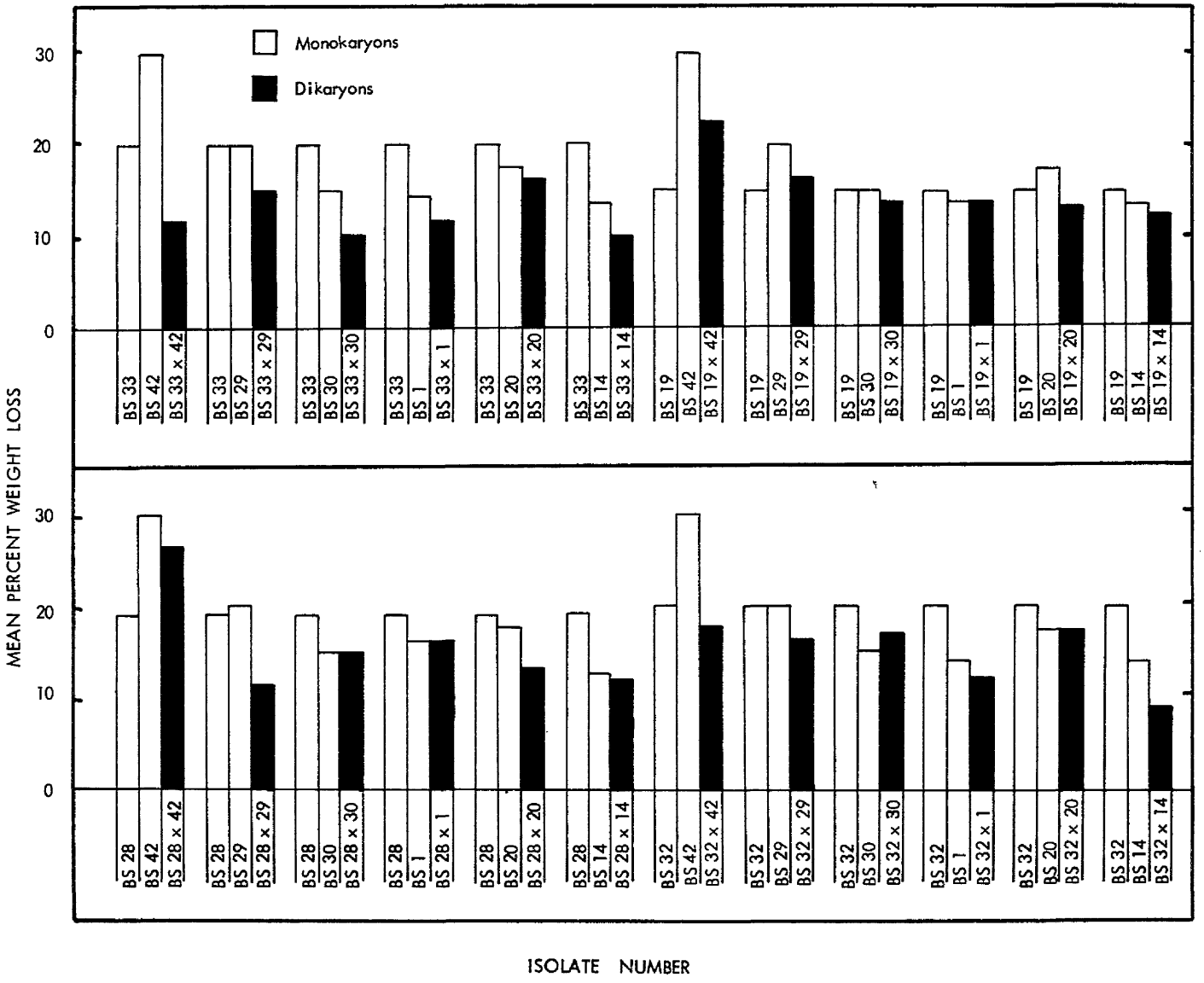
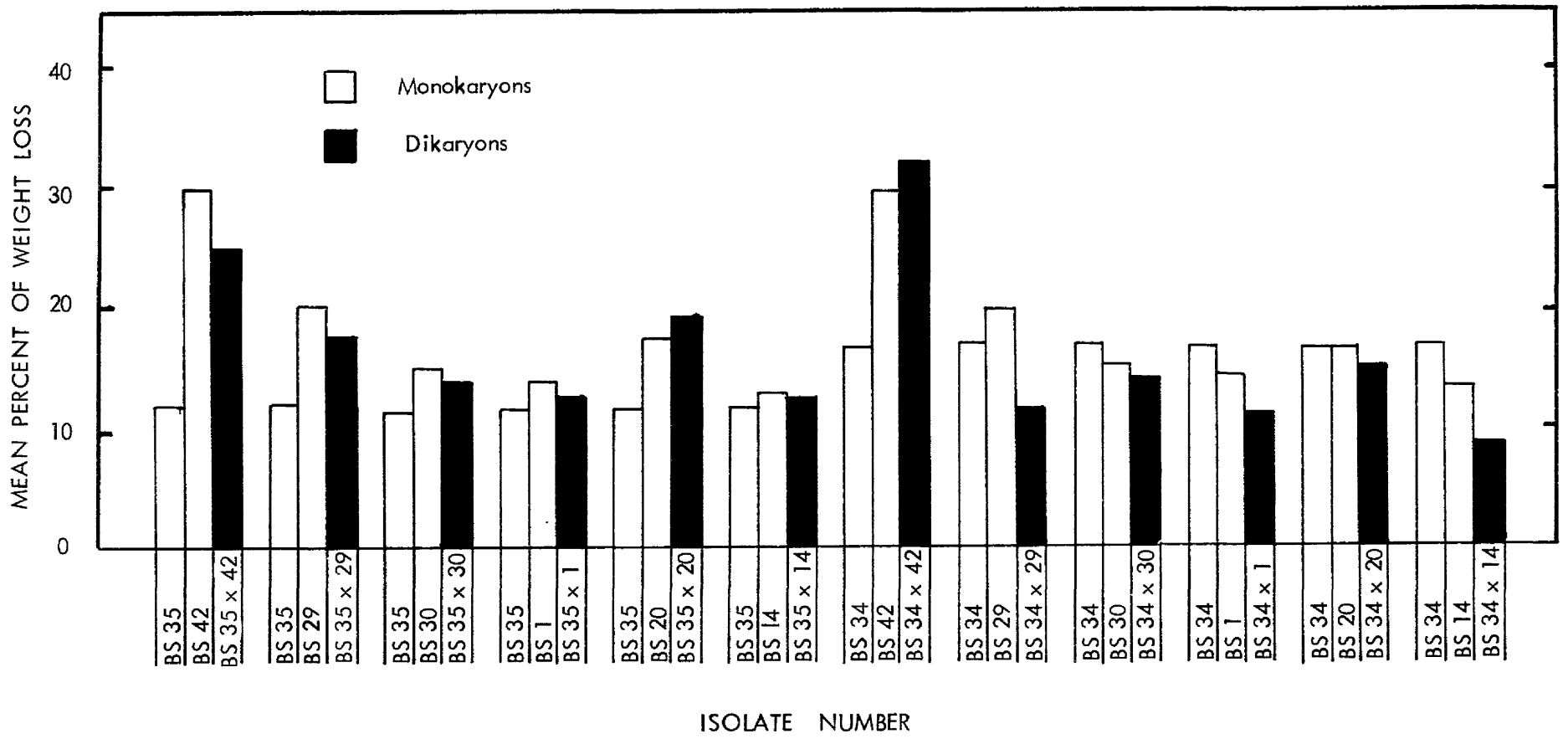

Monokaryons
Dikaryons
MEAN PERCENT WEIGHT LOSS
0
10
20
30
40
AS 15
AS 7
AS 15 x 7
AS 15
AS 11
AS 15 x 11
AS 15
AS 24
AS 15 x 24
AS 5
AS 26
AS 5 x 26
AS 5
AS 27
AS 5 x 27
AS 5
AS 7
AS 5 x 7
AS 5
AS 11
AS 5 x 11
AS 5
AS 24
AS 5 x 24
AS 13
AS 26
AS 13 x 26
AS 13
AS 27
AS 13 x 27
AS 13
AS 7
AS 13 x 7
AS 13
AS 11
AS 13 x 11
AS 13
AS 24
AS 13 x 24
AS 19
AS 26
AS 19 x 26
AS 19
AS 27
AS 19 x 27
AS 19
AS 7
AS 19 x 7
AS 19
AS 11
AS 19 x 11
AS 19
AS 24
AS 19 x 24
AS 20
AS 26
AS 20 x 26
AS 20
AS 27
AS 20 x 27
AS 20
AS 7
AS 20 x 7
AS 20
AS 11
AS 20 x 11
AS 20
AS 24
AS 20 x 24
AS 15
AS 26
AS 15 x 26
AS 15
AS 27
AS 15 x 27
ISOLATE NUMBER

FIGURE 13

Comparison of wood-decay ability of monokaryons (isolated from sporophore B) and their synthesized dikaryons formed by mating the monokaryons in all possible combinations.


Monokaryons
Dikaryons
MEAN PERCENT WEIGHT LOSS
30
20
10
0
BS 33
BS 42
BS 33 x 42
BS 33
BS 29
BS 33 x 29
BS 33
BS 30
BS 33 x 30
BS 33
BS 1
BS 33 x 1
BS 33
BS 20
BS 33 x 20
BS 33
BS 14
BS 33 x 14
BS 19
BS 42
BS 19 x 42
BS 19
BS 29
BS 19 x 29
BS 19
BS 30
BS 19 x 30
BS 19
BS 1
BS 19 x 1
BS 19
BS 20
BS 19 x 20
BS 19
BS 14
BS 19 x 14
BS 28
BS 42
BS 28 x 42
BS 28
BS 29
BS 28 x 29
BS 28
BS 30
BS 28 x 30
BS 28
BS 1
BS 28 x 1
BS 28
BS 20
BS 28 x 20
BS 28
BS 14
BS 28 x 14
BS 32
BS 42
BS 32 x 42
BS 32
BS 29
BS 32 x 29
BS 32
BS 30
BS 32 x 30
BS 32
BS 1
BS 32 x 1
BS 32
BS 20
BS 32 x 20
BS 32
BS 14
BS 32 x 14
ISOLATE NUMBER


MEAN PERCENT OF WEIGHT LOSS
40
30
20
10
0
Monokaryons
Dikaryons
BS 35
BS 42
BS 35 x 42
BS 35
BS 29
BS 35 x 29
BS 35
BS 30
BS 35 x 30
BS 35
BS 1
BS 35 x 1
BS 35
BS 20
BS 35 x 20
BS 35
BS 14
BS 35 x 14
BS 34
BS 42
BS 34 x 42
BS 34
BS 29
BS 34 x 29
BS 34
BS 30
BS 34 x 30
BS 34
BS 1
BS 34 x 1
BS 34
BS 20
BS 34 x 20
BS 34
BS 14
BS 34 x 14
ISOLATE NUMBER

ones with low decay ability.

(4) Genetical analysis

The design of the above experiment with monokaryons and the dikaryons synthesized therefrom was suggested by Dr C.G. Elliott with the aim of performing a genetical analysis of wood-decaying ability, using the techniques of biometrical genetics described by Mather and Jinks (1971) and Simchen and Jinks (1964).

The results of Dr Elliott's analysis may be summarized as follows:-

(a) The heritability of the character (percentage loss in weight of wood pieces) is low; only about 8% of the variation among dikaryons synthesized from sporophore A monokaryons and 14% from sporophore B is due to genetic factors, the remainder being experimental variation.

(b) In the sporophore A dikaryons, there is no evidence of dominance of one allele over the other for any of the genes segregating, or of any interaction between different genes. All gene action is additive; that is, the genetic component of the character measured is the sum of the contributions of the several genes, and the contribution of each gene is the sum of the contributions of its two alleles present.

(c) In sporophore B, there is evidence of dominance; alleles contributed by monokaryon BS42 are recessive to those contributed by the other monokaryons. Gene action in all cases excluding BS42 appears to be purely additive. It will be noted that monokaryon BS42 has a much greater decay ability than the other eleven monokaryons used. This is in line with the observation that the dikaryons generally have lower decay abilities than the average of their monokaryon 'parents' (Table 3). However, the biometrical analysis tells us about genes active in the dikaryons, and as there appears to be no evidence of dominance apart from BS42, one ought not to conclude that the lower decay ability of

Table 2. Upper figures: mean percent weight loss of dikaryons synthesized from monokaryons indicated in margins.

Lower figures: mean percent weight loss of the two component monokaryons (isolated from sporophore A).

Monokaryons	AS5 21.92	AS13 27.48	AS15 32.72	AS20 34.00	AS19 36.12	Means
AS26	19.48*	20.12	17.64	18.84	23.76	19.97
16.92	19.42	22.20	24.82	25.46	26.52	
AS7	29.88*	29.16*	20.80	19.84	29.44*	25.82
20.16	21.04	23.82	26.44	27.08	28.14	
AS27	18.12	20.48	10.00	16.56	17.48	16.53
24.00	22.96	25.74	28.36	29.00	30.06	
AS11	19.76	28.36*	23.20	23.68	21.92	23.38
25.92	23.92	26.70	29.32	29.96	31.02	
AS24	16.92	27.20*	20.00	20.40	30.32	22.97
26.24	24.08	26.82	29.48	30.12	31.18	
Means	20.83	25.06	18.33	19.86	24.58	

* Dikaryons showed higher values than the average of their component monokaryons.

Table 3. Upper figures: mean percent weight loss of dikaryons synthesized from monokaryons indicated in margins.

Lower figures: mean percent weight loss of the two component monokaryons (isolated from sporophore B).

Monokaryons	BS14 12.64	BS1- 14.48	BS30 14.96	BS20 16.52	BS29 19.80	BS42 29.56	Means
BS35	9.16	12.28	14.04*	18.60*	18.08*	25.24*	16.23
12.28	12.46	13.38	13.62	14.40	16.04	20.92	
BS19	11.64	14.44	13.96	13.32	15.68	19.68	14.79
14.68	13.66	14.58	14.82	15.60	17.24	22.12	
BS34	7.08	11.36	14.12	15.16	10.56	31.72*	15.00
17.52	15.08	16.00	16.24	17.02	18.66	23.54	
BS32	9.12	11.40	15.88	18.48	16.72	17.52	14.85
19.32	15.98	16.90	17.14	17.92	19.56	24.44	
BS28	11.32	16.32	14.84	13.04	11.04	25.40*	15.33
19.64	16.14	17.06	17.30	18.28	19.72	24.60	
BS33	13.08	12.48	10.12	10.12	15.20	12.08	12.18
20.44	16.54	17.46	17.70	18.48	20.12	25.00	
Means	10.23	13.05	13.83	14.79	14.55	21.94	

* Dikaryons showed higher values than the average of their component monokaryons.

the dikaryons is due to a recessive condition of the high decay-promoting alleles manifest in the monokaryons.

SECTION 2

THE EFFECT OF STORAGE CONDITIONS ON WOOD DECAYING ABILITY OF SERPULA LACRIMANS

Materials and Methods

A long term investigation has been started to investigate comparative changes in wood-decay ability of cultures stored on wood blocks and on 2% malt agar at each of three temperatures (15, 20 and 24°C).

Four dikaryotic (4, 5, 7, 8) and three monokaryotic (AS9, AS15, AS7) cultures with different degrees of saprophytic ability were chosen for this purpose.

Agar cultures were set up normally in Roux bottles. Wood block cultures were set up by inoculating the cultures in small quantities of malt agar in test tubes (20 centimetres long by 3.5 centimetres in diameter at the mouth) and placing a sterile standard piece of Scots Pine sapwood on the surface of each colony after two weeks incubation at 20°C.

One culture was set up for each of the seven strains. It was thought that replication by using of 7 strains would in these conditions be more informative than replication using one strain only.

The saprophytic ability of the cultures was tested by the standard methods after 6 and 12 months storage. At the time of testing, each malt agar culture was sub-cultured into fresh medium in similar Roux bottles. The wooden block cultures were also sub-cultured into small quantities of fresh malt agar in test tubes containing new pieces of wood.

Results

The results after 6 months storage are given in Appendix Tables 22a, 22b and summarized in text figures 14, 15 and 16.

The results after oneyear storage are given in Appendix Tables 23a, 23b and summarized in text figures 14, 15 and 16.

Conclusion

The most interesting result from the experiment so far is that while saprophytic ability declined during storage on agar at 20°C, it increased during storage on wood. These results are consistent and statistically significant ($P = 0.05$).

The effects of storage at 15°C and at 24°C are generally similar, but the differences are not statistically significant.

FIGURE 14

Comparison of loss in dry weight in standard tests of cultures after storage on wood pieces and on malt agar for periods of six and twelve months. All results are means of measurements of five wooden test pieces in each of five fungal cultures.

(Storage at 20°C.)

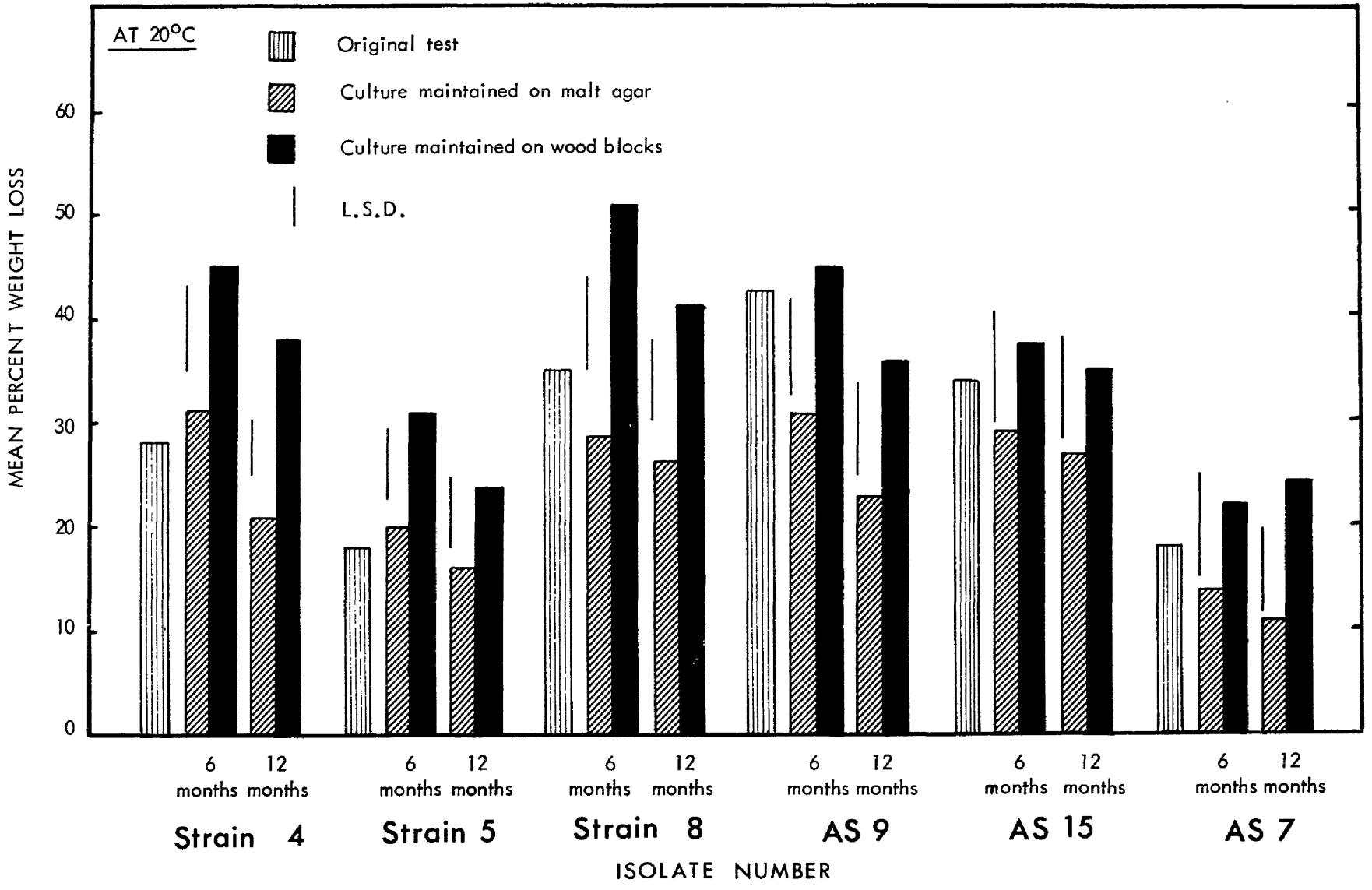

AT 20°C
Original test
Culture maintained on malt agar
Culture maintained on wood blocks
L.S.D.
MEAN PERCENT WEIGHT LOSS
0
10
20
30
40
50
60
6 months
12 months
Strain 4
Strain 5
Strain 8
AS 9
AS 15
AS 7
ISOLATE NUMBER

FIGURE 15

Comparison of loss in dry weight in standard tests of cultures after storage on wood pieces and on malt agar for periods of six and twelve months. All results are means of measurements of five wooden test pieces in each of five fungal cultures.

(Storage at 15°C.)

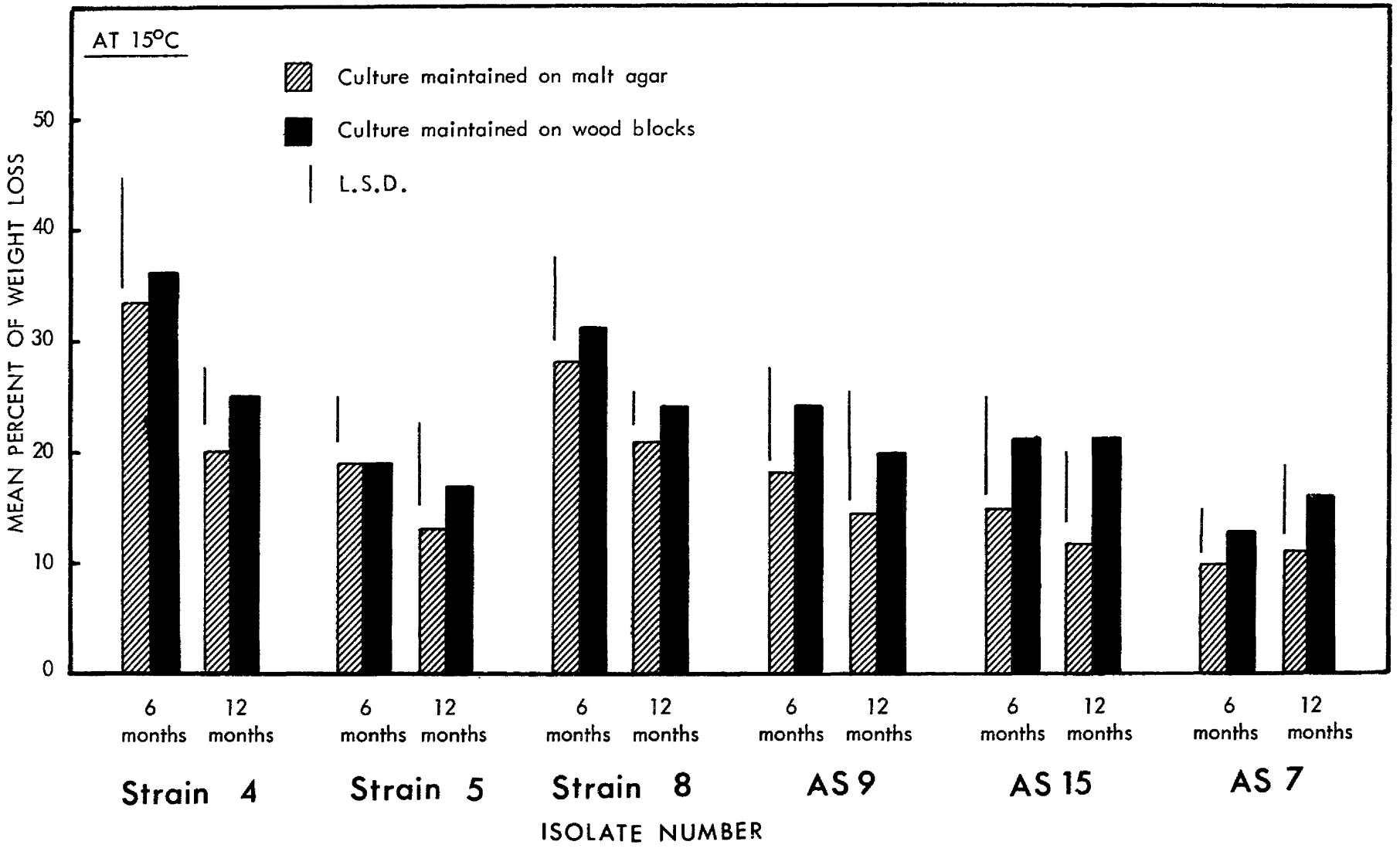
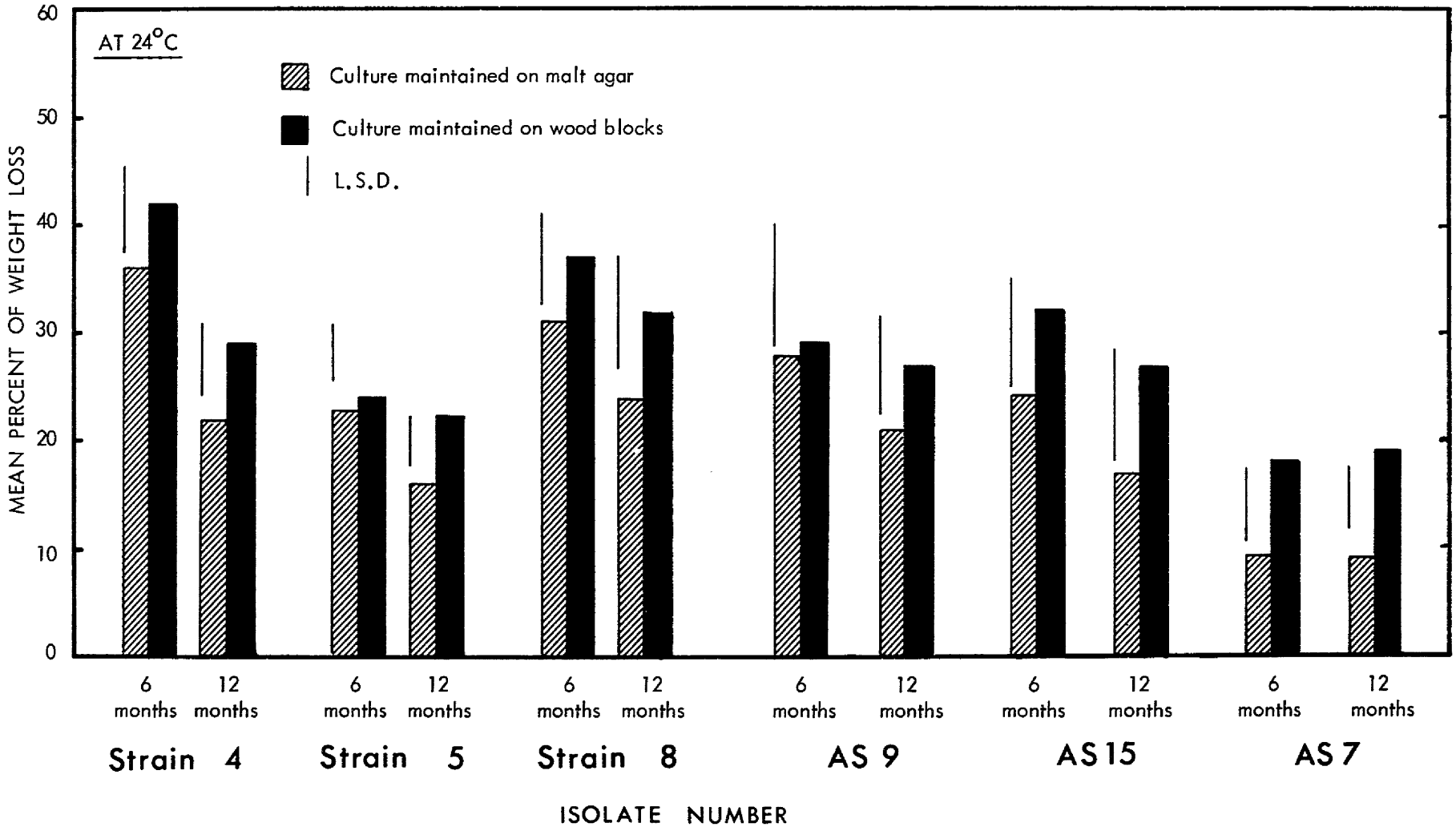

AT 15°C
Culture maintained on malt agar
Culture maintained on wood blocks
L.S.D.
MEAN PERCENT OF WEIGHT LOSS
50
40
30
20
10
0
6 months
12 months
Strain 4
Strain 5
Strain 8
AS 9
AS 15
AS 7
ISOLATE NUMBER

FIGURE 16

Comparison of loss in dry weight in standard tests of cultures after storage on wood pieces and on malt agar for periods of six and twelve months. All results are means of measurements of five wooden test pieces in each of five fungal cultures.

(Storage at 24°C.)


AT 24°C
Culture maintained on malt agar
Culture maintained on wood blocks
L.S.D.
MEAN PERCENT OF WEIGHT LOSS
60
50
40
30
20
10
0
6 months
12 months
Strain 4
Strain 5
Strain 8
AS 9
AS 15
AS 7
ISOLATE NUMBER

PART 5

Effects of heat on mycelial development and decay ability

In some field conditions it has been found necessary to attempt to eradicate Serpula infection in material by heat treatment in situ. It has been found difficult to apply this in completely rigorous conditions, and the Building Research Establishment (B.R.E.) has expressed interest in the possibility that sub-lethal exposure in parts of a site may have a significant effect on the saprophytic ability of surviving mycelia. The penetration of heat will presumably be affected by the size of the wood involved, the water content of wood, and its density (which will have been affected by the amount of decay which has gone on before treatment).

It is also common knowledge that the time required at various temperatures to kill fungi varies considerably according to the physical conditions of the medium in which the fungus is growing; e.g. the drier the medium the longer the time required. In most of the tests which have been carried out the fungi have been grown either in agar medium or in small pieces of wood containing a high moisture content and only very little information is yet available about the resistance to heat of fungal mycelium in air-dry wood. Snell (1923) subjected small test blocks of Sitka Spruce which had been decayed by five wood destroying fungi to various times and temperatures of moist and dry heat; he did not, however, include any species of Merulius in his tests. His results confirm that moist heat is much more effective in killing the fungi than dry heat, e.g., in moist heat, the most resistant fungus, Lenzites trabea, was killed in 12 hours at 55°C, but in dry heat, this species was not killed by 3 days at 70°C, although it succumbed in 12 hours at 105°C dry heat.

Liese (1931), using test tube cultures of 18 wood decaying fungi on agar, found the most sensitive was S. lacrimans which was killed by

15 min. exposure to a temperature of 40°C, while the most resistant were Lentinus squamosus, Lenzites abietina, L. sepiaria and schizophyllum, which were killed only after 30-60 min. exposure to 60°C. Montgomery (1936) reported that S. lacrimans growing on 2% malt agar or in small blocks of pine wood was killed after only 15 minutes exposure to a temperature of 40°C. He also noticed that inocula from the upper end of a sloped tube, where drier conditions existed, were viable after longer periods of exposure to heat than inocula from the middle of the slope where more moisture was present.

Langvad and Goksøyr (1967) found that the optimum temperature for rate of increase of colony diameters of S. lacrimans on 2% malt agar was 22°C, and that at 27°C there was slight aerial growth above the inoculum but no increasable change in diameter. At 28°C there was no visible growth. They also found that colonies incubated for 4 hours or more at 37.5° did not increase in size on subsequent incubation at 22°C; after more than 250 hours incubation at 28°C colonies increased in size on return to incubation at 22°C. They use the term "thermal death time" to refer to this temperature/time relationship needed to stop further increase in colony size. Their usage is confusing, however, as they pointed out that the respiration rate of the cells exposed to 37.5°C for 4 hours was "... not directly affected, as an appreciable respiration occurred even after 6 hours". They concluded that the "... detrimental effects of supraoptimal temperatures on this fungus include a degradation of nucleic acids and a subsequent leakage of the nucleotides out of the cells".

Subsequently, Langvad (1972) studied the effect of these treatments on the fine structures of the cells of S. lacrimans. His work was supported by electron micrographs. He found the following successive effects of the heat on the cells of the fungus. The first effect of heat was

observed on mitochondria, nuclei and the cytoplasm after 20 min. exposure to 37.5°C. Mitochondria seemed to be very sensitive to heat. After 20 min. exposure at 37.5°C the cristae started to break down and soon disappeared leaving double membrane vesicles. After 1 hour normal mitochondria could no longer be observed.

An early effect of high temperature was also observed on the nuclei; the nuclear membrane broke up, and the nucleoli leaked out of the cells. After 40 min. exposure, only a few compartments showed this damage but after 1 hour exposure normal nuclei could no longer be observed.

The cytoplasm assumed a granular appearance when exposed to high temperatures. Prolonged exposure at 37.5°C caused severe cytological damage. After 4 hours the hyphae were completely disorganized. All organelles and membrane systems, including the plasma membrane, were disrupted.

Langvad also noticed that when the fungus is exposed to high temperatures, some material, most probably nucleic acid degradation products, is excreted into the medium.

Langvad's work has not, however, examined the possibility that sub-lethal exposure to heat may reduce the growth rate of the surviving cells to an economically useful degree.

The Building Research Establishment (Savory, personal communication) has expressed interest in this question. It was therefore decided to investigate the following problems:-

(1) To determine the time of exposure to a range of high temperatures necessary to stop the increase of size of colonies of a representative isolate growing on 2% malt agar.

(2) To examine the nature of the effects of sub-lethal high temperature on the morphology and growth rates of the fungus, and to correlate the growth rates and decay ability of the surviving colonies with the growth

rate and decay ability of the parent culture.

(3) Continuation of the work, in a long term investigation, of determining the permanency of any effects found.

Materials and Methods

The fungus (Strain 8) was grown on 2% malt agar using 100 ml Erlenmeyer conical flasks; the flasks were first incubated at 21°C for four days after inoculation, and two marked diameters of each colony were measured.

The treatment was then applied by immersing a number of these conical cultures in thermostatically controlled water baths maintained at constant temperatures (30, 35, 38 and 40°C) for the following intervals - 10, 15, 20, 25, 30 and 35 minutes.

At each time interval, five conical flask cultures were removed, allowed to cool, and incubated further at 21°C for at least three weeks. The amount of growth was then determined by re-measuring the previously marked diameters.

The results of this test are recorded in text table 4 and illustrated in Plates 6 and 7. These results showed that the colonies did not increase in size after 20 minutes exposure to 40°C; however, 15 minutes of exposure to 40°C, or 25 minutes exposure to 38°C has had different effects on different parts of the young colonies. The mycelium at these stages was much slower in growth than the parent cultures, and it started to grow vertically from the centre of inoculum and then it spread over the surface of the medium. This change in the growth form induced by heat treatment has been studied in some detail.

The objective of this study is to find out whether or not the change in the growth form resulting from the heat treatment will be:-

Table 4 The effect of short period of exposures to various high temperatures upon the mycelium of Serpula lacrimans (Strain 8) growing on 2% malt extract agar.

Temp. of incubation (°C)	No. of Flask	Time of incubation (minutes)					
		10	15	20	25	30	35
	1	+	+	+	+	+	+
	2	+	+	+	+	+	+
30	3	+	+	+	+	+	+
	4	+	+	+	+	+	+
	5	+	+	+	+	+	+
	1	+	+	+	+	+	+
	2	+	+	+	+	+	+
35	3	+	+	+	+	+	+
	4	+	+	+	+	+	+
	5	+	+	+	+	+	+
	1	+	+	+	+	-	-
	2	+	+	+	+	-	-
38	3	+	+	+	+	+	-
	4	+	+	+	+	-	-
	5	+	+	+	-	-	-
	1	+	+	-	-	-	-
	2	+	+	-	-	-	-
40	3	+	+	-	-	-	-
	4	+	-	-	-	-	-
	5	+	-	-	-	-	-

Note. Each (+) or (-) indicates the presence or absence of fungal growth from a single flask culture.

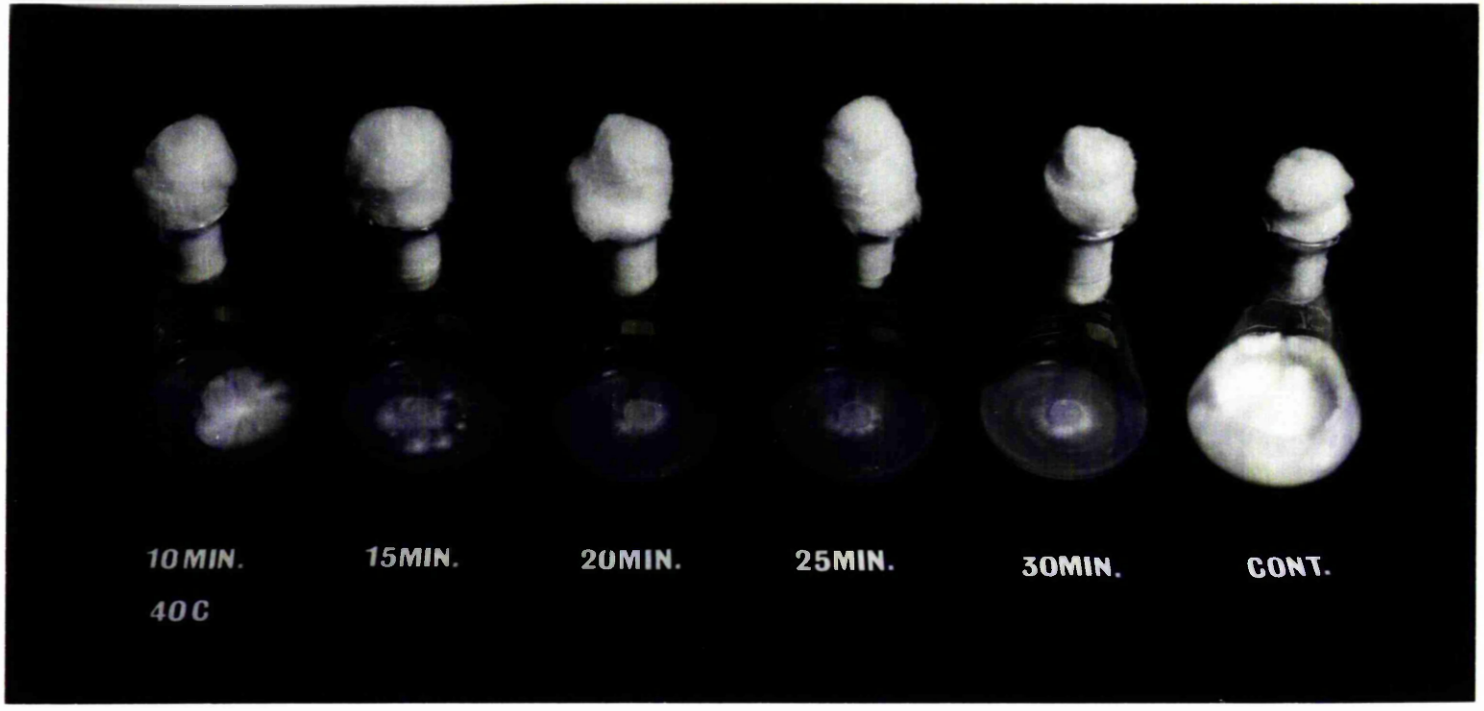


Plate 6. Photograph showing the effect of short period of exposures to high temperature (40°C) upon the mycelium of S. lacrimans (Strain 8) growing on 2% malt agar. For more details see Appendix tables 24, 25, 26 and text figures 17 and 18.

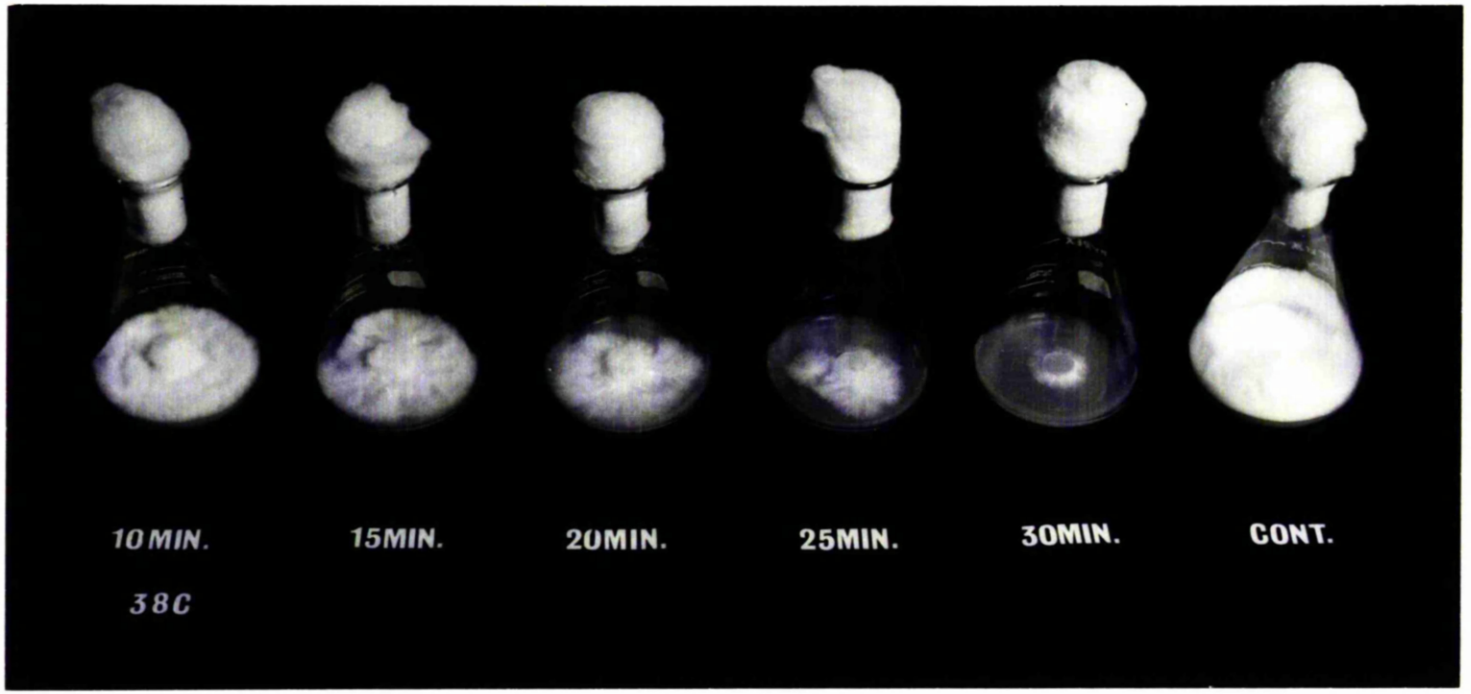


Plate 7. Photograph showing the effect of short period of exposures to high temperature (38°C) upon the mycelium of S. lacrimans (Strain 8) growing on 2% malt agar medium. For more details see Appendix tables 24, 25, 26 and text figures 17 and 18.

(i) Retained through successive subculturing.

(ii) Correlated with any change in decay ability.

The maintenance of the differences in growth form and decay ability after successive sub-culturing was measured by the following techniques:-

Pieces of mycelia from fast and slow growing sectors of the cultures which had been exposed to 40°C for 15 minutes, or to 38°C for 25 minutes, were transferred to 2% malt agar slopes in test tubes.

After two weeks incubation at 21°C, ten petri dishes were inoculated from each of these cultures, and incubated for seven days at the same temperature. The growth of these cultures was compared with the growth of ten controls set up from untreated culture.

Wood decaying ability of these different growing sectors and the parent culture has also been measured by the technique already described in the "general methods".

The cultures which had been subjected to high temperatures had been incubated further on malt agar at 21°C, and subcultures have been made at convenient intervals. Their increase in colony diameters and of decay ability have been tested once again after a period of six months storage.

Results and Discussion

The results of tests of cultures made within 30 days of heat treatment is shown in Appendix tables 24a, 24b, 26 and illustrated in text figure 17.

It can be seen from the results that the first transfers made from the most vigorously growing sectors of the treated culture tended to grow better than transfers of the slow growing sector. However, both of these differently affected parts were significantly slower in their

growth than the parent culture (P = 0.05).

No differences in the decay ability were found between the treated cultures and the parent control (P = 0.05).

The results of tests made of cultures which had been stored on malt agar for 6 months after the heat treatment are represented in Appendix tables 25a, 25b, 27 and illustrated in text figure 18.

In this test, the rate of increase of colony diameters of the cultures isolated from the fast growing sectors was not significantly different from that of the parent control. However, cultures isolated from slow growing sectors were just significantly lower than the parent control (P = 0.05).

No significant (P = 0.05) differences were found between the wood-decaying ability of the two growth forms (Table 5).

It must be mentioned that the results are of work on one strain only (Strain 8).

A further investigation has been started in this Department in collaboration with Mrs D. Leake. In the first experiment, the period at 40°C needed to stop all further growth of a colony has varied from 10 minutes to 20 minutes with three different strains. This work is being continued.

Table 5. Comparison of variances of wood decaying ability of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperatures for different periods of time.

	Percent of weight loss		Breaking Strength	
	Test (1)	Test (2)	Test (1)	Test (2)
Mean	34.8%	28.4%	137 Newtons	188 Newtons
Range	-29.8 +30.2	-21.4 +30.6	-137 +263	-188 +252
Variance	346.0	273.6	18086.1	16612.8
Standard deviation	18.6	16.5	134.5	128.9
95% Fiducial limit of true mean	±3.29	±2.92	±23.8	±22.8
	$F^{124}_{124} = 1.26$*		$F^{124}_{124} = 1.09$*	

* Not significant at 0.05 level.

(1) Results of tests of cultures made within 30 days of heat treatment.

(2) Results of tests made of cultures which had been stored on malt agar for 6 months after the heat treatment.

(For detailed results see Appendix tables 24a, 24b, 25a, and 25b.)

FIGURE 17

Comparison of saprophytic ability of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperature for different periods of time.

(1) Results of tests of cultures made within 30 days of heat treatment.

Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 5 Parent culture (Strain 8).

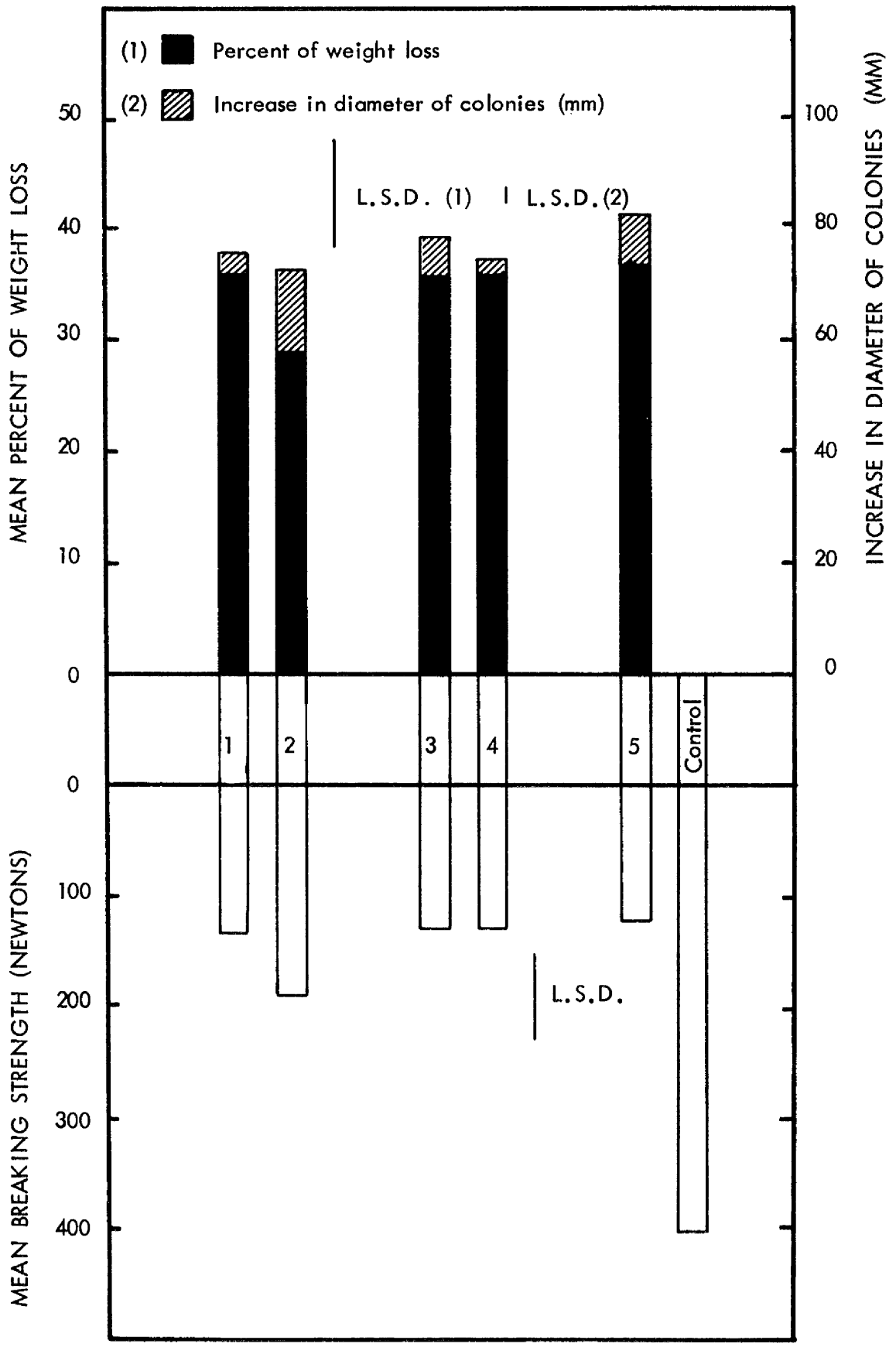

(1) Percent of weight loss
(2) Increase in diameter of colonies (mm)
L.S.D. (1)
L.S.D.(2)
MEAN PERCENT OF WEIGHT LOSS
INCREASE IN DIAMETER OF COLONIES (MM)
MEAN BREAKING STRENGTH (NEWTONS)
50
40
30
20
10
0
100
80
60
40
20
0
0
100
200
300
400
1
2
3
4
5
Control
L.S.D.

FIGURE 18

Comparison of saprophytic ability of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperatures for different periods of time.

(2) Results of tests made of cultures which had been stored on malt agar for 6 months after the heat treatment.

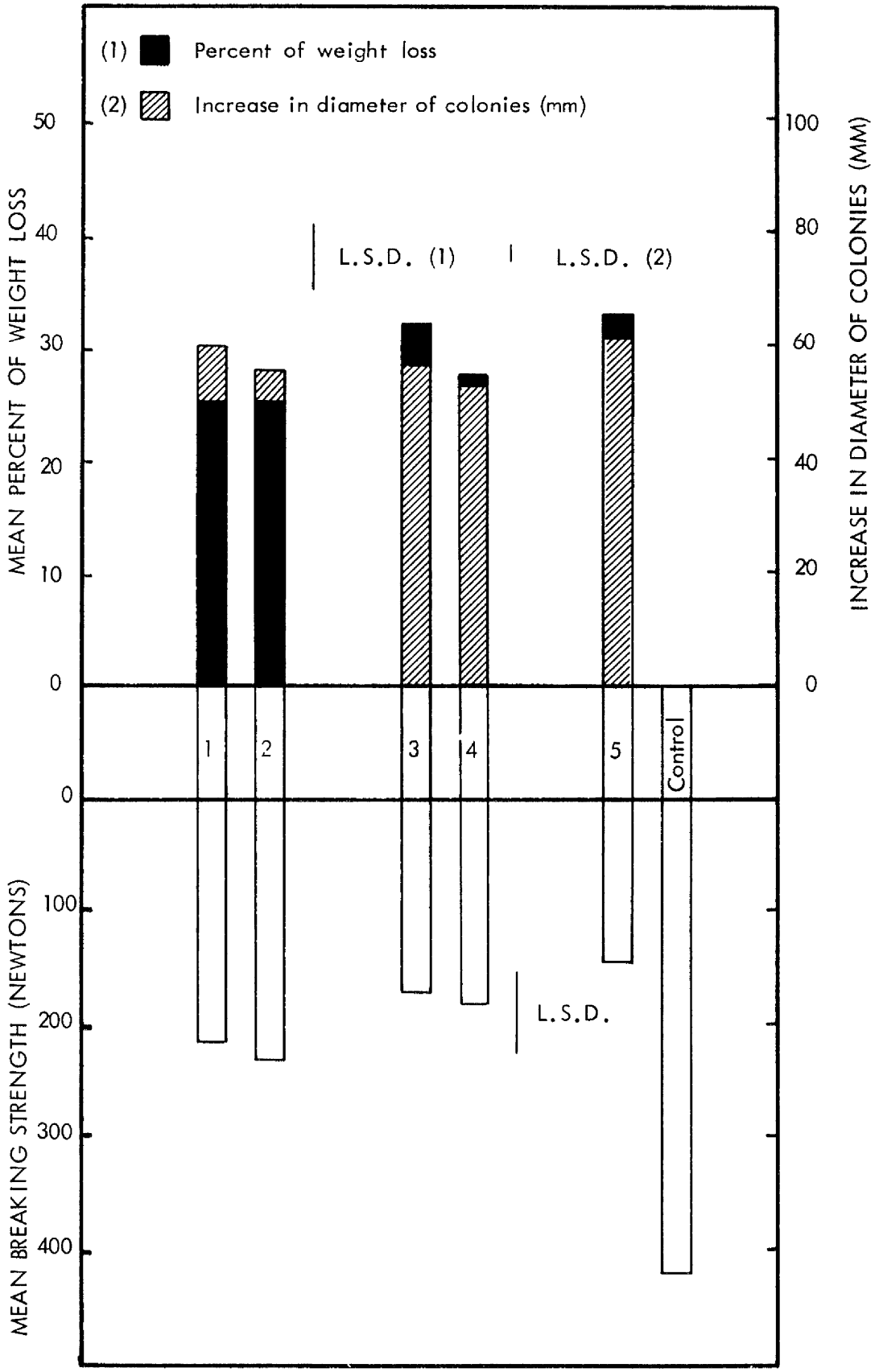
Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 5 Parent culture (Strain 8).


(1) Percent of weight loss
(2) Increase in diameter of colonies (mm)
MEAN PERCENT OF WEIGHT LOSS
INCREASE IN DIAMETER OF COLONIES (MM)
MEAN BREAKING STRENGTH (NEWTONS)
50
40
30
20
10
0
100
80
60
40
20
0
0
100
200
300
400
L.S.D. (1)
L.S.D. (2)
L.S.D.
1
2
3
4
5
Control

PART 6

Comparison of wood-decay ability of strains of *S. lacrimans* on common building timbers

Introduction

It would be inappropriate here to attempt to review the whole of the work on relative durability of wood from different species of tree when exposed to fungal attack. It is common knowledge from this that woods can be graded into many rough categories of durability, e.g. softwoods are generally likely to decay faster than most hardwoods, teak and oak are generally durable, beech and birch are liable to decay quickly.

This survey of activity on wood of *Pinus sylvestris* has therefore been extended in a minor way by the examination of the effects of a few representative strains on four other timbers, e.g. Norway Spruce (*Picea excelsa* (Lam) Link), Sitka Spruce (*Picea sitchensis* Carr.), Beech (*Fagus sylvatica* L.) and Oak (*Quercus* spp.). These were chosen arbitrarily as a range which were conveniently available locally.

Methods

All tests were carried out with the standard methods described in Part 1. Five replicate Roux bottles each containing 5 pieces of wood were used for each treatment.

The wood used in the experiment were kindly supplied by Robinson Dunn & Co. in Glasgow.

Results

The results are recorded in Appendix 5, Tables 28a, 28b and illustrated in text Figure 19.

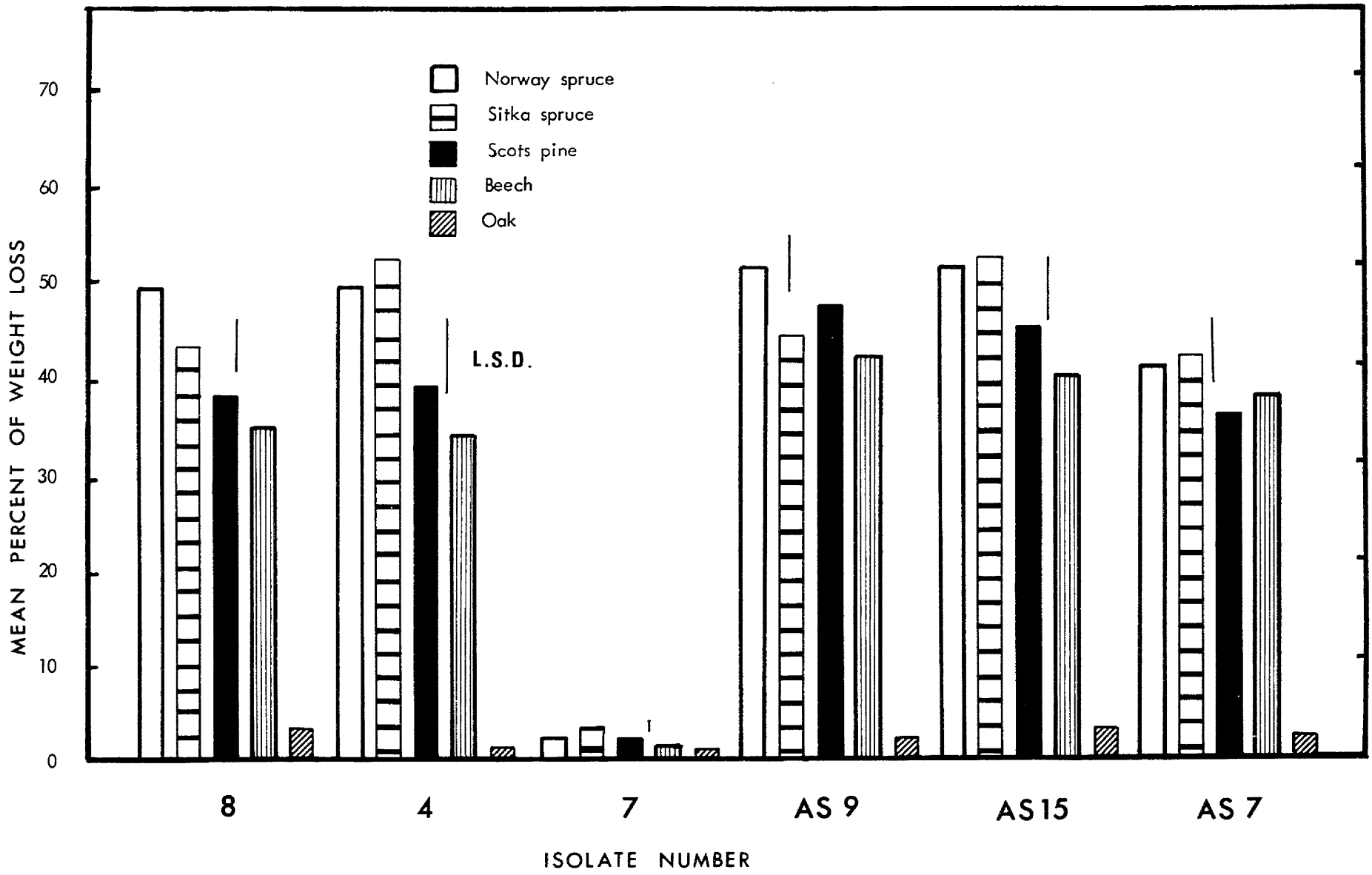
Conclusion

The patterns followed that of the survey with P. sylvestris. They suggest that Sitka Spruce wood might be a more sensitive "indicator" than that of Pinus sylvestris, but no useful, new information is likely to be obtained by using a greater range of test woods in the routine survey.

It may be that differences in relative saprophytic ability on more resistant woods might be shown if measurements were made after a much longer investigation period.

FIGURE 19

Histogram showing the comparison of wood decaying abilities of three dikaryotic (8, 4, 7) and three monokaryotic (AS9, AS15, AS7) cultures of S. lacrimans on five common building timbers.


Norway spruce
Sitka spruce
Scots pine
Beech
Oak
L.S.D.
MEAN PERCENT OF WEIGHT LOSS
0
10
20
30
40
50
60
70
8
4
7
AS 9
AS15
AS 7
ISOLATE NUMBER

PART 7

Extension to other biological studies; the effect of mechanical damage to mycelium of the fungus

Introduction

Irregularities in the growth from different inoculae of S. lacrimans used during isolation work drew our attention to the possible relationships of inoculum size to survival of the transferred mycelium.

This work was intended as a preliminary investigation, and the main object of the work was to study the possibility of the survival of different lengths of hyphal tip inoculae after their severance from the parent hypha, and to see whether any of these fragments continued growth to form colonies.

The work has also continued to some extent to identify the nuclear arrangement within each of these hyphal apical cells. The correlation of these factors to inoculum size has been subject to further studies. Very little is known concerning these factors in S. lacrimans.

Materials and Methods

A thin layer of 2% malt agar medium was poured into a 9 cm petri dish and inoculated at the centre with a small inoculum (approx. 7 mm in diameter). All inoculum discs were cut from the margins of actively growing culture (Strain 8).

The cultures were incubated for one week at 21°C. The plates were then placed under a binocular microscope, and selected hyphal tips were cut off from the colonies by use of a glass needle on a micromanipulator. Cuts were made at different distances from the edge of the colony. Pieces of agar with the hyphal tips were then transferred to another sterilized petri dish containing a wet filter paper and incubated further at the same temperature.

Linear growth of the isolated hyphal tips was measured with a micrometer eyepiece. Measurements were taken at intervals of six and twelve hours for four days beginning at least two hours after the discs of the agar were cut out from the edge of the colony.

Cytological study

A fluorescent technique has been used to determine the nuclear distribution within each of these apical cells. This method has been used and developed by Milne (1967). The procedure employed was as follows:-

Sterilized cover slips were placed on top of the agar surface close to the edge of 5 days old colonies. The fungus was allowed to grow over the cover slip until the latter was half covered (usually takes 2-3 days). Coverslips were then removed and stained by the following technique:-

(1) Fix in Carnoys solution [30 ml Absolute alcohol; 5 ml Glacial acetic acid; 15 ml Chloroform] by adding a few drops onto the surface of the coverslip and allowing it to evaporate off.

(2) Stain with acridine orange [25 mg acridine orange, N Michrom NO87, kindly supplied by Dr D.D. Clarke, per one litre of phosphate buffer, pH 7.0] for ½-1 minute, the exact time varied and was determined by experiment.

(3) Rinse in phosphate buffer for 30 seconds, mount in fresh phosphate buffer and examine immediately under blue fluorescent light. The nuclei of stained hyphal tips fluoresced yellow/green.

Results and Conclusion

The results are recorded in text tables 6, 7 and illustrated in Plate 8.

Experimental observations with different lengths of hyphal tip inoculae have shown that pieces which are more than 100 μ may be viable inoculae, but those which are less than 100 μ long do not survive.

Pieces, however, between 100 μ and 1000 μ long have shown much variation in growth rate after severance from their parent hypha.

The results also have shown that apical cells are generally 100 μ to 200 μ long, and nuclei tend to lie in the centres of the cells. These results support the hypothesis that the minimum length of hypha which is a viable inoculum is one which contains at least one complete "cell".

Table 6. Measurements of length (μ) of hyphae growing from hyphal tip inoculae of different lengths.

No. of hyphae	Length after further incubation at 21°C					
	Original lengths of inoculum (μ)	Length after 24 hrs	Length after 48 hrs	Length after 60 hrs	Length after 70 hrs	Length after 84 hrs
1	1000	1300	1450	1580	1650	1820
2	840	900	1220	1440	1500	1620
3	720	950	1300	1420	1440	1480
4	550	590	610	620	640	660
5	490	530	550	590	590	600
6	400	480	500	540	540	540
7	380	430	430	470	470	490
8	210	300	350	350	410	430
9	140	270	330	365	410	420
10	350	360	380	400	400	400
11	320	350	350	360	360	360
12	200	240	260	290	320	350
13	130	180	180	210	230	260
14	240	240	260	260	260	260
15	180	180	180	190	190	190
16	60	80	90	90	90	90
17	50	70	70	90	90	90
18	80	80	80	80	80	80
19	70	70	70	70	70	70
20	60	60	60	60	60	60

Table 7. Measurements of the length of apical cells and relative position of nuclei of different hyphal tips.

No. of apical cell	Length of the apical cell (μ)	Distance between first nucleus and tip of the apical cell (μ)	Distance between second nucleus and tip of the apical cell (μ)
1	97	50	67
2	111	45	62
3	149	60	82
4	159	57	97
5	108	48	68
6	130	50	70
7	165	97	108
8	149	69	100
9	124	52	76
10	100	47	57
11	119	41	65
12	119	63	81
13	116	49	68
14	154	87	105
15	113	54	65
16	108	64	84
17	100	55	78
18	135	76	92
19	95	35	51
20	97	54	70

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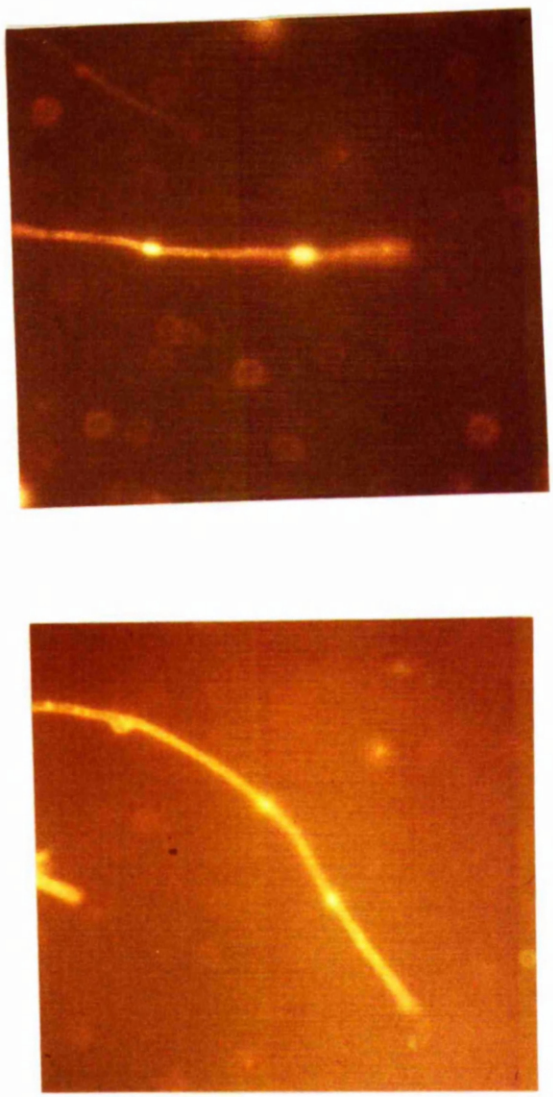

10μ

Plate 8. Photographs showing the nuclei of different hyphal tips stained with acridine orange and viewed in blue fluorescent light.

PART 8

CONCLUSIONS

The aim of the work described in this thesis was to investigate the variation in wood-decaying ability of isolates of S. lacrimans, and to study the factors contributing to any differences found.

The following main conclusions may be stated:

(1) There is a substantial difference in saprophytic ability among various strains of the fungus. This may be an important factor which could influence the degree of risk which might be taken in remedial work.

(2) No consistent relationship could be demonstrated between the rate of increase of colony diameter of monokaryotic and dikaryotic isolates and their ability to cause decay of wood. A close and consistent relationship was, however, observed between saprophytic ability and enzyme activity of 6 strains of the fungus.

(3) It is interesting to note that the monokaryotic cultures generally had a greater ability to cause decay than the dikaryotic cultures.

This was so for dikaryotic cultures taken from sporophores tissue compared with monokaryons made from single spores isolated from these sporophores, and to dikaryons established artificially by pairing monokaryons of known activity.

Formal genetical analysis showed that this may be controlled by different systems in different populations.

These findings may provide useful information regarding fungus control in the field. They have also proved interesting to geneticists

who are developing them further.

It is possible to expand this work so as to serve the long-term objective of looking for patterns of the geographical distribution of differences in wood-decaying ability. It can also be extended to cover the study of variation in other characteristics affecting field decay, e.g., possible differences in ability to transfer water along hyphae in relation to different external humidity gradients.

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APPENDICES

APPENDIX 1

Cultural data and source of isolates of Serpula lacrimans used in the present investigation.

Isolate No.	Collection Source	Locality	Date of Collection
1	Isolated from diseased wood from Bute Hydro Hotel, Rothesay. (Glasgow University Collection)	Rothesay	Established 17.4.71.
2	Isolated from Sporophore from Lily-bank Gardens, Glasgow W2.	Glasgow	Established 19.10.71.
3	Isolated from Sporophore from house at Hampton Hill; received from Forest Products Research Laboratory, England. Culture No. 12C.	Middlesex	Established 1947 and received 25.10.71.
4	BAM (Ebw) No. 315. Received from Eberswalde 1936 as stamn Urdingen Ebw 315. Cen test stain 1971 received from FPRL, England. Culture No. 12D.	Eberswalde	Established 1936 and received 25.10.71.
5	Isolated from Sporophore collected from house at Dowanside Road, Glasgow W2.	Glasgow	Established 29.9.71.
6	Origin not known, but believed to have been isolated circa 1917. Received from FPRL, England. Culture No. 12.		Established 1917 and received 25.9.71.
7	From Uerdingen as M. domesticus. Received from FPRL, England. No. 12B.	Uerdingen	Received 25.9.71.
8	Received from Forest Products Research Laboratories, England. No. 169A.		Received 25.9.71
9	Isolated from aerial mycelium collected from the cellar of a house in Mill Lane, Liverpool. University Collection. LU6.	Liverpool	Established Dec. 1971 and received 4.2.72.
10	Germinated from basidiospores collected from a sporophore produced on acidity malt agar, Liverpool University Collection. LU7.	Liverpool	Established April 1971 and received 4.2.72.
11	Germinated from basidiospores collected from a sporophore from Lily-bank Gardens, Glasgow W2.	Glasgow	Established 10.1.72.

Isolate No.	Collection Source	Locality	Date of Collection
12	Obtained from Centraal Bureau Voor Schimmelcultures, Baarn, Netherlands. Culture No. 217.29.	Netherlands	Received April 1972.
13	Isolated from Sporophore collected from a house at Deanston Drive, Glasgow.	Glasgow	Established 28.4.72.
14	Isolated from infected wood from a house at West Princes Street, Glasgow, W2.	Glasgow	Established 9.5.72.
15	Polysporous culture isolated from building timber in a house in the Hague. Received from Plant Research Institute, Dept. of Agriculture, Mycology Section, Canada. Schure No. 11.	Hague Netherlands	Established Nov., 1958. Received 6.6.72.
16	Culture from Sporophore collected near Leiden in Oegstgeest, Netherlands, and received from Plant Research Institute, Canada. Schure No. 15.	Oegstgeast Netherlands	Established 29.4.59 and received 6.6.72.
17	Tissue culture from Sporophore on Picea glauca board covering a wall in a basement of house in Ottawa. Obtained from Plant Research Institute, Canada. Culture No. 5435.	Ottawa	Established 14.5.57. Received 6.6.72.
18	Obtained from Centraalbureau, Baarn, Netherlands. Culture No. CO5-235-33.	Netherlands	Received 6.6.72.
19	Isolated from Sporophore collected from house at Newton Place, Glasgow.	Glasgow	Established 10.8.72.
20	Germinated from basidiospores collected from a sporophore from a house at Hillhead St., Glasgow W2.	Glasgow	Established 10.10.72.
21	Isolated from rot in a board of "buckeye" in a garage with associated sporophore. Received from Forest Products Laboratory, Madison, Wisconsin, U.S.A.	North Carolina U.S.A.	Established Oct., 1946. Received 22.12.72.
22	Received from Department of Botany, University of Cambridge.	Cambridge	Received 25.11.72.
23) 24) 25)	Received from Department of Forest Products, Royal College of Forestry, Stockholm, Sweden. Culture Nos. A102, A109 and A332BAM respectively.	Stockholm	Received 11.12.72.
26	Isolated from Sporophore collected from Garscube, Glasgow N.W.	Glasgow	Established 20.7.73.

Isolate No.	Collection Source	Locality	Date of Collection
27	Isolated from sporophore collected from a church at Bromm Hill, Glasgow G11.	Glasgow	Established 14.8.73.
28	Isolated from decayed wood collected from old building at Park Circus, Glasgow C3.	Glasgow	Established 6.12.73.
29	Isolated from sporophore collected from Garscube, Glasgow, NW.	Glasgow	Established 13.12.73.
30	Isolated from basidiospores collected from sporophore from old building at Park Circus, Glasgow, C3.	Glasgow	Established 10.1.74.
31	Isolated from infected wood from a house at Dumbarton Road, Glasgow, W4.	Glasgow	Established 12.1.74.
32	Isolated from sporophore collected from an infected house at Dumbarton Road, Old Kilpatrick, Glasgow.	Glasgow	Established 7.3.74.
33	Isolated from sporophore collected from a house at University Gardens, Glasgow, W2.	Glasgow	Established 28.3.74.
34	Isolated from sporophore collected from an infected house at Park Terrace, Glasgow, C3.	Glasgow	Established 1.4.74.
35	Isolated from decayed wood collected from Shawlands area, Glasgow, W.	Glasgow	Established 2.4.74.
36	Isolated from decayed wood collected from an infected house in Southpark Avenue, Glasgow, C3.	Glasgow	Established 10.4.74.

APPENDIX 2

The Relationship between Breaking Strength of Pinus sylvestris Sap Wood and the Orientation of Grain and Breaking Force.

The work in this Appendix has been done under the supervision of Dr S.A. Hutchinson; Mrs D. L. Leake assisted in the technical aspects of the project.

Introduction

Selection of timber to fine limits of uniformity is expensive and time consuming. In particular, selection for uniformity of grain orientation involves wasteful sawing angles which can only be set up on elaborate saw benches. This investigation examines the value of such a selection in relation to a current survey of decay potential of Serpula lacrimans; its findings may be useful in other work.

Materials and Methods

A plank of sap wood of Pinus sylvestris was sawn to yield strips 90 cm x 1 cm x 0.5 cm, each with longitudinal grain in which the annual rings lay at an angle α between 0° and 45° to the narrow long edge. Three of these strips were chosen in which angle $\alpha = 0°$, and three were chosen in which it lay between 10° and 45°. Each of the six strips was then sawn transversely to yield fourteen 6 cm x 1 cm x 0.5 cm pieces. The pieces were dried for 12 hrs at 100°C; they were then weighed, angle α for each block was measured, and their breaking strength across the narrow long axis (A-A Fig. 1) was measured with a Hounsfield Tensometer.

In a confirmatory test six similar strips were cut from a plank of sap wood of Pinus sylvestris from a different source, three with angle $\alpha = 0°$, three with angle α between 10° and 45°. Two similar pieces were cut from each end and two were cut from the middle of each strip. They were dried for 12 hrs at 100°C, and one of each pair of pieces was then immersed in deionised water for ten minutes. Angle α was measured as above.

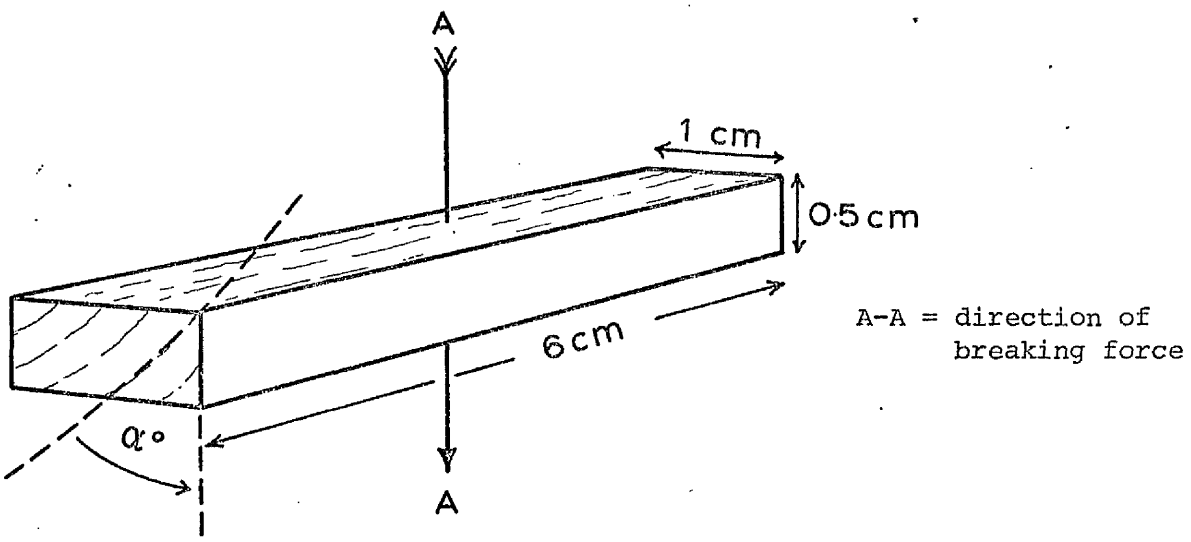


Fig. 1

Dimensions and orientation of test pieces

Results

The results are recorded in Figures 2 and 3, and summarised and analysed in Tables 1 and 2.

Discussions and Conclusions

In the principal experiment the mean breaking strength of population ABC (α between 10° and 45°) is significantly lower than that of population DEF (α = 0°) [t = 6.5], but the difference between the variances of the two is not significant [$F^{41}_{41} = 1.2$]. The varienace of the total population ABCDEF (α between 0° and 45°) is just significantly bigger than that of the selected population DEF [$F^{83}_{41} = 1.8$]. This is obviously the result of combining two populations with significantly different means, though the variance of each is similar.

Empirical judgement of Table 1 and Figure 3 shows that there is no significant difference between the variances of the total population ABCDEF and that in which α lies between 0° and 34° (ACDEF). There is a significant difference between the variance of the total population ABCDEF and that in which α lies between 0° and 26° (CDEF) [$F^{83}_{55} = 1.65$]. The further sorting of the population for α = 0° (DEF) obviously has no significant additional effect on variance. The results of the confirmatory

experiment (Table 2) agree generally with these, and they give no evidence to suggest that variance in wet samples is less than that in dry ones.

The relevance of these results to the design of decay tests for wood rotting fungi depends on the possibility of grain angle having other unmeasured effects on decay rates, and on the fineness of the measurements required. The first possibility seems unlikely in these conditions. The sorting of the pieces for a population with α between 0° and 26° recorded above resulted in a reduction of the 95% Fiducial Limit from ± 123 Newtons to ± 96 Newtons. In current tests with Serpula lacrimans differences of the order of 30 to 300 Newtons have been recorded; if the possibility of other effects can be discounted this improvement in sensitivity by ± 30 Newtons does not appear to justify the waste of material and cost of labour involved in this selection. Some useful ad hoc selection might be done if finer judgement of virulence is required, but the relationship of breaking strength to density suggested by Figure 2 indicates that piece weight might be a more useful first criterion. Density is also more likely to have a direct effect on rate of penetration by fungal hyphae, which might be a significant variable in tests.

The variance between strips is significantly greater than the variance between pieces in these tests. This is more likely to be a reflection of the large number of replicate pieces and the small number of strips than a measure of a real pattern of difference in the plank.

Table 1. Analysis of Breaking Strength Measurements of a Population of Pieces

Groups of strips from which pieces were cut	No. of pieces in samples	Range of angle α	Mean Breaking Strength	σ Newtons	95% Fiducial Limits
ABC	42	10° to 45°	350	44	± 85
DEF	42	0°	440	47	± 93
ABCDEF	84	0° to 45°	390	63	± 123
CDEF	56	0° to 26°	430	49	± 96
ACDEF	70	0° to 34°	410	65	± 128

Table 2. Analysis of Breaking Strength Measurements and Comparison of Variability of Measurements of Populations of Wet and of Dry Pieces

		Wet Pieces			Dry Pieces			
Groups of strips from which pieces were cut	Range of angle α	No. of pieces in sample	Mean Breaking Strength	σ Newtons	95% Fiducial Limit	No. of pieces in sample	Mean Breaking Strength	σ Newtons	95% Fiducial Limit
GHI	10° to 45°	18	270	32	± 51	18	360	32	± 51
JKL	0°	18	290	51	± 101	18	390	40	± 71
GHIJKL	0° to 45°	36	280	42	± 82	36	380	37	± 73

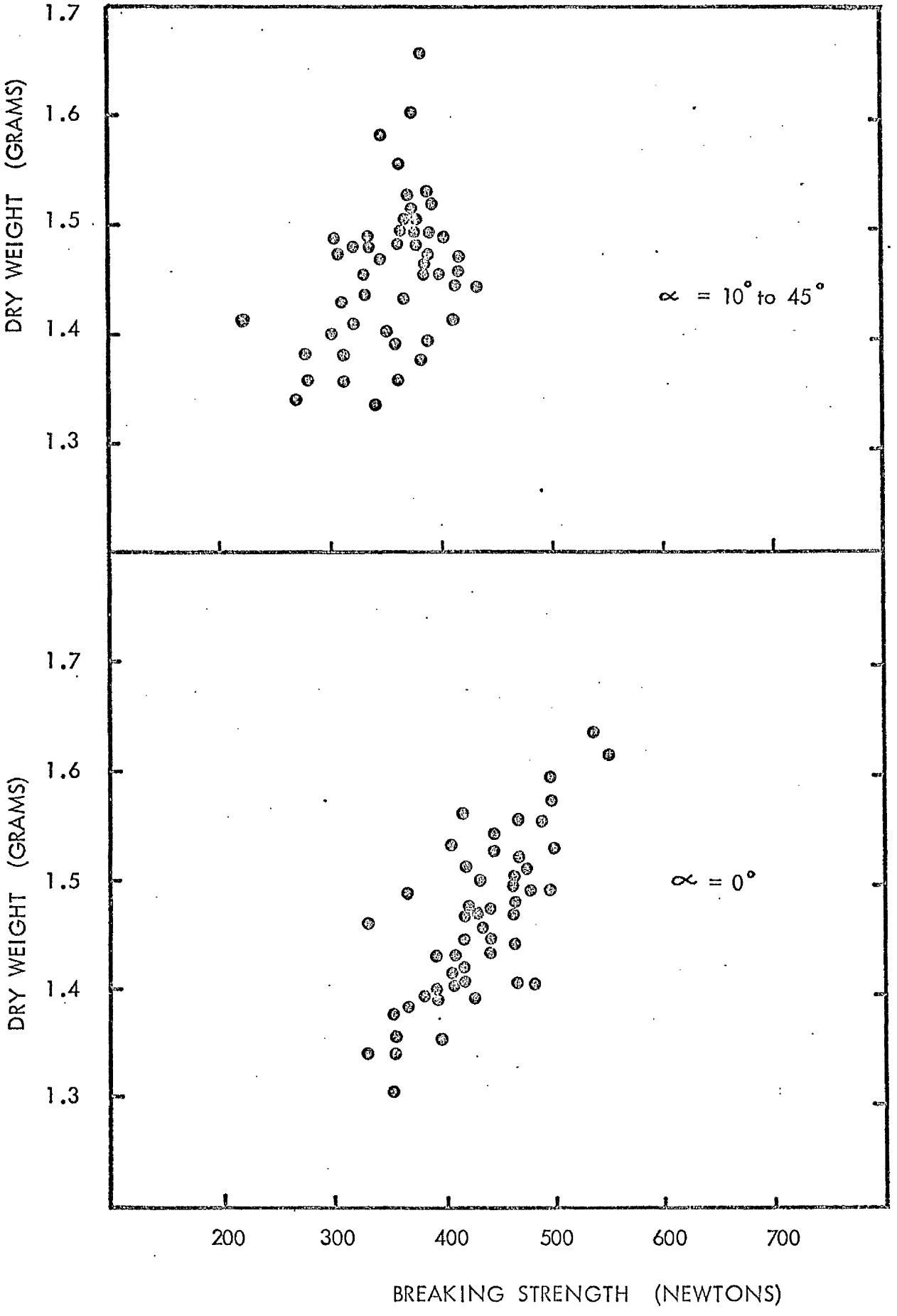


Figure 2. Comparison of weights and breaking strengths of two populations of wooden pieces.

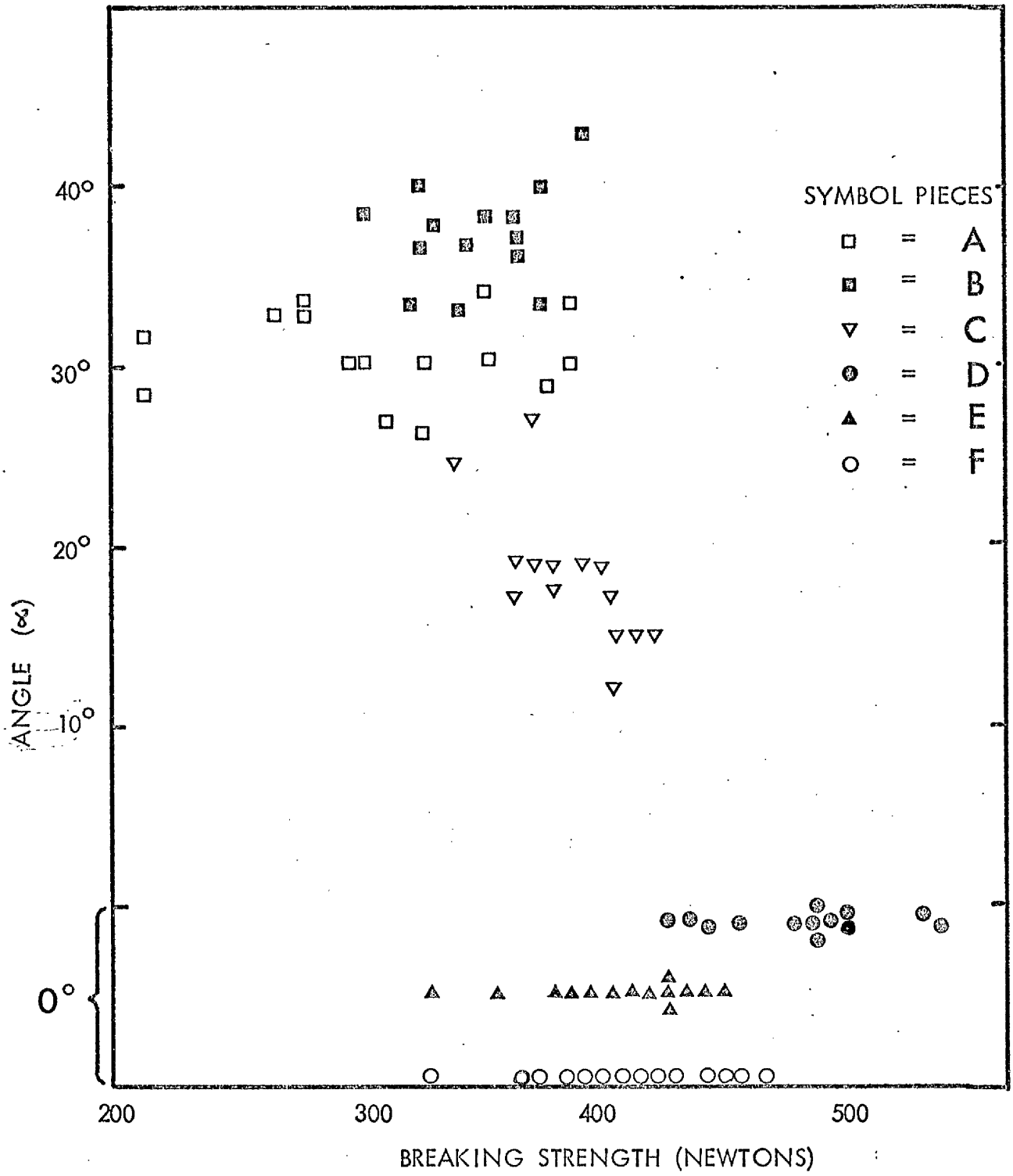


Figure 3. Comparison of breaking strength of wooden pieces and orientation of annual rings to the direction of breaking force.

APPENDIX 3

The effect of drying a sample of sapwood of Pinus sylvestris on the consistency of measurements of its cross-grain breaking strength

100 test pieces each 60 mm x 10 mm x 5 mm, cut from a single plank of even grained P. sylvestris showing approximately 4 rings per cm. The cuts were made so that the rings were approximately parallel to the narrow longitudinal axis. The pieces were dried at 110°C to constant weight. Half the pieces, chosen at random, were then immersed in tap water in a sealed container. The atmospheric pressure in the container was reduced to a few mm of Hg for 10 minutes, then allowed to return to normal. This process was repeated once. The pieces were then removed from the water and superficial water was shaken off. The breaking strength across the grain radial to the tree was then measured by a three point bending attachment on a Hounsfield Tensometer (of. Fig. 4).

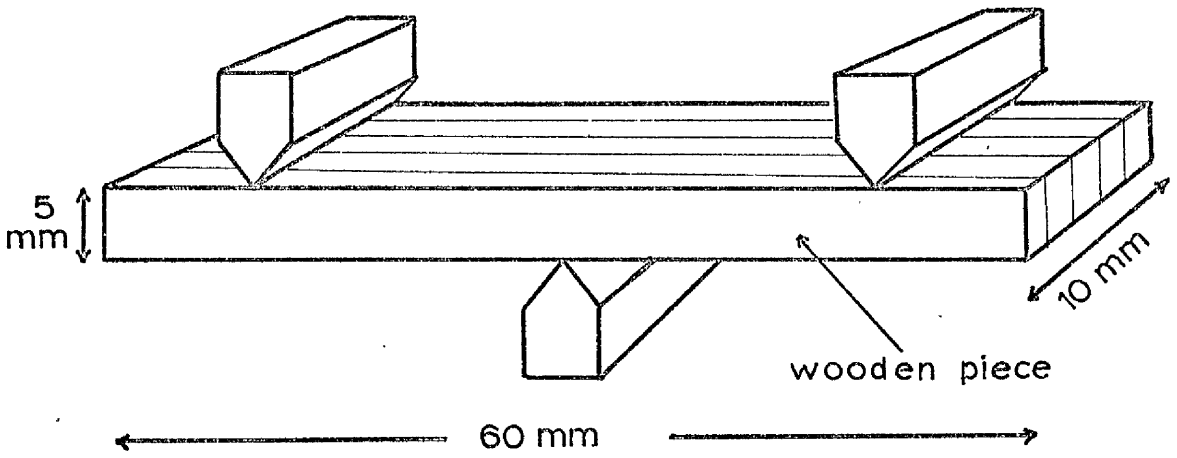


Fig. 4. Diagram of standard wooden pieces in 3-point bending machine.

The tests were carried out in a continuous series at uncontrolled laboratory temperature and humidity, and they took two hours to complete. The results are shown in Fig. 5 and Tables 3 and 4.

Table 3. Comparison of range of measurements of breaking strength of wet pieces and dry pieces of P. sylvestris sapwood

	Wet Pieces	Dry Pieces
Mean breaking strength	223 Newtons	393 Newtons
Range	-93 +127 Newtons	-103 +157 Newtons
Variance	2121	3055
Standard deviation	46.1	55.2
95% Fiducial limits of true mean	± 13.2 Newtons	± 15.8 Newtons

$F_{49}^{49} = 1.4$ $\leqslant 0.05$ significance

Discussion

The mean breaking strength is clearly significantly different in the two populations without mathematic analyses, but the difference in the variance of the two populations is not significant in this test. The shape of Figure 5 suggests that greater consistency might well be found in the "wet" groups if more individuals were measured. The additional information is unlikely to justify the effort involved in many investigations, however; in the current survey useful information has been obtained from comparison of 25 individuals per treatment, in which the effect of wetness or dryness at testing would be less likely to be significant. It is therefore concluded that for this work the choice may be determined by convenience of other factors; e.g. it seems likely that errors due to crushing at the three suspension points in the bending test will be increased with wood softened by fungal attack, and that this would be minimised by measuring dry wood.

Table 4. Comparison of variability of breaking strength (Newtons) of measurements of populations of wet and dry pieces of *P. sylvestris* sapwood.

DRY PIECES

Group / Replicate	1	2	3	4	5
I	295	420	350	365	335
II	450	460	380	410	375
III	355	550	390	380	350
IV	340	370	500	385	410
V	355	390	410	470	430
VI	440	380	410	290	340
VII	385	370	420	420	420
VIII	345	375	430	440	350
IX	350	320	410	550	470
X	380	380	350	320	385
Mean	370	402	405	403	387

Analysis of variance

Source of variance	S.S.	°F	M.S.	V.R.
Between groups	9108	4	2277	0.73*
Within groups (error)	140586	45	3124	
Total	149694	49	3054.5	

L.S.D. = 50.5 Newtons

WET PIECES

Group / Replicate	1	2	3	4	5
I	290	170	245	135	190
II	195	270	210	230	190
III	190	225	150	220	175
IV	255	220	200	220	250
V	190	235	230	245	350
VI	300	250	200	260	205
VII	275	230	230	210	130
VIII	290	210	215	250	190
IX	230	210	185	230	260
X	185	210	340	220	130
Mean	240	223	221	222	207

Analysis of variance

Source of variance	S.S.	°F	M.S.	V.R.
Between groups	5510	4	1378	0.62*
Within groups (error)	98402	45	2187	
Total	103912	49	2120.7	

L.S.D. = 42.2 Newtons

* Not significant at 0.05 level

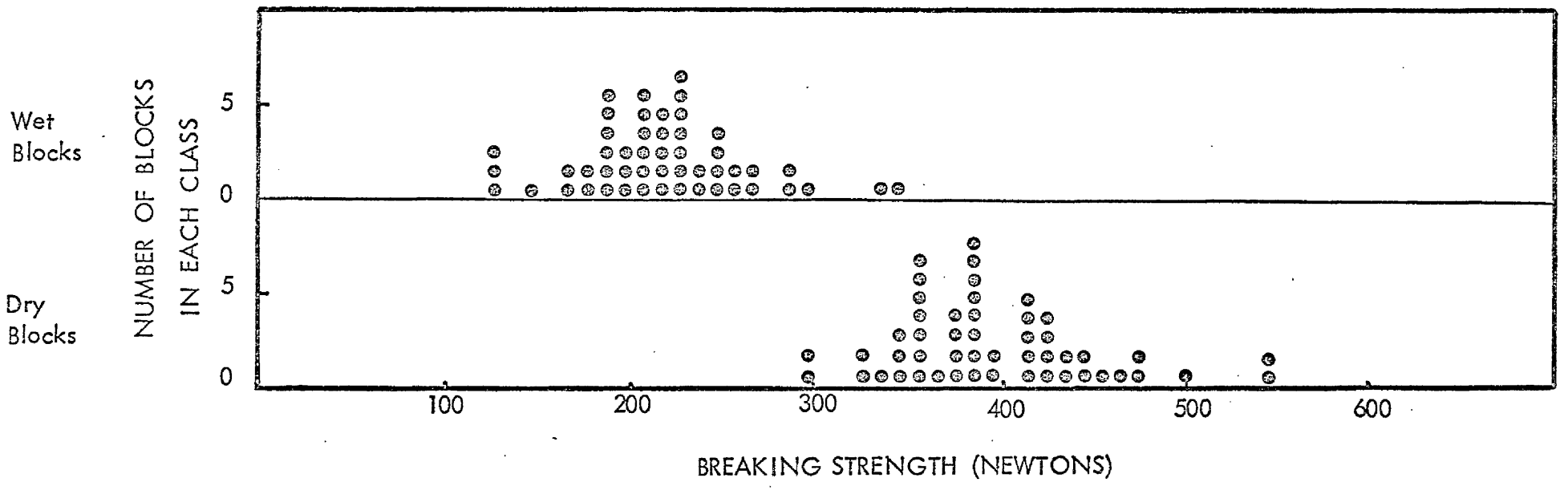


Figure 5. Distribution of cross grain breaking strengths of wet and dry samples of Pinus sylvestris sapwood.

APPENDIX 4

Initial Work made to Determine the Convenient Design for the Decay Experiments

This preliminary investigation was carried out to determine the period of incubation which would be suitable for our decay studies, and the amount of replication of cultures which would be required.

Methods

Five replicate cultures of each test strain were set up on 2% malt agar in Roux bottles and ten sterile test pieces were placed in standard pattern on the surface of each culture. One piece of wood was removed from each culture at fortnightly intervals (from 2-18 weeks), for drying, weighing and measurement of breaking strength. The results were compared with those of control pieces incubated in similar assemblies on uninoculated 2% malt agar.

Results

Tables of results are recorded in Appendix Tables 5-13 and summarised in Appendix Figure 6.

Discussion

From experimental observation, it was decided to examine the results after 4 weeks and after 10 weeks in detail.

Tables 6 and 9 show that range of difference in breaking strength between most individuals in each strain is generally small, except for the occurrence of a small number which give grossly lower readings than the others. At 4 weeks there were 6 of these (1 strain 2, 2 strain 4, 1 strain 9, 1 strain 10, 1 control) in 60 individuals, at 10 weeks there were 4 (2 strain 4, 2 strain 8) in 60 individuals.

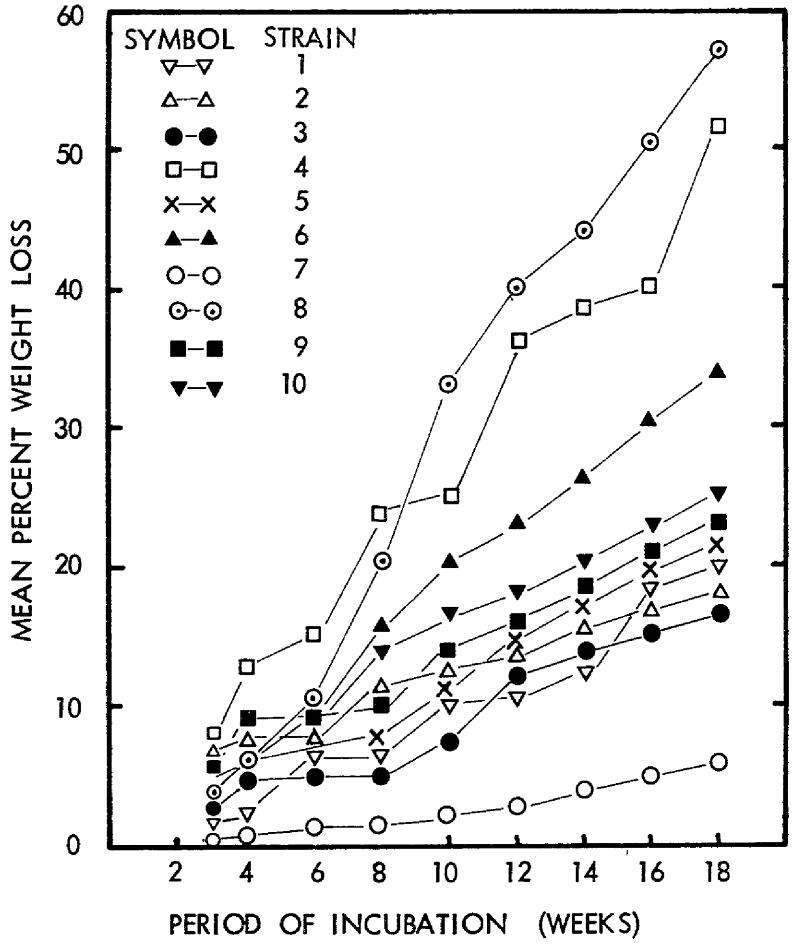
The consistency of general pattern of the results, and the close correlation between breaking strength and loss of dry weight (at 4 weeks = -0.133, at 10 weeks = -0.438) suggests that these erratic results were not due to experimental error in the use of the tensometer; it seems more likely that they are the result of differences between the wood of the test pieces. Their effects can therefore be reduced by increasing the number of pieces used for each experiment.

Hence, in a subsequent experiment the number of pieces tested was increased to 25, and the measurements were made at 4 weeks and 10 weeks only. The results (Figure 7) showed that 4 week measurements yielded little useful additional information to those from the 10 week measurement. Since the differences at 10 weeks were consistently bigger and easier to read, this period was chosen as a basis for the design of the main survey. This has produced a useful saving in apparatus, time, and labour involved in the measurements.

FIGURE 6

Graphs showing the mean percent of weight losses and reduction in breaking strength of test pieces of *P. sylvestris* decayed by 10 strains of *S. lacrimans* at various periods of incubation.

(Each point in these graphs is the mean of the measurements of five test pieces each taken from a separate culture.)


SYMBOL STRAIN
1
2
3
4
5
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MEAN PERCENT WEIGHT LOSS
0
10
20
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60
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8
10
12
14
16
18
PERIOD OF INCUBATION (WEEKS)

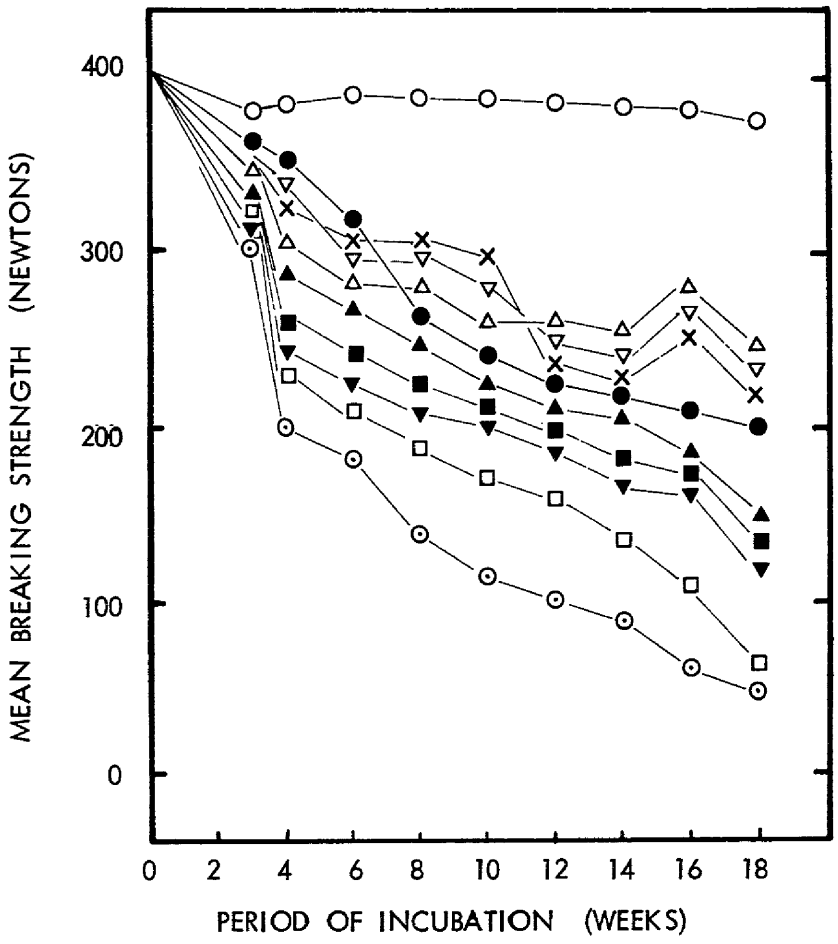
MEAN BREAKING STRENGTH (NEWTONS)
0
100
200
300
400
0
2
4
6
8
10
12
14
16
18
PERIOD OF INCUBATION (WEEKS)

FIGURE 7

Histograms showing the mean percent of weight losses and reduction in breaking strength of test pieces of P. sylvestris sapwood decayed by 10 strains of the fungus at 4 and at 10 weeks incubations.

(Each column in these histograms represents the mean of the measurements of five test pieces in each of five culture bottles.)

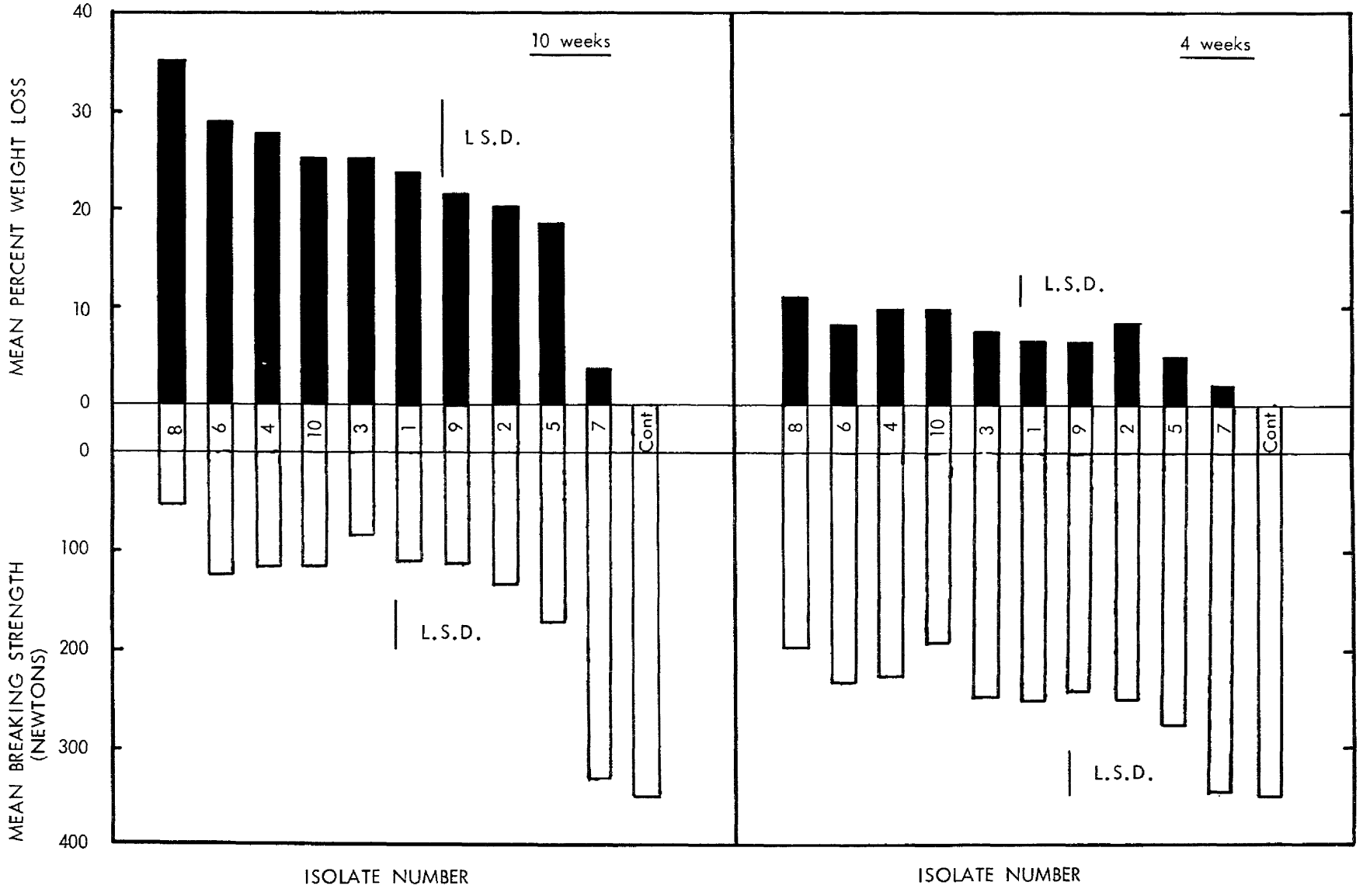
40
30
20
10
0
0
100
200
300
400
MEAN PERCENT WEIGHT LOSS
MEAN BREAKING STRENGTH (NEWTONS)
10 weeks
4 weeks
L.S.D.
L.S.D.
L.S.D.
L.S.D.
8
6
4
10
3
1
9
2
5
7
Cont
ISOLATE NUMBER
ISOLATE NUMBER

TABLE 5. Changes in measurement of decay of pieces of Pinus sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 3 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10
1	2	3	7	11	4	9	1	7	0	4
2	2	9	2	3	5	3	1	3	3	4
3	1	3	5	5	3	0	0	5	2	9
4	2	12	0	12	4	5	2	10	1	5
5	2	2	5	2	4	3	1	6	1	2
Mean	1.8	5.8	3.8	6.6	4.0	4.0	1.0	6.2	1.4	4.8

B. Breaking Strength (Newtons) of wood pieces after 3 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10	Control
1	345	350	300	355	335	290	325	270	320	375	300
2	350	290	410	325	360	340	420	305	325	335	460
3	350	340	350	320	370	310	400	315	380	170	390
4	330	300	390	310	320	390	395	290	300	375	385
5	325	360	350	330	400	350	380	270	360	335	380
Mean	340	328	360	328	357	336	384	290	337	318	383

TABLE 6. Changes in measurement of decay of pieces of Pinus sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 4 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10
1	2	18	3	20	3	3	1	6	10	12
2	1	10	8	6	5	14	2	9	4	8
3	3	1	2	20	12	7	0	6	11	12
4	3	3	4	11	2	11	1	14	13	10
5	4	1	3	5	7	7	2	8	10	2
Mean	2.6	6.6	4.0	12.4	5.8	8.4	1.2	8.6	9.6	8.8

B. Breaking Strength of wood pieces after 4 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10	Control
1	350	50	310	140	420	280	460	260	320	330	450
2	330	350	360	300	360	270	370	220	290	160	420
3	330	360	420	130	260	300	340	225	140	250	360
4	340	420	330	270	310	320	440	190	260	180	330
5	320	370	350	330	300	290	350	190	270	300	410
Mean	334	310	354	234	330	292	392	217	256	244	394

TABLE 7. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 6 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10
1	6	4	2	12	4	12	2	5	13	12
2	2	27	7	4	5	10	2	10	6	7
3	11	3	2	14	11	5	2	10	11	14
4	6	2	11	36	5	14	1	21	12	5
5	7	1	5	6	6	11	2	9	10	9
Mean	6.4	7.4	5.4	14.4	6.2	10.4	1.8	11.0	10.4	9.4

B. Breaking strength of wood pieces after 6 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10	Control
1	285	295	335	295	300	365	420	260	210	300	465
2	355	70	275	300	280	240	275	215	330	260	425
3	300	280	285	240	260	345	420	150	200	130	340
4	275	360	310	25	365	185	435	115	190	210	415
5	285	400	360	210	265	200	420	240	220	190	530
Mean	300	281	313	214	294	267	394	196	230	218	435

TABLE 8. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 8 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10
1	10	16	4	15	13	8	1	41	9	14
2	6	9	7	29	7	12	2	11	19	22
3	3	20	4	10	9	16	2	11	13	15
4	6	5	7	57	4	9	2	35	10	11
5	7	5	5	9	7	26	2	7	8	6
Mean	6.4	11.0	5.4	24.0	8.0	14.2	1.8	21.0	11.8	13.6

B. Breaking strength of wood pieces after 8 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10	Control
1	330	80	350	290	310	335	400	30	220	200	480
2	300	290	235	20	260	255	405	200	150	160	500
3	285	230	350	345	270	235	420	265	170	180	455
4	350	355	210	10	355	350	385	25	250	220	425
5	290	390	155	270	275	150	395	275	320	305	420
Mean	311	269	260	187	294	265	401	159	222	213	456

TABLE 9. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 10 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10
1	17	9	6	23	9	29	3	41	20	22
2	7	18	9	11	11	12	2	28	9	12
3	5	14	8	17	8	18	1	25	11	10
4	9	11	9	14	16	29	2	35	15	19
5	8	7	10	60	8	10	2	18	18	18
Mean	9.2	11.8	8.4	25.0	10.4	19.6	2.0	29.4	14.6	16.2

B. Breaking strength of wood pieces after 10 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10	Control
1	200	300	220	150	280	190	375	30	165	140	390
2	290	220	270	250	220	230	380	160	235	180	410
3	310	230	200	190	290	245	420	185	210	210	470
4	300	290	310	230	310	200	400	25	230	240	460
5	320	240	260	10	300	245	405	205	200	260	450
Mean	284	256	252	166	280	222	396	121	208	206	436

TABLE 10. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 12 weeks incubation.

Strain No. / Piece No.	1	2	3	4	5	6	7	8	9	10
1	9	10	6	22	16	28	1	35	30	14
2	10	11	17	17	13	18	4	51	8	12
3	9	13	12	62	13	14	3	34	22	11
4	14	24	15	56	16	33	2	20	12	19
5	11	7	14	24	10	17	3	59	10	26
Mean	10.6	13.0	12.8	36.2	13.6	22.0	2.6	39.8	16.4	18.4

B. Breaking strength of wood pieces after 12 weeks incubation.

Strain No. / Piece No.	1	2	3	4	5	6	7	8	9	10	Control
1	280	200	215	250	280	200	410	130	120	175	455
2	290	220	200	270	285	250	350	20	210	215	485
3	305	280	210	0	220	275	380	150	180	230	455
4	175	210	225	5	200	110	405	190	260	190	295
5	200	340	220	285	265	240	370	0	280	120	395
Mean	250	250	214	162	250	215	383	98	210	186	417

TABLE 11. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 14 weeks incubation.

Strain No. / Piece No.	1	2	3	4	5	6	7	8	9	10
1	13	25	11	33	29	37	4	46	28	16
2	12	15	17	66	11	18	5	59	10	35
3	11	13	11	30	8	12	2	33	17	11
4	14	14	9	40	16	30	6	52	32	28
5	13	9	15	24	19	33	3	30	11	12
Mean	12.6	15.2	12.6	38.6	16.6	26.0	4.0	44.0	19.5	20.4

B. Breaking strength of wood pieces after 14 weeks incubation.

Strain No. / Piece No.	1	2	3	4	5	6	7	8	9	10	Control
1	310	220	200	160	225	160	390	90	155	240	370
2	200	250	185	0	260	240	370	35	225	70	375
3	245	240	195	185	265	260	420	135	200	200	420
4	195	230	280	25	220	220	350	70	100	160	400
5	250	320	240	235	180	180	385	140	260	190	445
Mean	240	252	220	121	230	212	383	94	188	172	402

TABLE 12. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 16 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10
1	10	38	13	30	13	24	4	61	14	9
2	15	15	14	59	11	17	2	48	23	38
3	32	11	12	50	18	40	6	32	29	15
4	13	3	32	48	23	35	8	57	18	42
5	17	16	9	25	28	33	3	51	26	11
Mean	17.4	16.6	16.0	42.4	18.6	29.8	4.6	49.8	22.0	23.0

B. Breaking strength of wood pieces after 16 weeks incubation.

Piece No. \ Strain No.	1	2	3	4	5	6	7	8	9	10	Control
1	260	85	205	125	280	220	380	0	210	265	390
2	295	250	220	0	295	280	410	60	180	70	430
3	100	310	260	0	250	70	370	90	160	210	470
4	355	350	150	260	200	110	365	20	200	45	450
5	265	260	200	190	170	135	400	35	120	220	450
Mean	255	251	207	115	239	163	385	41	174	162	438

TABLE 13. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by 10 strains of S. lacrimans.

A. Weight loss as % of original dry weight after 18 weeks incubation.

Strain No. / Piece No.	1	2	3	4	5	6	7	8	9	10
1	28	10	13	65	24	45	5	62	16	46
2	16	25	17	34	20	35	4	57	21	18
3	9	16	17	28	14	29	2	48	37	29
4	26	11	22	64	15	19	7	54	14	20
5	20	32	18	65	28	39	9	59	35	14
Mean	19.8	18.8	17.4	51.2	20.2	33.4	5.4	56.0	24.6	25.4

B. Breaking strength of wood pieces after 18 weeks incubation.

Strain No. / Piece No.	1	2	3	4	5	6	7	8	9	10	Control
1	160	300	220	0	250	35	390	0	200	20	350
2	250	180	195	120	240	130	395	55	170	190	375
3	320	240	200	190	245	200	410	65	60	100	460
4	230	270	180	0	230	260	380	40	210	130	430
5	190	150	205	10	150	80	355	35	70	200	440
Mean	230	228	200	64	223	141	386	39	142	128	411

APPENDIX 5

Table 14a. Changes in measurement of decay of pieces of Pinus sylvestris sapwood incubated for 10 weeks with 36 strains of S. lacrimans.

A. Weight loss as % of dry weight after incubation period.

Bottle No.	Piece No.	1	2	3	4	5	6	7	8	9	10	11	5	12	13	14	15	16	17	18	19	20	21	22	23	24	25	5	26	27	28	29	30	31	32	33	34	35	36	5
	1	48	39	27	41	30	33	4	58	16	32	16	33	25	11	17	23	55	15	33	22	42	25	46	6	48	31	8	12	6	15	39	8	3	22	44	2	4	9	16
	2	7	34	26	47	7	38	4	18	39	12	8	14	40	40	26	35	37	59	32	33	32	17	24	3	68	53	20	8	11	11	2	10	12	5	49	14	5	22	13
I	3	42	29	38	56	6	43	3	40	20	18	56	43	24	29	36	46	20	44	9	30	39	39	40	2	7	47	9	8	33	5	3	5	4	25	5	5	54	3	43
	4	26	11	49	29	4	61	3	58	33	27	22	11	12	32	42	24	56	42	40	29	22	30	29	3	53	57	34	6	5	10	11	24	5	6	8	26	46	49	14
	5	15	28	21	23	13	44	4	18	30	22	13	9	47	27	47	46	43	22	36	26	24	38	38	3	66	52	21	7	0	5	2	16	7	8	4	12	28	3	45
	6	9	35	19	12	18	49	3	28	17	23	45	29	4	15	15	44	54	7	2	17	24	42	33	3	37	30	24	11	12	8	17	9	3	24	34	24	52	5	12
	7	17	30	34	57	18	27	3	29	9	20	16	38	11	17	6	31	26	29	23	17	11	21	26	5	48	7	42	8	6	5	10	10	13	20	9	11	61	2	7
II	8	39	36	34	43	42	17	3	19	8	12	13	40	22	35	55	49	59	30	20	11	32	22	20	6	50	41	18	8	7	10	7	11	18	16	6	57	7	4	39
	9	26	14	13	23	5	11	4	16	49	49	20	20	28	40	32	9	52	23	46	33	30	27	28	3	13	63	29	11	2	6	6	9	7	7	6	13	7	3	42
	10	22	12	7	21	16	4	4	27	14	20	15	6	41	21	25	35	55	57	37	46	51	36	50	2	19	55	21	9	5	8	49	9	6	11	31	22	8	6	20
	11	14	9	27	9	8	30	2	42	40	20	5	10	23	25	38	20	45	29	14	13	36	38	49	4	64	15	28	13	7	8	4	31	3	9	47	0	13	19	5
	12	11	9	16	10	15	40	2	19	13	26	4	6	4	32	20	36	50	11	21	16	35	19	23	4	11	1	28	26	4	13	7	6	39	11	20	0	17	0	9
III	13	37	3	16	24	27	30	3	16	27	7	10	11	43	37	24	17	57	11	32	49	30	29	17	4	66	3	21	20	4	8	4	25	8	28	6	51	60	8	13
	14	14	3	21	30	5	31	3	33	15	54	52	20	49	42	8	41	42	34	2	36	16	20	30	3	34	32	23	10	5	7	2	7	1	23	22	5	25	52	12
	15	21	2	24	11	24	11	4	63	13	14	6	24	22	18	26	24	58	55	37	31	19	45	32	2	48	5	21	20	53	3	5	7	4	8	26	23	3	3	17
	16	28	20	33	61	9	30	3	37	18	25	7	17	33	37	36	35	55	8	30	32	35	23	37	5	17	5	22	47	52	16	15	8	12	35	28	2	12	15	5
	17	30	9	40	20	18	43	3	26	9	33	10	4	36	35	7	40	39	6	23	29	34	22	28	2	62	25	16	14	7	9	11	7	23	24	20	4	34	3	5
IV	18	24	21	18	22	33	5	3	32	11	59	5	4	44	41	28	41	53	22	25	25	28	27	37	3	49	35	18	8	6	26	3	10	17	30	28	53	14	5	40
	19	20	46	40	1	11	13	3	56	6	19	21	44	17	24	3	35	56	34	35	17	23	33	22	4	50	16	25	10	5	10	3	10	2	5	46	4	6	26	3
	20	37	35	9	3	24	3	4	36	53	13	41	10	34	3	45	49	41	20	34	39	38	35	15	3	7	6	16	18	25	11	5	7	2	12	7	3	5	19	11
	21	18	22	21	38	5	57	4	64	27	17	13	3	43	14	8	16	53	47	17	18	23	27	37	4	57	57	20	9	1	6	8	7	9	7	30	16	12	14	26
	22	27	7	20	4	21	42	3	56	14	35	12	4	9	49	16	41	56	38	30	35	13	18	32	5	54	26	25	13	45	8	3	8	2	36	38	2	20	2	8
V	23	8	16	23	55	27	17	3	54	17	26	13	26	46	13	36	44	26	32	33	7	26	25	31	1	66	55	16	7	23	9	49	7	28	4	3	29	35	16	16
	24	16	7	21	42	36	10	3	17	17	6	18	4	44	21	43	18	51	25	13	11	35	25	35	2	52	52	17	28	4	11	7	12	11	12	13	36	19	19	12
	25	11	13	23	3	28	8	4	21	18	26	47	3	12	40	19	45	59	40	29	32	37	23	30	4	22	1	32	18	7	7	9	8	36	12	3	59	15	32	23
Mean		22.7	19.6	24.8	27.4	18.0	27.9	3.3	35.3	21.3	24.6	19.5	17.3	28.5	27.9	26.3	33.8	47.9	29.6	26.1	26.2	29.4	28.2	31.6	3.4	42.7	30.8	22.2	14.0	13.4	9.4	11.2	10.8	11.0	16.0	21.3	18.9	22.5	13.6	18.2

L.S.D. = 7.6% (P = 0.05)

L.S.D. = 7.1% (P = 0.05)

L.S.D. = 6.4% (P = 0.05)

Analysis of variance for percent weight losses

Strain 1-11 inclusive, the standard strain

Source of variation	SS	°F	MS	Variance ratio
Between strains	16696.2	11	1517.8	8.0 *
Between bottles	8066.2	48	168.0	0.89**
Within bottles (error)	45468.2	240	189.5	
TOTAL	70230.6	299		

Strains 12-25 inclusive, the standard strain

Source of variation	SS	°F	MS	Variance ratio
Between strains	32619.4	14	2330	14.0 *
Between bottles	9737.4	60	162.3	0.98**
Within bottles (error)	49896.0	300	166.3	
TOTAL	92252.8	374		

Strains 26-36 inclusive, the standard strain

Source of variation	SS	°F	MS	Variance ratio
Between strains	18195.6	11	1654.1	12.29 *
Between bottles	5940.2	48	123.8	0.92**
Within bottles (error)	32303.2	240	134.6	
TOTAL	56439.0	299		

* Significant at 0.01 level.
** Not significant at 0.05 level

For illustration see text figure 2.

Table 14b. Changes in measurement of decay of pieces of Pinus sylvestris sapwood incubated for 10 weeks with 36 strains of S. lacrimans.

B. Breaking strength (Newtons) of wood pieces after incubation period.

Bottle No.	Piece No.	1	2	3	4	5	6	7	8	9	10	11	5	Cont.	12	13	14	15	16	17	18	19	20	21	22	23	24	25	5	Cont.	26	27	28	29	30	31	32	33	34	35	36	5	Cont.
	1	0	20	40	20	80	20	280	0	120	90	180	40	340	80	70	100	40	0	100	40	80	15	25	10	310	30	10	210	400	220	440	180	60	290	500	200	25	300	370	280	200	400
	2	250	10	60	0	210	190	380	110	130	160	290	130	420	30	20	60	50	70	10	50	40	30	170	50	360	0	10	170	400	350	190	390	360	320	320	335	20	250	300	180	180	300
I	3	10	30	0	0	140	100	300	0	150	150	0	0	370	120	40	0	20	190	50	80	40	20	20	10	450	350	15	190	400	230	150	320	330	410	370	140	375	310	5	330	20	470
	4	260	230	10	60	290	250	360	0	50	80	180	260	330	100	30	0	130	0	40	20	70	60	30	50	370	0	5	120	460	370	390	250	280	110	390	440	410	130	30	20	210	460
	5	190	30	70	50	140	10	370	120	40	100	260	210	350	0	40	0	10	40	110	20	40	40	20	10	170	0	0	150	280	210	410	460	370	280	340	350	340	210	150	320	20	450
	6	120	10	50	80	150	0	340	70	100	70	0	130	280	130	110	50	10	0	60	380	80	30	20	60	370	80	40	155	380	360	310	370	230	490	460	195	20	50	10	320	180	340
	7	100	10	20	0	140	150	340	60	290	110	200	0	350	130	70	90	130	150	40	40	90	390	190	60	390	20	190	70	480	400	330	500	270	340	340	275	385	300	0	400	240	420
II	8	10	30	40	40	20	130	330	220	230	230	220	20	290	60	100	0	0	0	100	50	90	40	70	180	350	30	5	135	210	400	360	285	230	140	220	290	365	5	270	270	60	420
	9	40	190	120	90	250	100	370	70	0	0	140	100	350	50	20	0	140	0	120	10	50	250	50	80	470	230	0	120	450	350	440	400	300	360	470	435	450	250	320	340	40	400
	10	70	220	220	80	210	350	290	90	110	90	130	280	390	10	10	40	20	0	10	30	20	10	30	10	400	80	5	110	420	230	320	370	10	400	400	315	130	210	320	300	170	420
	11	130	130	40	290	250	0	310	0	0	120	130	200	270	60	60	0	150	0	30	50	130	30	20	10	260	0	100	110	300	290	360	420	370	100	390	395	40	210	300	150	180	310
	12	230	190	70	280	160	0	320	160	170	80	100	300	370	130	40	40	60	0	70	110	90	30	110	80	250	90	370	120	420	140	350	320	300	360	40	340	230	270	150	360	170	440
III	13	20	300	200	200	90	110	340	100	80	280	180	200	360	10	40	110	150	0	160	50	0	30	80	160	360	0	230	115	420	190	310	300	310	170	340	160	360	10	5	310	160	410
	14	190	220	170	60	290	50	280	0	200	0	0	110	270	10	10	160	30	80	20	330	20	110	50	30	370	120	50	135	400	410	400	400	370	410	440	150	135	290	140	40	220	440
	15	80	380	130	280	120	200	380	0	160	190	240	80	360	70	20	40	70	0	0	10	40	150	10	30	280	0	260	140	350	380	15	330	370	370	410	385	250	180	260	310	250	370
	16	70	50	70	0	130	0	390	0	260	60	270	60	380	160	180	10	30	0	170	30	30	30	50	30	290	120	290	160	360	10	20	260	220	400	320	35	130	350	280	230	220	400
	17	30	200	10	160	100	0	380	50	330	20	180	170	380	30	30	320	20	100	200	90	60	30	80	20	300	0	140	200	400	170	310	440	290	350	130	95	170	360	110	300	200	480
IV	18	80	120	160	70	30	250	320	40	150	0	310	260	400	20	60	90	20	5	100	40	40	80	50	30	280	30	60	175	400	440	380	90	290	315	280	90	170	10	390	340	40	380
	19	120	0	10	190	110	140	350	0	210	290	180	0	390	190	50	160	10	0	60	40	150	110	40	100	380	30	190	170	430	210	460	200	370	410	370	380	20	290	300	140	210	480
	20	20	10	100	370	70	390	310	40	0	270	20	230	320	50	70	0	10	100	150	30	40	10	30	160	190	350	310	190	440	190	220	380	310	290	400	340	360	230	160	100	150	380
	21	180	140	50	10	230	0	320	0	50	80	180	340	410	20	20	100	190	0	20	260	80	120	150	20	380	0	0	210	470	330	460	380	290	400	280	310	60	220	280	240	80	410
	22	80	150	120	30	40	20	260	0	240	50	210	270	380	250	100	100	10	0	20	40	40	220	90	40	350	0	110	130	410	330	15	370	310	230	410	45	300	340	200	240	200	480
V	23	120	220	40	0	30	190	360	0	170	80	130	50	230	20	10	10	10	105	10	60	240	40	80	50	360	0	10	225	400	230	260	360	20	410	90	390	400	120	150	330	150	270
	24	190	230	80	0	20	280	280	190	170	270	180	230	400	40	180	20	100	0	60	130	140	30	50	20	305	25	0	155	460	100	510	470	330	390	270	320	300	90	100	330	150	380
	25	170	320	80	220	30	230	320	80	130	50	0	330	420	150	10	80	0	0	10	50	30	30	70	20	220	130	330	180	380	110	200	320	290	330	50	300	340	0	140	110	50	410
Mean		110	138	78	103	133	126	331	56	142	117	156	160	358	77	56	63	56	34	69	82	69	81	63	53	329	69	109	154	397	270	304	343	275	323	321	268	231	226	190	252	150	400

L.S.D. = 45.2 Newtons (P = 0.05)

L.S.D. = 39.4 Newtons (P = 0.5)

L.S.D. = 82.1 Newtons (P= 0.05)

Analysis of variance for breaking strength (exclusive controls)

Strains 1-11 inclusive the standard strain

Source of variation	SS	°F	MS	Variance ratio
Between strains	1275400.0	11	115945.5	15.0 *
Between bottles	530432.0	48	11050.7	1.43***
Within bottles (error)	1850840.0	240	7711.8	
TOTAL	3656672.0	299		

Strains 12-25 inclusive the standard strain

Source of variation	SS	°F	MS	Variance ratio
Between strains	1782987.3	14	127356.2	24.75 *
Between bottles	415506.0	60	6925.1	1.35 ***
Within bottles (error)	1543550.0	300	5145.2	
TOTAL	3742043.3	374		

Strains 26-36 inclusive the standard strain

Source of variation	SS	°F	MS	Variance ratio
Between strains	944449.0	11	85859.0	3.84 **
Between bottles	1489302.0	48	31027.1	1.39 ***
Within bottles (error)	5368440.0	240	22374.8	
TOTAL	7802691.0	299		

* Significant at 0.01 level
** Significant at 0.05 level
*** Not significant at 0.05 level

For illustration see text figure 2.

Table 15. Measurements of rate of increase of colony diameter (in mm) for 36 strains after 7 days incubation on 2% malt agar at 21°C.

Strain / Replicate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
I	39	58	50	45	51	59	35	61	38	49	69	62	44	50	57	19	45	60	59	64	46	63	47	37	18	60	53	53	35	26	51	41	47	53	40	38
II	40	53	57	38	53	53	27	66	37	52	68	68	49	51	58	23	36	61	58	56	40	64	43	38	14	59	50	47	30	26	57	36	43	46	48	36
III	38	58	58	33	50	42	42	64	44	48	68	64	47	40	70	16	38	60	57	59	30	57	47	35	13	57	58	49	36	26	55	38	48	50	51	43
IV	40	56	54	28	48	35	41	61	42	53	71	59	50	38	68	14	50	53	55	61	40	63	34	34	15	59	57	43	39	24	53	34	43	48	47	39
V	34	53	59	46	54	51	41	66	40	43	59	63	48	43	60	26	46	63	58	57	43	56	32	37	14	56	45	48	33	25	47	40	51	53	53	45
VI	56	53	53	38	52	53	38	70	38	53	62	61	47	36	58	26	30	57	56	59	39	55	27	42	12	45	42	56	32	22	50	58	48	45	44	35
VII	36	53	52	55	55	58	27	72	22	47	64	63	42	31	66	22	38	63	58	61	42	59	48	34	13	50	49	53	38	24	49	56	49	54	50	42
VIII	41	52	55	51	54	53	23	71	21	53	68	63	47	39	63	22	53	61	63	60	45	63	47	43	15	50	46	52	39	27	45	40	50	55	43	39
IX	56	59	56	35	45	50	30	71	35	46	66	57	42	29	76	19	34	63	62	58	39	49	28	38	20	44	43	46	31	27	47	39	45	47	40	45
X	40	59	57	30	52	47	23	66	35	56	55	53	46	33	73	16	30	59	58	59	42	48	23	34	15	43	47	53	37	25	41	40	48	49	54	38
Mean	42.0	55.4	55.1	39.9	51.4	50.1	32.7	66.7	35.2	50.0	65.0	61.3	46.2	39.0	64.9	20.3	40.0	60.0	58.4	59.4	40.6	57.7	37.6	37.2	14.9	52.3	49.0	50.0	35.0	25.2	49.5	42.2	47.2	50.0	47.0	40.0

L.S.D. (P = 0.05) between the means of colony diameters = 4.78 mm

Analysis of variance for growth

Source of variance	SS	°f	MS	Variance ratio
Between strains	52119.7	35	1489.1	50.7 *
Within strains (error)	9508.6	324	29.4	
TOTAL	61628.3	359		

* Significant at 0.001 level

For illustration see text figure 5.

Table 16. Measurements of rate of increase of colony diameter (in mm) for 25 monokaryotic cultures (isolated from sporophore A) after seven days incubation on 2% malt agar at 21°C.

Strain / Replicate	AS1	AS2	AS3	AS4	AS5	AS6	AS7	AS8	AS9	AS11	AS12	AS13	AS15	AS16	AS18	AS19	AS20	AS21	AS22	AS23	AS24	AS25	AS26	AS27
I	34	37	40	41	40	40	37	45	37	37	34	23	41	41	23	37	40	40	40	24	40	41	38	36
II	38	42	38	40	38	43	38	45	38	34	36	22	42	40	20	38	42	39	34	25	38	40	37	40
III	35	37	30	41	37	40	36	38	39	32	39	23	39	41	35	33	41	37	42	22	40	42	32	38
IV	33	41	32	37	36	41	37	42	37	28	32	22	40	40	31	38	40	38	39	24	37	39	38	36
V	34	34	38	42	40	40	38	35	40	40	34	21	41	39	26	36	42	39	38	26	39	41	39	35
VI	35	40	35	41	34	38	39	43	39	38	30	23	42	41	31	31	40	40	41	25	38	42	35	33
VII	36	41	31	40	35	40	37	37	37	39	34	20	40	39	30	34	41	37	37	24	37	39	37	34
VIII	38	39	36	37	34	38	36	35	40	40	32	19	45	31	26	36	39	38	40	23	35	41	38	36
IX	34	40	30	42	40	40	32	32	37	38	37	21	41	33	22	40	42	40	41	26	37	40	32	34
X	33	39	32	38	35	39	37	25	37	40	36	20	40	41	30	34	41	40	40	24	38	35	37	36
Mean	35.0	39.0	34.2	39.9	36.9	39.9	36.7	37.7	38.1	36.6	34.4	21.4	41.1	38.6	27.4	35.7	40.8	38.8	39.2	24.3	37.9	40.0	36.3	35.8

L.S.D. (P = 0.05) between the means of colony diameters = 2.40 mm

Analysis of variance for growth

Source of variance	SS	°F	MS	Variance ratio
Between strains	5727.9	23	249.04	33.6 *
Within strains (error)	1599.9	216	7.41	
TOTAL	7327.8	239	30.66	

* Significant at 0.001 level.

For illustration see text figure 6.

Table 17. Measurements of rate of increase of colony diameter (in mm) for 42 monokaryotic cultures (isolated from sporophore B) after seven days incubation on 2% malt agar at 21°C.

Strain / Replicate	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS8	BS9	BS10	BS11	BS12	BS13	BS14	BS15	BS16	BS17	BS18	BS19	BS20	BS21	BS22	BS23	BS24	BS25	BS26	BS27	BS28	BS29	BS30	BS31	BS32	BS33	BS34	BS35	BS36	BS37	BS38	BS39	BS40	BS41	BS42
I	37	46	39	41	23	47	37	31	40	40	31	52	38	37	28	47	32	47	33	46	23	42	34	28	34	32	32	37	47	44	34	38	40	50	50	50	51	54	50	52	33	50
II	35	38	31	43	38	43	41	33	42	36	27	50	46	38	31	45	39	43	30	45	25	41	41	27	30	31	30	44	44	41	33	40	42	47	46	49	50	53	44	48	35	47
III	32	39	45	39	29	46	38	37	36	39	25	53	47	32	34	48	35	45	37	50	26	34	42	30	27	38	32	41	42	44	34	35	40	48	47	48	47	55	48	51	40	52
IV	37	35	41	38	27	39	37	40	40	37	33	52	43	33	29	46	33	48	32	45	25	38	44	26	31	35	31	39	45	38	37	36	41	45	48	50	49	51	50	49	37	50
V	33	42	49	39	26	36	34	41	44	40	30	46	39	30	39	45	35	45	37	51	28	36	45	30	29	36	29	44	47	43	36	37	42	47	50	47	41	53	52	51	30	49
VI	35	48	40	40	23	41	36	42	39	42	31	49	47	32	31	43	41	46	31	52	31	39	41	27	32	34	26	40	40	42	32	40	40	46	44	45	51	56	45	50	32	47
VII	32	46	45	42	24	39	34	37	40	43	32	50	44	31	28	41	36	47	35	50	25	38	40	24	33	36	32	38	44	50	38	41	39	42	47	46	50	55	41	48	33	50
VIII	37	40	39	44	30	45	40	38	38	39	27	54	38	35	29	46	51	48	30	49	30	34	45	22	36	32	29	40	48	46	32	36	49	45	48	47	49	54	50	51	33	46
IX	33	44	43	46	35	41	35	37	33	42	33	53	42	32	31	42	40	46	35	48	26	40	41	27	35	30	34	39	47	51	35	45	40	47	50	50	51	56	49	48	33	50
X	33	47	55	43	42	36	39	38	32	40	31	50	41	33	33	45	44	48	30	50	25	37	38	21	31	40	29	39	40	44	35	39	40	48	47	45	51	53	50	45	33	50
Mean	34.4	42.6	42.7	41.5	29.7	41.3	37.1	37.4	38.4	39.8	30.0	50.9	42.5	33.3	31.3	44.8	38.6	46.3	33.0	48.6	26.4	37.9	41.1	26.2	31.8	34.4	30.4	40.1	44.4	44.3	34.6	38.7	41.3	46.5	47.7	47.7	49.0	54.0	47.9	49.6	33.8	49.1

L.S.D. (P = 0.05) between the means of colony diameters = 2.8 mm

Analysis of variance for growth

Source of variance	SS	°F	MS	Variance ratio
Between strains	20543.6	41	501.1	49.3 *
Within strains (error)	3840.2	378	10.2	
TOTAL	24383.8	419		

* Significant at 0.001 level.

For illustration see text figure 7.

Table 18a. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 25 monokaryotic cultures (isolated from sporophore A) of S. lacrimans

A. Weight loss as % of dry weight after incubation.

Bottle No.	Piece No.	AS1	AS2	AS3	AS4	AS5	AS6	AS7	AS8	AS9	AS11	AS12	AS13	AS15	AS16	AS17	AS18	AS19	AS20	AS21	AS22	AS23	AS24	AS25	AS26	AS27
	1	38	13	30	43	6	35	15	19	17	30	20	38	29	12	24	6	18	61	36	38	4	21	47	14	33
	2	2	47	3	27	19	39	6	50	47	27	33	13	53	28	5	32	23	6	22	12	8	47	15	17	20
I	3	14	51	13	15	9	11	40	4	11	34	13	61	54	58	53	38	40	13	27	11	19	14	60	11	31
	4	28	50	32	6	36	48	11	6	42	41	65	47	5	62	58	8	60	12	66	60	36	16	9	2	25
	5	27	22	15	67	43	32	40	20	54	60	69	61	10	50	56	13	51	44	11	40	51	26	14	19	32
	6	17	41	5	10	49	13	61	47	8	6	10	45	59	43	23	23	63	9	17	14	11	16	45	33	32
	7	13	22	48	37	51	40	16	6	8	60	18	31	36	42	62	14	60	12	53	33	15	32	19	31	45
II	8	9	40	8	51	20	14	3	8	8	11	17	46	32	14	55	19	65	42	22	21	11	29	28	10	12
	9	7	33	23	46	6	27	2	11	54	55	43	41	36	47	52	30	16	36	42	12	58	25	26	32	36
	10	35	23	30	13	32	28	9	5	63	61	50	6	60	55	3	43	57	62	49	13	19	28	21	25	39
	11	25	57	36	19	7	27	6	13	17	5	8	27	67	23	22	41	65	20	19	45	9	19	8	25	28
	12	37	49	51	41	18	19	4	13	42	58	40	48	14	12	36	35	59	25	24	65	8	45	45	28	25
III	13	48	15	9	55	10	30	20	27	59	45	10	35	16	27	61	23	27	13	64	23	57	31	4	6	34
	14	3	42	42	40	17	11	27	22	57	29	33	18	12	56	51	30	46	9	55	34	10	16	22	16	33
	15	8	46	15	22	36	7	9	46	55	54	59	60	16	65	20	60	23	65	26	24	7	30	39	39	42
	16	4	38	7	14	7	7	8	36	57	58	17	44	22	11	30	18	26	19	41	59	17	35	34	22	19
	17	40	45	47	49	9	8	42	10	7	13	55	51	52	51	8	60	14	32	11	59	40	42	17	14	43
IV	18	27	13	12	5	42	49	36	16	49	16	47	46	50	44	54	9	59	36	42	44	21	42	45	35	11
	19	37	36	5	46	5	15	5	50	57	25	55	61	48	49	59	39	55	41	59	45	8	27	24	34	38
	20	41	41	35	19	30	49	14	43	63	63	41	56	26	18	18	45	32	60	55	18	25	36	22	34	17
	21	23	17	23	30	3	31	9	8	47	22	22	24	37	9	22	16	43	36	38	21	57	27	24	36	39
	22	8	61	54	18	36	50	7	6	42	32	41	10	33	16	20	25	59	14	43	48	28	39	20	13	28
V	23	8	7	45	21	34	18	11	54	59	66	46	16	49	36	18	10	58	25	47	63	53	39	29	20	9
	24	15	45	23	26	12	4	6	41	61	61	60	16	25	50	18	21	48	59	58	63	12	13	30	11	21
	25	27	47	18	16	53	27	9	12	60	17	61	30	15	54	50	13	9	59	52	15	39	33	29	28	37
	Mean	21.6	36.0	25.2	29.4	23.6	25.6	16.6	22.9	41.8	38.0	37.3	37.2	34.2	37.3	35.1	26.8	43.0	32.4	39.2	35.2	24.9	29.1	27.0	22.2	29.2

L.S.D. (P = 0.05) between means of percent weight loss = 9.3%

Analysis of variance

Source of variation	SS	°F	MS	Variance ratio
Between isolates	30005.0	24	1250.2	4.26*
Between bottles	21763.4	100	217.6	0.74**
Within bottles (error)	146719.6	500	293.4	
TOTAL	198488.0	624		

* Significant at 0.01 level.

** Not significant at 0.05 level.

For illustration see text figure 8.

Table 18b. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 25 monokaryotic cultures of S. lacrimans.

B. Breaking strength (Newtons) of wood pieces after incubation period.

Bottle No.	Piece No.	AS1	AS2	AS3	AS4	AS5	AS6	AS7	AS8	AS9	AS11	AS12	AS13	AS15	AS16	AS17	AS18	AS19	AS20	AS21	AS22	AS23	AS24	AS25	AS26	AS27	Control
	1	40	24	20	40	90	30	170	90	165	145	180	25	40	170	120	130	220	0	40	90	180	150	10	190	80	430
	2	150	0	110	40	250	40	110	30	0	100	35	170	0	25	150	50	100	235	150	235	295	0	300	100	80	400
I	3	100	0	110	90	240	250	20	220	100	90	260	0	0	0	0	40	5	200	125	210	125	70	5	120	60	320
	4	40	0	50	160	50	20	90	120	0	0	0	20	140	0	0	245	0	150	0	0	60	70	90	5	80	480
	5	40	290	80	0	10	60	30	50	0	0	0	0	100	0	0	285	0	40	180	15	10	60	85	90	40	250
	6	60	10	290	80	10	60	0	0	140	85	200	40	0	30	60	130	0	160	180	150	250	70	10	65	35	290
	7	80	60	10	10	0	10	80	100	240	0	150	90	75	0	0	140	0	260	0	85	170	60	60	10	10	480
II	8	270	30	110	0	50	330	230	90	120	135	215	20	50	140	0	140	0	60	60	160	260	65	40	190	180	460
	9	410	10	50	10	130	30	410	90	0	0	10	20	10	0	0	165	180	30	30	300	0	55	80	45	15	390
	10	60	150	20	250	40	120	120	310	0	0	0	290	0	5	130	25	0	0	15	300	165	100	85	50	15	340
	11	60	0	40	50	110	50	230	190	185	100	235	80	0	60	90	50	0	115	170	50	255	75	170	90	50	440
	12	40	0	20	20	120	90	170	50	15	0	25	0	180	65	70	10	20	145	150	0	340	5	5	40	110	350
III	13	0	80	230	0	260	50	40	70	0	0	80	15	230	75	0	130	25	215	0	195	0	50	210	100	20	440
	14	50	20	30	20	190	100	70	80	0	70	55	220	160	0	0	75	70	170	0	60	190	260	50	80	10	350
	15	150	10	80	170	60	140	90	30	0	0	0	0	60	0	85	0	105	0	150	125	295	20	5	20	15	480
	16	160	10	250	100	230	100	150	40	0	0	110	0	0	260	55	60	295	215	90	0	90	35	10	140	145	360
	17	30	10	30	20	350	160	30	100	245	140	0	10	0	0	115	0	0	90	250	0	60	15	160	185	10	480
IV	18	40	240	190	220	10	10	40	110	5	85	0	10	0	65	0	170	0	0	40	10	260	15	5	15	285	540
	19	20	30	140	10	290	90	100	20	0	90	0	0	80	25	0	10	75	30	0	20	265	60	40	10	50	450
	20	0	20	40	170	40	0	80	10	0	0	20	0	35	165	70	45	0	0	0	65	130	20	125	35	160	500
	21	80	90	50	90	150	30	210	70	0	120	175	150	15	180	190	160	0	25	30	160	0	45	70	25	15	420
	22	130	0	10	130	10	10	110	110	0	40	40	100	0	190	160	145	0	150	70	15	80	10	20	100	80	520
V	23	340	110	0	120	40	60	260	0	0	0	0	90	65	55	0	205	5	100	0	0	0	15	40	45	110	500
	24	60	20	120	80	140	220	330	10	0	0	0	190	175	0	10	130	130	0	0	0	200	110	30	150	70	430
	25	20	20	70	100	0	90	90	190	0	175	0	35	230	0	15	280	0	0	0	280	15	35	195	90	35	300
	Mean	96	57	85	78	114	84	129	87	49	55	72	63	66	60	53	113	49	96	69	100	148	59	76	90	70	415

L.S.D. (P = 0.05) between means of breaking strength = 45.2 Newtons.

Analysis of variance for breaking strength (exclusive controls)

Source of variation	SS	°F	MS	Variance ratio
Between isolates	394942.6	24	16455.9	2.4 *
Between bottles	733264.0	100	7332.6	1.08 **
Within bottles (error)	3395590.0	500	6791.2	
TOTAL	4523796.6	624		

* Significant at 0.05 level

** Not significant at 0.05 level

For illustration see text figure 8.

Table 19a. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 42 monokaryotic cultures of S. lacrimans

A. Weight loss as % of dry weight after incubation period.

Bottle No.	Piece No.	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS8	BS9	BS10	BS11	BS12	BS13	BS14	BS15	BS16	BS17	BS18	BS19	BS20	BS21	BS22	BS23	BS24	BS25	BS26	BS27	BS28	BS29	BS30	BS31	BS32	BS33	BS34	BS35	BS36	BS37	BS38	BS39	BS40	BS41	BS42
	1	8	12	6	7	14	6	8	8	54	8	11	55	6	11	8	10	39	11	12	11	23	10	6	12	40	15	23	30	34	44	9	15	13	46	6	43	36	31	55	9	57	27
	2	9	27	5	17	13	9	54	7	22	10	65	5	7	10	10	53	8	12	9	10	7	8	7	29	32	23	9	7	44	7	6	40	26	13	9	48	39	10	35	13	5	41
I	3	10	10	7	27	12	6	8	27	45	8	8	10	7	6	4	8	7	61	8	17	35	8	59	10	39	27	25	8	4	33	52	11	23	10	9	7	25	54	17	11	18	52
	4	14	11	25	34	11	47	41	7	12	41	7	49	49	10	10	10	53	10	29	9	18	50	7	8	5	26	40	41	6	10	13	49	16	12	13	29	19	6	8	11	3	49
	5	8	6	60	9	22	35	31	6	26	27	7	27	9	8	10	7	12	12	43	12	32	12	8	17	33	35	19	39	10	14	17	7	21	3	8	15	38	36	4	52	23	10
	6	8	26	9	10	11	7	25	10	24	10	6	4	28	23	6	13	12	48	23	9	23	7	25	56	4	28	15	33	40	49	27	11	9	16	22	50	19	42	55	7	10	7
	7	5	21	10	9	12	9	14	11	9	8	6	51	8	11	10	23	18	12	10	12	8	12	9	13	25	34	21	16	36	46	44	11	23	9	9	4	37	4	2	44	5	31
II	8	7	28	10	9	12	10	8	34	11	13	9	41	20	11	8	20	13	39	59	9	47	9	12	10	18	30	11	8	21	25	40	11	10	59	13	7	36	12	6	3	27	32
	9	4	17	45	17	60	38	17	16	59	40	36	7	8	9	11	9	13	28	12	13	7	11	9	7	31	17	19	38	25	4	10	11	13	8	29	17	43	12	14	8	6	21
	10	14	24	10	8	10	31	14	12	11	9	11	8	12	26	8	11	21	69	5	14	11	16	9	11	33	30	39	35	6	16	10	43	11	17	21	4	32	7	22	47	4	28
	11	5	20	33	58	47	6	38	17	8	11	30	4	43	10	14	7	11	32	13	10	6	16	15	38	38	9	32	26	7	17	13	38	34	21	24	23	25	11	22	6	9	7
	12	7	47	28	7	10	18	18	7	11	10	10	48	9	10	9	14	10	23	19	9	7	7	8	10	6	3	44	31	20	9	15	7	13	9	26	49	49	16	10	22	6	15
III	13	6	9	11	5	10	4	50	14	50	13	9	9	7	18	4	7	8	11	49	10	8	9	8	9	39	23	44	32	46	16	23	23	6	36	38	15	37	47	8	56	22	37
	14	7	7	3	9	12	50	10	23	15	9	26	20	10	11	8	53	42	11	11	46	7	9	9	7	31	38	21	6	43	7	6	45	57	10	9	41	20	11	37	16	38	9
	15	55	8	16	2	9	8	18	9	14	12	12	45	19	13	41	28	10	19	7	7	33	9	53	15	38	15	18	30	40	13	48	21	11	15	12	7	7	9	37	5	19	43
	16	13	8	7	11	16	9	10	10	47	24	9	18	13	9	9	6	14	24	30	8	11	7	12	63	7	33	46	3	4	38	48	18	44	21	46	22	7	5	52	28	26	9
	17	8	13	44	11	16	7	8	9	12	13	14	14	13	9	4	30	10	37	50	24	16	7	15	83	5	4	2	10	26	12	25	24	48	11	26	3	7	21	8	11	18	35
IV	18	24	9	25	3	40	10	10	9	15	51	9	52	11	7	18	56	47	8	11	6	20	8	13	14	29	4	4	23	24	8	23	12	10	6	3	49	9	23	40	31	11	34
	19	7	9	20	8	15	17	50	46	14	7	14	10	12	11	4	56	42	8	20	13	25	10	11	19	7	46	26	37	32	7	20	9	12	11	19	39	28	58	7	37	14	31
	20	8	11	29	4	18	13	12	5	25	9	11	57	70	10	8	45	29	11	9	11	15	9	9	12	23	4	47	42	45	21	6	49	13	11	26	26	36	4	21	36	41	
	21	15	9	11	12	21	9	10	7	7	14	12	40	4	11	12	15	15	35	30	10	11	9	10	12	2	6	20	10	5	13	23	54	40	11	14	7	36	39	11	24	8	51
	22	10	9	6	3	21	25	11	5	5	5	13	45	7	10	34	8	11	27	8	7	9	8	16	22	44	12	7	12	44	16	49	13	24	11	16	29	14	2	9	12	24	18
V	23	8	22	11	17	10	18	12	7	38	3	12	4	8	11	9	46	11	19	10	10	11	9	11	25	18	10	21	24	5	8	19	4	10	6	8	42	28	19	9	39	30	8
	24	53	49	5	11	13	36	12	10	38	60	9	11	11	7	7	8	10	12	10	10	9	7	11	21	26	10	7	37	8	30	6	27	15	10	12	13	12	44	8	42	16	14
	25	9	8	9	7	12	27	12	13	14	24	9	7	10	12	6	10	11	13	8	6	9	10	11	10	16	9	10	28	3	5	19	28	50	17	15	15	44	11	6	40	11	41
	Mean	12.9	16.8	17.8	12.6	17.9	18.2	20.0	13.2	23.4	17.6	14.6	25.6	16.0	11.4	10.9	22.1	19.1	19.8	23.7	12.1	16.3	11.1	14.5	21.3	23.6	19.6	22.8	24.2	23.1	18.7	22.8	23.2	22.1	15.9	17.3	24.1	27.4	21.4	20.1	24.6	18.2	26.6

L.S.D. (P = 0.05) between means of percent weight loss = 8.3%.

Analysis of variance

Source of variation	SS	*F	MS	Variance ratio
Between isolates	21119.5	41	515.0	2.25 *
Between bottles	45896.5	168	273.2	1.19**
Within bottles (error)	192386.5	840	229.0	
TOTAL	259402.5	1049		

* Significant at 0.05 level

** Not significant at 0.05 level

For illustration see text figure 9.

Table 19b. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 42 monokaryotic cultures of S. lacrimans.

B. Breaking strength (Newtons) of wood pieces after incubation period.

Bottle No.	Piece No.	BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS8	BS9	BS10	BS11	BS12	BS13	BS14	BS15	BS16	BS17	BS18	BS19	BS20	BS21	BS22	BS23	BS24	BS25	BS26	BS27	BS28	BS29	BS30	BS31	BS32	BS33	BS34	BS35	BS36	BS37	BS38	BS39	BS40	BS41	BS42	Control
	1	250	210	390	280	300	400	370	210	10	190	410	10	210	220	250	390	80	360	220	340	130	260	350	160	30	330	200	40	60	50	220	360	220	25	410	20	35	130	0	350	5	100	400
	2	220	125	270	350	280	160	10	240	130	210	10	280	270	370	220	10	190	200	200	270	170	300	220	130	50	150	360	220	20	370	220	50	190	210	220	20	40	290	60	140	270	40	300
I	3	150	180	170	130	300	400	210	120	10	250	360	160	160	180	300	230	350	0	340	130	30	150	0	270	20	120	200	360	370	170	10	400	170	430	270	300	200	15	250	350	310	10	480
	4	390	270	100	30	220	10	70	380	210	20	250	35	5	270	210	330	10	150	210	390	140	20	210	200	200	180	20	10	150	400	340	10	270	240	250	110	200	250	150	290	120	10	350
	5	160	330	0	450	130	60	90	350	100	120	180	230	200	280	330	200	50	180	150	340	60	400	250	330	30	20	160	30	250	190	310	360	320	180	350	180	20	80	330	0	150	220	450
	6	170	140	140	160	170	140	115	250	250	210	210	200	170	190	250	240	230	10	150	320	180	200	140	10	460	170	320	30	20	20	190	420	400	330	270	15	100	100	15	250	400	230	420
	7	180	150	420	250	310	170	120	140	350	140	270	15	380	200	220	280	160	370	180	140	330	220	340	270	150	10	340	180	20	15	20	360	170	420	240	340	15	420	470	10	370	180	500
II	8	340	170	360	240	300	270	190	25	150	270	380	30	160	340	260	310	360	30	5	210	5	150	170	400	310	20	370	190	200	130	40	300	390	0	440	160	30	360	350	430	210	120	520
	9	400	315	15	220	0	90	190	100	5	100	100	120	380	230	340	180	330	100	140	350	170	300	140	430	40	350	240	40	250	220	330	170	360	320	170	360	20	240	290	380	150	320	400
	10	230	160	310	200	240	85	250	240	200	230	370	400	270	110	240	150	190	340	460	300	180	260	180	360	70	20	40	20	360	240	330	5	460	180	150	380	40	330	190	10	300	30	410
	11	215	130	80	0	20	260	30	160	330	190	140	390	50	210	260	170	190	130	200	180	310	165	215	40	50	290	50	50	400	140	400	50	80	180	310	140	150	350	80	390	340	150	380
	12	110	10	210	260	150	150	200	350	220	220	310	10	210	240	320	180	310	150	100	250	140	160	150	140	290	260	10	40	180	350	280	260	300	370	190	20	30	210	390	200	430	270	420
III	13	410	190	340	170	390	230	10	210	0	360	170	290	320	330	410	300	430	210	10	280	150	330	240	215	10	230	30	50	15	250	290	200	320	80	60	260	170	20	380	5	190	10	400
	14	150	330	340	485	260	10	370	120	170	140	110	120	290	170	170	5	40	320	340	10	250	160	330	300	100	80	140	250	20	210	230	10	270	250	330	10	280	180	25	290	70	250	320
	15	0	430	290	150	290	180	160	340	150	120	410	10	100	300	30	140	180	140	360	150	60	210	5	210	20	340	250	30	30	120	140	100	350	390	320	220	340	270	50	350	270	10	440
	16	325	430	270	350	150	240	150	260	20	90	130	315	215	180	320	260	400	180	50	250	160	210	240	0	330	110	20	410	380	80	15	320	5	130	5	120	260	460	5	70	250	310	480
	17	210	200	10	180	140	220	410	320	400	300	290	170	320	360	450	80	230	50	10	250	300	285	290	330	430	410	490	240	80	250	140	100	5	240	170	230	150	250	150	370	240	20	490
IV	18	240	190	150	220	70	210	220	390	190	10	380	20	110	160	130	5	40	150	170	170	200	400	150	150	160	380	420	130	120	450	200	250	280	270	430	15	100	140	20	100	240	50	380
	19	395	240	220	400	250	310	10	15	200	220	140	275	180	340	430	0	20	120	250	270	90	320	320	310	210	30	160	40	60	450	320	420	210	370	190	30	70	5	320	10	250	80	400
	20	180	350	120	160	215	300	220	150	150	230	250	10	380	210	410	10	70	310	170	385	225	290	140	340	170	480	20	10	20	120	310	10	320	410	240	120	50	130	170	20	20	420	440
	21	225	230	150	325	190	210	220	240	190	150	170	40	200	210	400	160	250	120	160	170	340	390	220	370	400	280	100	240	320	300	330	5	90	280	430	370	260	40	280	190	350	15	400
	22	290	330	370	280	170	200	200	350	220	190	160	50	190	120	70	360	220	150	150	350	185	210	220	160	30	320	360	400	20	170	10	360	160	410	300	130	130	230	240	440	240	450	360
V	23	130	160	325	240	140	150	220	330	40	170	220	150	390	390	330	60	130	130	400	235	210	250	170	130	200	270	190	220	300	360	130	210	240	190	270	20	170	200	350	10	130	300	380
	24	10	10	210	400	200	110	320	320	15	0	210	340	290	220	180	270	310	220	365	250	150	150	310	215	120	370	340	30	430	110	240	100	350	220	370	150	15	15	340	20	260	130	390
	25	425	230	120	180	250	50	120	130	150	210	220	150	180	180	320	160	320	185	380	200	170	110	290	280	230	310	370	60	180	390	90	100	5	140	170	250	30	250	360	10	170	20	410
	Mean	232	220	215	244	205	185	179	230	154	174	234	153	225	240	274	179	204	159	207	248	173	236	213	215	164	221	208	133	170	222	205	197	237	251	262	159	116	199	211	187	230	150	413

L.S.D. (P = 0.05) between means of breaking strength = 61.8 Newtons.

Analysis of variance (exclusive control)

Source of variation	SS	°F	MS	Variance ratio
Between isolates	1338936.3	41	32657.0	2.57 *
Between bottles	2284356.0	168	13597.4	1.07 **
Within bottles (error)	1065678.0	840	12686.6	

* Significant at 0.05 level

** Not significant at 0.05 level

For illustration see text figure 9.

Table 20a. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 10 monokaryons of S. lacrimans (isolated from sporophore A) and 25 dikaryons formed by mating the monokaryons in all possible combinations.

A. Weight loss as % of dry weight after incubation period.

Bottle No.	Piece No.	AS19	AS13	AS15	AS20	AS5	AS11	AS24	AS27	AS26	AS7	AS19x11	AS19x24	AS19x27	AS19x26	AS19x7	AS13x11	AS13x24	AS13x27	AS13x26	AS13x7	AS15x11	AS15x24	AS15x27	AS15x26	AS15x7	AS20x11	AS20x24	AS20x27	AS20x26	AS20x7	AS5x11	AS5x24	AS5x27	AS5x26	AS5x7
	1	13	26	64	48	58	41	24	10	12	38	9	12	49	6	61	64	24	11	11	7	33	6	4	55	35	16	4	10	6	13	15	18	31	13	11
	2	23	20	31	36	10	13	25	22	17	7	27	18	7	9	29	9	22	6	8	34	45	5	31	15	32	54	34	7	5	7	30	23	31	13	29
I	3	50	69	35	41	11	19	25	40	12	54	36	24	9	39	9	62	13	45	14	58	10	8	6	14	15	27	28	14	5	17	48	15	25	50	14
	4	22	18	62	49	7	16	33	29	24	17	22	21	32	38	11	12	51	3	37	8	26	57	6	13	19	18	34	4	47	11	17	17	15	17	14
	5	22	18	60	48	24	44	33	46	27	54	14	28	20	8	51	18	23	33	17	56	15	7	9	12	19	18	36	5	6	8	41	13	33	8	25
	6	57	32	30	32	45	40	18	13	13	62	13	21	17	7	11	14	31	6	10	11	21	5	12	40	13	27	12	20	4	23	12	9	32	15	16
	7	51	32	58	31	60	23	16	39	20	7	19	57	13	48	22	16	37	7	40	35	10	17	4	15	18	64	34	22	30	5	29	14	6	13	36
II	8	40	28	46	17	39	25	23	42	14	55	14	12	32	4	50	13	16	9	8	9	14	7	14	12	19	34	26	22	4	58	14	13	9	27	48
	9	47	65	36	32	13	21	28	12	13	9	15	18	14	54	11	18	24	41	22	8	13	27	20	14	24	17	14	17	2	17	14	46	9	14	54
	10	42	20	39	16	17	12	20	17	13	9	8	59	31	46	62	20	24	63	2	41	11	9	7	3	12	19	9	24	32	10	13	35	9	15	8
	11	23	24	9	27	20	63	23	21	10	12	54	47	35	29	42	60	6	8	55	6	19	36	4	27	15	42	10	23	8	21	11	15	37	14	19
	12	49	25	13	34	15	18	37	37	10	10	34	42	10	24	33	7	53	7	7	34	58	17	3	21	13	12	1	13	64	23	10	8	28	10	7
III	13	15	26	63	44	11	53	35	42	19	9	8	17	9	8	57	7	39	12	9	24	9	6	4	11	13	13	11	8	12	10	16	5	5	18	29
	14	42	27	47	17	13	33	35	12	8	14	20	20	4	8	5	58	8	37	22	62	7	18	17	3	16	37	43	17	31	9	22	6	27	59	18
	15	39	27	7	22	17	21	22	20	12	13	21	52	7	23	54	58	2	21	4	25	60	4	4	37	19	11	26	7	10	34	11	37	5	16	51
	16	41	23	12	10	21	13	35	15	12	16	24	56	14	9	9	59	37	4	8	11	24	32	5	12	27	14	10	2	27	10	11	6	12	12	39
	17	46	19	27	29	9	21	25	27	21	10	5	13	9	30	34	16	23	7	35	12	21	16	4	12	11	17	43	22	11	9	35	23	10	17	7
IV	18	13	21	14	37	19	19	26	27	23	14	27	18	7	23	15	33	37	33	52	57	13	15	5	5	31	26	19	12	17	18	9	12	10	22	14
	19	45	20	29	46	15	15	29	29	34	15	18	20	13	49	45	16	30	21	9	28	17	10	3	13	17	21	39	19	10	61	34	8	7	21	51
	20	36	24	10	42	17	22	44	14	12	12	19	15	8	13	38	9	31	53	6	51	29	36	58	29	32	16	23	6	7	11	39	5	5	32	59
	21	47	29	15	38	70	32	19	17	5	14	21	15	19	13	25	11	44	25	8	55	9	32	8	32	31	21	7	5	9	37	14	9	7	15	57
	22	17	16	13	36	9	20	18	11	43	10	15	42	27	51	36	6	17	4	6	57	56	32	5	11	10	15	28	51	28	40	12	35	25	17	58
V	23	7	24	14	40	13	15	25	11	9	13	11	14	17	6	3	35	35	3	37	29	6	17	6	11	30	23	9	22	9	17	14	10	9	21	11
	24	45	27	21	35	10	25	22	18	13	13	50	62	21	42	16	25	17	27	21	7	46	39	6	13	29	16	7	13	61	8	13	31	28	15	57
	25	61	27	63	43	5	24	16	29	27	17	44	55	13	7	7	63	36	26	55	4	8	42	5	11	20	14	3	49	26	19	10	10	38	13	15
	Mean	36.1	27.5	32.7	34.0	21.9	25.9	26.2	24.0	16.9	20.2	21.9	30.3	17.5	23.8	29.4	28.4	27.2	20.5	20.1	29.2	23.2	20.0	10.0	17.6	21.8	23.7	20.4	16.6	18.8	19.8	19.8	16.9	18.1	19.5	29.9

Table 20b. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 10 monokaryons of S. lacrimans (isolated from sporophore A) and 25 dikaryons formed by mating the monokaryons in all possible combinations.

B. Breaking strength (Newtons) of pieces after incubation period.

Bottle No.	Block No.	A$19	A$13	A$15	A$20	A$5	A$11	A$24	A$27	A$26	A$7	A$19x11	A$19x24	A$19x27	A$19x26	A$19x7	A$13x11	A$13x24	A$13x27	A$13x26	A$13x7	A$15x11	A$15x24	A$15x27	A$15x26	A$15x7	A$20x11	A$20x27	A$20x26	A$20x7	A$5 x 11	A$5x24	A$5x27	A$5x26	A$5x7	Control
	1	235	260	0	20	0	50	290	300	240	100	310	320	40	340	0	0	100	330	200	230	105	300	420	5	80	190	280	270	230	200	340	170	280	300	400
	2	60	190	70	50	260	200	220	210	230	310	170	220	260	250	180	280	110	350	220	55	25	285	240	170	100	50	350	300	330	140	140	280	260	150	410
I	3	0	0	90	20	230	170	190	10	265	0	110	250	290	20	265	0	150	20	160	5	300	270	290	210	260	180	260	350	260	190	270	165	20	310	480
	4	125	180	0	0	220	220	80	110	150	220	230	200	70	40	270	250	10	290	130	280	275	10	260	250	230	220	375	20	310	200	270	250	260	300	470
	5	195	290	0	0	90	80	10	20	150	0	130	170	230	230	30	230	115	70	270	0	220	320	290	270	250	170	350	270	240	60	240	50	230	230	370
	6	0	290	70	60	40	70	260	330	250	5	215	180	250	325	310	120	70	360	320	250	260	350	270	10	250	200	260	250	140	300	250	100	275	85	300
	7	0	220	5	30	0	180	270	40	200	320	190	0	240	20	240	240	40	350	20	100	250	290	310	250	230	5	260	90	300	240	260	300	250	25	480
II	8	10	260	50	220	55	210	200	40	270	5	250	230	120	430	10	220	80	230	300	390	230	340	260	250	190	160	265	350	10	270	270	210	190	10	440
	9	0	0	80	70	200	220	220	320	270	270	260	250	260	10	290	160	90	20	200	290	280	120	250	200	160	220	230	250	155	210	20	280	250	300	330
	10	50	160	90	180	170	245	250	165	290	170	240	0	160	30	0	210	90	0	330	90	320	250	310	330	300	170	200	70	190	220	100	290	290	190	420
	11	160	210	330	200	200	0	240	240	200	305	10	10	30	110	20	0	290	340	10	320	180	100	330	100	280	60	280	270	290	350	200	75	320	340	470
	12	15	200	210	60	190	230	220	35	305	220	65	30	250	200	120	260	20	310	310	70	10	250	350	160	260	240	300	0	290	250	320	130	320	175	480
III	13	300	230	0	20	240	10	120	50	250	225	310	260	350	280	10	250	60	365	260	160	315	280	340	270	270	285	225	230	240	210	320	240	220	250	390
	14	15	230	20	220	225	140	80	380	300	260	250	310	320	330	330	10	190	125	220	0	240	250	270	330	200	80	180	80	280	220	280	150	10	90	410
	15	85	260	390	165	200	190	310	260	320	230	240	10	310	230	10	0	300	210	310	160	0	380	290	20	190	330	265	280	50	340	70	210	160	110	480
	16	90	310	355	250	170	200	50	300	210	260	240	0	220	360	330	0	30	320	330	325	240	170	290	290	130	200	320	110	290	210	260	250	350	300	390
	17	20	270	240	210	200	260	140	210	270	210	200	340	280	120	90	250	60	290	190	360	240	220	330	290	340	230	190	310	340	100	120	270	120	250	420
IV	18	210	250	310	110	190	270	200	235	190	250	230	320	150	230	280	80	10	100	0	0	320	260	350	340	90	190	170	190	300	320	220	190	280	15	470
	19	0	220	100	20	0	290	130	290	40	240	260	270	180	250	10	170	90	230	280	140	260	240	340	330	220	160	140	220	5	50	300	290	250	5	380
	20	60	230	290	35	240	190	10	330	230	220	250	200	350	10	50	270	70	10	260	5	180	30	5	120	100	290	330	310	275	130	300	310	90	10	490
	21	30	250	190	75	250	80	330	300	330	300	200	230	250	280	270	320	20	240	240	0	300	90	320	140	80	220	375	290	100	250	260	220	270	5	500
	22	150	0	290	90	280	260	260	335	10	310	290	45	200	50	100	280	160	280	310	0	5	90	300	360	310	210	10	130	75	250	100	190	220	240	380
V	23	300	200	200	50	265	250	150	240	330	230	300	280	230	170	290	50	50	310	70	60	290	240	360	210	100	225	170	200	230	250	200	300	230	5	420
	24	40	270	120	60	285	190	250	290	250	230	20	0	215	60	240	170	135	260	120	260	40	40	320	200	170	190	230	0	335	290	130	90	240	250	450
	25	0	200	0	10	585	230	270	190	200	220	60	0	260	250	300	0	30	225	0	360	300	10	240	320	200	300	0	115	270	280	215	70	350	170	370
	Mean	86	207	140	90	180	177	190	209	230	206	197	157	162	185	162	154	95	225	201	156	208	207	295	215	200	192	241	196	222	217	219	204	225	183	422

Table 21a. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 12 monokaryons of S. lacrimans (isolated from sporophore B) and 36 dikaryons formed by mating the monokaryons in all possible combinations.

A. Weight loss as % of dry weight after incubation period.

Bottle No.	Piece No.	BS28	BS32	BS33	BS19	BS35	BS34	BS42	BS29	BS30	BS1	BS20	BS14	BS28x42	BS28x29	BS28x30	BS28x1	BS28x20	BS28x14	BS32x42	BS32x29	BS32x30	BS32x1	BS32x20	BS32x14	BS32x42	BS33x29	BS33x30	BS33x1	BS33x20	BS33x14	BS19x42	BS19x29	BS19x30	BS19x1	BS19x20	BS19x14	BS35x42	BS35x29	BS35x30	BS35x1	BS35x20	BS35x14	BS34x42	BS34x29	BS34x30	BS34x1	BS34x20	BS34x14
	1	12	21	18	8	20	9	67	5	6	40	10	9	13	15	14	4	27	5	48	5	28	4	27	13	10	19	3	9	10	9	5	17	21	6	8	7	11	9	16	2	12	7	42	10	26	17	8	8
	2	44	14	3	4	9	15	9	7	4	16	9	3	11	15	14	8	11	3	13	7	3	5	8	28	14	18	8	25	20	10	31	12	9	6	8	4	55	5	12	26	4	8	9	7	14	11	11	9
I	3	10	32	2	7	8	14	68	30	24	8	29	32	51	4	8	8	8	3	18	15	12	30	7	14	9	50	2	8	5	6	25	12	23	5	10	8	9	10	12	27	22	5	48	21	14	4	9	8
	4	16	26	28	28	51	14	5	11	3	12	4	6	11	3	6	13	9	7	10	31	30	14	11	17	9	10	12	12	6	7	28	12	44	5	54	4	9	13	6	3	24	3	16	11	12	6	69	16
	5	41	15	13	41	9	9	14	12	11	14	6	8	51	12	12	41	7	7	10	10	9	12	26	5	6	11	2	11	4	8	14	24	12	5	17	14	14	39	9	5	18	8	52	5	29	5	12	4
	6	20	13	2	8	14	6	67	10	6	10	17	6	21	5	5	21	7	12	7	24	13	3	8	18	19	20	4	11	9	40	56	7	20	6	11	18	50	15	9	23	12	18	12	3	13	17	18	5
	7	7	24	50	10	12	68	22	8	13	11	12	4	25	16	7	23	8	9	10	5	2	14	47	4	7	36	3	17	26	10	25	10	9	6	16	9	12	20	8	6	10	6	52	5	11	38	7	9
II	8	9	50	3	11	3	30	11	12	11	15	21	2	17	6	7	4	8	55	5	48	32	5	44	3	17	14	3	23	12	26	5	15	28	15	10	5	22	8	12	32	8	8	5	6	13	4	10	8
	9	7	16	1	7	20	13	53	20	18	11	25	10	15	3	7	14	53	27	7	7	19	9	10	5	8	26	8	9	5	10	5	8	8	31	28	5	48	12	11	10	7	14	5	14	16	6	6	26
	10	7	16	44	8	14	16	11	10	18	13	18	46	6	4	6	4	9	23	36	26	9	3	40	4	31	14	2	9	9	14	8	23	6	7	22	8	19	10	10	2	57	5	58	16	10	8	47	4
	11	9	10	42	8	11	14	17	10	14	9	10	42	9	5	41	18	8	4	7	20	12	4	7	4	11	6	8	7	3	10	25	16	10	2	4	3	29	7	7	4	8	8	16	14	14	2	5	6
	12	12	14	49	9	5	8	9	50	20	8	29	9	11	13	13	9	8	6	22	13	36	42	25	4	25	22	14	12	9	18	27	10	6	21	5	2	38	7	11	3	6	5	65	8	12	22	19	7
III	13	7	9	67	4	8	6	61	11	11	7	26	13	57	6	10	25	10	4	51	15	24	3	8	14	12	29	6	8	4	10	10	37	6	40	10	48	46	37	5	7	45	19	6	9	14	4	27	5
	14	8	25	6	51	8	1	50	13	24	10	26	6	11	17	11	8	28	4	12	20	26	12	8	17	4	6	18	7	3	13	14	9	4	4	13	20	14	47	13	5	41	5	4	15	9	3	11	2
	15	36	14	39	26	9	27	15	59	15	35	26	52	14	39	14	52	15	16	10	4	20	14	6	4	2	8	27	7	21	6	8	32	5	14	7	15	11	6	25	3	9	13	54	19	13	5	6	3
	16	21	10	13	8	20	11	11	9	13	14	8	7	27	13	4	8	5	8	11	54	25	37	9	4	6	8	5	20	11	21	7	18	46	15	10	16	18	47	10	23	17	19	23	4	11	3	9	3
	17	13	16	10	8	5	18	14	30	40	14	9	8	43	14	13	12	26	18	9	7	28	13	12	14	24	16	2	26	20	10	31	6	8	12	9	4	23	9	8	3	15	16	52	19	10	6	10	16
IV	18	36	20	13	51	8	18	29	29	7	17	71	4	19	15	3	4	9	7	23	7	6	15	18	3	11	17	47	22	6	11	7	19	17	39	12	15	14	12	22	10	12	4	44	5	15	6	7	3
	19	24	32	9	6	5	19	26	8	8	5	4	4	25	4	19	16	15	6	24	8	1	2	46	11	4	6	4	6	9	17	3	9	14	30	12	17	68	38	17	12	13	9	35	18	13	4	7	5
	20	26	16	14	7	5	9	14	43	30	22	24	9	50	17	5	48	5	26	25	6	2	4	22	7	25	4	23	8	7	29	26	8	10	3	17	16	14	10	12	31	8	8	31	9	21	7	12	7
	21	46	12	9	26	39	14	43	19	24	10	26	9	10	21	35	15	8	7	13	20	7	4	10	3	4	4	4	13	13	14	5	30	7	9	9	28	17	30	27	7	51	2	22	8	14	16	6	5
	22	26	35	9	9	2	10	9	9	6	6	10	2	55	7	36	26	6	6	32	34	4	4	12	4	13	15	13	21	18	6	44	8	6	20	18	4	39	39	8	11	38	4	63	16	13	6	8	4
V	23	24	11	47	7	5	14	53	49	11	29	25	16	30	4	7	12	9	7	13	8	5	4	10	3	15	9	2	7	8	9	51	25	10	35	9	8	16	9	19	35	11	6	64	8	9	18	42	4
	24	15	16	8	9	10	41	11	23	14	17	18	8	12	3	27	6	6	5	10	10	15	8	31	10	13	7	15	8	10	7	5	10	13	20	8	3	22	6	40	10	6	9	7	9	13	21	6	4
	25	15	16	12	6	4	34	50	8	23	9	14	2	41	15	47	7	21	8	12	14	29	20	10	15	3	5	18	6	3	6	7	15	7	5	6	10	13	7	22	7	11	20	8	6	14	45	7	4
	Mean	19.6	19.3	20.4	14.7	12.3	17.5	29.6	19.8	15.0	14.5	16.5	12.7	25.4	11.0	14.8	16.3	13.0	11.3	17.5	16.7	15.9	11.4	18.5	9.1	12.1	15.2	10.1	12.5	10.1	13.1	19.7	15.7	14.0	14.4	13.3	11.6	25.2	18.1	14.1	12.3	18.6	9.2	31.7	10.6	14.1	11.4	15.2	7.1

Table 21b. Changes in measurement of decay of pieces of P. sylvestris sapwood incubated for 10 weeks with 12 monokaryons of S. lacrimans (isolated from sporophore B) and 36 dikaryons formed by mating the monokaryons in all possible combinations.

B. Breaking strength (Newtons) of pieces after incubation period.

Bottle No.	Block No.	BS28	BS32	BS33	BS19	BS35	BS34	BS42	BS29	BS30	BS1	BS20	BS14	BS28x42	BS23x29	BS28x30	BS28x1	BS28x20	BS28x14	BS32x42	BS32x29	BS32x30	BS32x1	BS32x20	BS32x14	BS33x42	BS33x29	BS33x30	BS33x1	BS33x20	BS33x14	BS19x42	BS19x29	BS19x30	BS19x1	BS19x20	BS19x14	BS35x42	BS35x29	BS35x30	BS35x1	BS35x20	BS35x14	BS34x42	BS34x29	BS34x30	BS34x1	BS34x20	BS34x14	Control
	1	200	210	160	230	270	280	0	170	230	100	250	130	290	200	290	280	170	320	50	320	135	330	170	120	310	230	350	260	290	490	300	230	230	260	250	200	330	350	75	280	220	320	0	270	190	280	200	340	390
	2	80	260	350	300	260	230	310	180	250	240	320	400	220	250	190	330	270	350	340	215	290	360	265	170	290	250	280	115	250	430	180	200	300	230	270	270	5	260	300	180	230	330	280	270	340	230	270	250	440
I	3	220	100	280	260	315	290	0	150	180	260	180	90	10	340	230	250	280	320	230	230	350	60	260	250	280	20	320	280	310	270	150	280	180	360	360	220	300	240	300	150	220	310	30	120	170	320	290	260	480
	4	220	80	70	130	20	220	250	190	300	310	400	410	220	320	210	265	300	300	320	100	60	250	280	260	340	310	270	290	250	290	110	280	20	290	0	200	330	290	325	340	220	350	200	260	180	330	380	120	400
	5	100	160	250	15	300	240	240	290	210	260	360	175	0	270	220	30	310	240	260	320	300	280	220	410	340	320	320	270	260	320	170	210	360	270	320	190	275	140	325	280	240	190	5	270	110	370	215	390	480
	6	170	150	290	320	220	320	0	230	280	240	360	250	230	330	240	180	240	280	370	160	270	430	275	110	240	110	280	280	230	110	10	270	280	330	300	300	40	200	335	160	220	180	270	340	370	210	100	420	450
	7	200	110	10	300	250	0	190	260	260	240	320	380	120	300	360	170	340	290	310	320	330	230	100	360	310	40	280	200	175	420	100	240	250	330	200	280	280	210	290	280	190	300	0	340	280	250	200	310	380
II	8	180	10	300	230	225	130	260	270	330	260	300	320	250	260	240	310	280	10	335	10	40	370	30	400	290	160	380	250	140	220	340	250	110	220	330	370	260	360	270	130	200	330	370	290	210	320	270	400	450
	9	200	210	330	270	260	320	20	160	290	310	190	260	250	300	240	210	0	110	260	250	140	380	280	310	200	100	240	210	400	270	260	310	290	40	190	380	40	280	330	260	300	250	360	210	300	210	310	130	490
	10	210	220	10	290	270	280	290	290	300	230	200	10	280	330	230	230	290	340	190	140	260	290	60	450	130	270	280	280	230	400	320	200	320	300	210	350	270	280	340	300	0	290	0	210	220	270	5	370	360
	11	190	240	10	275	220	240	210	300	310	310	300	10	270	370	20	205	270	330	360	210	320	230	320	300	240	360	350	240	300	400	120	310	220	280	330	370	150	330	375	350	230	320	350	280	390	400	200	350	480
	12	210	230	10	250	270	280	190	0	210	290	170	270	280	260	200	220	240	270	260	290	20	30	190	280	150	180	220	210	280	200	5	260	290	90	385	380	70	330	290	270	320	330	0	310	230	100	150	290	470
III	13	290	280	350	300	320	235	0	250	340	280	150	300	10	320	290	190	270	420	10	270	170	350	430	250	240	200	280	270	370	260	218	90	230	30	290	30	100	110	290	260	60	150	340	300	180	340	170	330	500
	14	270	150	290	20	370	310	50	230	180	240	180	200	250	230	310	300	75	350	240	210	40	230	300	220	340	300	150	240	320	240	280	320	320	330	250	290	230	30	230	440	60	330	270	230	240	320	170	370	360
	15	110	220	20	260	260	160	290	0	210	40	160	10	240	30	200	10	280	210	180	300	190	280	325	450	410	200	160	325	230	320	320	160	320	210	310	250	230	360	210	270	250	300	0	230	360	380	180	360	410
	16	150	250	290	330	230	215	260	250	270	310	350	300	150	260	230	370	400	330	200	10	150	20	290	290	340	430	260	150	290	190	280	200	20	240	290	300	280	20	260	160	170	130	240	260	160	330	170	400	380
	17	200	210	250	260	320	100	210	90	20	310	310	150	40	250	260	270	160	240	300	270	40	280	300	260	210	260	340	110	200	280	70	350	270	240	290	310	140	340	210	310	240	230	0	180	180	325	110	270	365
IV	18	100	190	290	10	245	210	210	110	340	190	260	270	150	210	350	300	300	310	200	250	350	190	150	300	320	260	10	210	360	320	330	250	230	30	290	300	215	300	200	280	270	380	30	280	210	260	370	270	480
	19	140	90	230	280	300	170	260	210	320	260	390	330	180	340	140	215	290	290	185	290	420	350	70	250	360	330	350	350	190	170	340	270	190	40	250	300	0	75	240	270	300	310	80	120	330	360	380	430	490
	20	140	210	240	310	290	300	280	10	80	220	190	260	15	175	280	15	270	160	200	270	350	380	225	340	170	310	110	250	290	160	10	320	350	340	280	250	230	200	230	10	200	320	125	280	340	300	310	320	400
	21	0	190	250	200	50	220	60	240	140	280	170	300	270	115	50	250	290	310	290	260	330	330	330	340	370	300	300	300	240	240	330	110	350	360	390	150	190	110	190	300	40	400	150	310	270	300	260	280	380
	22	160	90	250	200	260	265	280	330	250	260	320	360	5	360	80	185	290	360	180	175	350	380	240	260	290	280	350	215	210	380	20	220	320	200	200	270	200	20	370	290	100	320	0	240	220	380	210	360	470
V	23	120	210	50	280	280	140	10	20	380	170	180	330	210	275	300	280	260	370	200	315	270	430	270	350	170	240	440	320	260	420	5	170	320	100	290	280	190	200	230	140	240	350	0	300	180	160	50	310	380
	24	190	200	250	310	280	40	310	150	270	270	260	320	250	350	150	280	340	380	290	215	240	340	130	260	210	260	270	350	240	400	270	240	170	270	320	300	250	325	25	240	280	320	300	250	120	140	160	390	380
	25	140	230	240	330	290	140	0	230	180	290	230	310	60	260	20	315	250	250	230	270	50	165	240	150	300	370	240	370	310	220	200	260	400	350	290	270	210	230	150	300	240	160	320	310	210	10	370	330	500
	Mean	168	180	203	238	255	213	167	184	245	247	260	246	170	268	213	226	259	286	240	227	219	279	230	286	274	244	273	254	265	297	190	240	254	230	275	272	193	224	256	250	202	286	149	258	240	276	220	322	432

Table 22a. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by three dikaryotic (4, 5, 8) and three monokaryotic(AS9, AS15, AS7) isolates of S. lacrimans after they had been stored on malt agar or on wood blocks at three temperatures for a period of six months.

A. Weight loss as % of original dry weight after 10 weeks incubation.

		24°C										20°C																15°C							
Bottle	Piece	4		5		8		AS9		AS15		AS7		4		5		8		AS9		AS15		AS7		4		5		8		AS9		AS15		AS7	
No.	No.	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood
	1	13	49	13	18	26	43	23	64	28	16	16	46	24	63	28	53	31	22	17	30	7	60	68	15	41	56	24	38	57	40	8	36	7	9	8	7
	2	47	21	9	7	15	38	17	61	10	41	5	4	54	47	20	45	27	42	61	29	16	15	10	10	34	7	22	12	26	3	16	7	5	8	6	5
I	3	51	33	14	16	30	41	50	8	13	18	8	12	29	61	23	29	17	62	11	60	48	1	8	10	43	53	23	28	18	40	12	34	9	9	10	9
	4	50	28	34	39	56	33	6	2	6	47	6	26	23	55	27	46	19	64	9	59	46	60	7	5	36	36	13	17	17	35	31	57	25	68	6	25
	5	22	26	16	27	34	18	33	34	12	33	13	18	55	65	23	32	23	59	13	63	29	4	6	37	47	23	23	34	54	44	24	18	16	29	7	16
	6	41	39	34	34	41	59	14	8	14	10	8	5	16	58	15	44	58	63	41	39	26	11	2	55	23	1	19	7	30	14	28	55	12	3	5	12
	7	22	53	31	33	23	47	62	65	26	4	20	15	43	68	15	47	26	65	29	28	13	1	3	17	1	53	18	27	27	27	17	7	44	67	5	30
II	8	40	34	18	32	40	33	53	15	9	60	7	21	30	46	33	30	18	38	44	60	40	59	1	5	39	59	14	21	16	14	21	29	9	5	43	9
	9	33	28	15	43	14	49	40	9	6	54	5	6	30	60	25	29	17	63	43	36	43	51	5	40	60	9	12	24	19	26	40	8	8	1	5	8
	10	23	62	22	6	24	28	42	8	43	39	30	67	40	50	33	49	54	59	53	33	33	18	2	11	55	43	27	19	22	32	16	8	4	6	8	4
	11	57	58	24	22	34	7	12	16	26	7	13	6	14	56	6	13	26	63	6	35	12	59	3	4	52	18	15	17	20	20	15	10	8	16	9	8
	12	49	66	34	29	25	7	21	8	4	31	11	15	33	50	10	54	55	65	37	20	5	31	3	37	1	35	17	20	25	35	17	40	9	14	7	9
III	13	15	63	27	16	22	55	22	66	64	47	13	9	60	67	20	54	30	43	39	60	28	66	7	7	47	8	17	21	18	33	13	9	8	9	6	8
	14	42	36	13	11	34	45	59	12	65	13	4	14	62	35	7	43	51	58	17	57	42	58	1	49	34	33	6	16	12	30	9	7	9	15	15	9
	15	46	43	6	14	31	44	49	13	30	47	6	14	17	25	43	11	22	47	52	36	45	12	1	57	45	23	18	29	57	34	12	52	8	10	6	8
	16	38	33	42	11	34	8	53	62	50	55	8	6	52	62	42	36	49	72	2	45	46	11	59	56	21	46	31	4	49	42	7	4	7	9	10	7
	17	45	45	30	27	21	45	13	64	64	11	5	8	23	60	29	33	18	15	27	57	10	58	61	4	1	51	28	25	17	47	33	35	42	12	12	31
IV	18	13	66	25	28	57	23	43	4	63	20	13	10	62	44	32	52	25	44	31	66	46	13	64	4	57	40	32	19	24	29	7	54	8	6	11	8
	19	36	17	39	21	28	61	31	2	19	46	4	14	59	24	21	26	33	39	49	61	54	64	27	9	40	5	11	22	32	26	32	1	44	7	8	33
	20	41	39	28	46	30	44	3	63	14	44	5	66	55	21	33	30	11	34	42	30	38	58	2	14	42	26	14	15	10	17	40	55	3	17	9	3
	21	17	46	11	20	20	47	1	6	6	4	5	6	20	56	15	28	20	26	17	29	61	64	4	25	42	41	7	16	26	39	11	1	10	17	7	10
	22	61	20	33	10	56	39	12	54	4	40	6	14	14	47	24	40	25	38	26	28	10	29	1	8	43	30	24	6	54	29	7	9	4	51	25	4
V	23	7	39	13	35	49	58	8	1	8	47	7	11	13	19	44	46	19	56	24	66	24	8	4	28	55	47	12	18	30	40	5	34	6	66	6	6
	24	45	52	32	14	17	48	10	4	15	46	6	24	23	57	44	23	13	63	4	47	1	68	5	33	11	26	12	1	51	39	11	16	28	63	4	28
	25	47	31	20	20	28	17	12	64	14	19	4	11	38	41	42	43	58	70	62	48	8	39	1	6	37	52	23	23	21	40	13	14	28	22	9	38
	Mean	36.0	41.0	23.3	23.2	31.6	37.5	27.6	28.5	24.5	32.0	9.0	18.0	35.6	49.5	26	37.4	29.8	50.8	31.0	44.9	29.2	36.7	14.2	21.8	36.3	32.8	18.5	19.2	29.3	31.0	17.8	24.0	14.8	21.6	9.9	13.4

Table 22b. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by three dikaryotic (4, 5, 8) and three monokaryotic (AS9, AS15, AS7) isolates of S. lacrimans after they had been stored on malt agar or on wood blocks at three temperatures for a period of six months.

B. Breaking strength (Newtons) of pieces after 10 weeks incubation.

		24°C												
Bottle No.	Piece No.	4		5		8		AS9		AS15		AS7		Control
		Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	
	1	180	10	80	210	150	35	290	5	275	445	260	10	390
	2	20	160	155	340	250	25	320	0	255	25	370	320	370
I	3	120	30	135	260	75	65	10	330	250	425	370	300	450
	4	115	160	40	60	5	55	370	320	370	15	330	160	390
	5	5	75	170	90	55	225	180	130	310	45	360	200	400
	6	180	60	30	140	15	0	380	280	275	405	160	260	450
	7	35	0	30	90	145	10	15	0	240	395	360	280	310
II	8	75	60	155	80	45	25	140	350	260	5	230	270	385
	9	120	25	245	20	210	5	90	390	350	0	320	300	480
	10	25	0	160	320	95	40	60	280	65	65	70	0	470
	11	115	0	150	250	115	190	350	350	190	400	220	330	250
	12	60	0	85	220	145	355	220	350	270	195	240	340	390
III	13	0	0	140	290	115	5	290	0	0	5	320	360	350
	14	0	45	280	310	55	10	0	320	0	460	200	350	400
	15	270	20	260	210	60	35	30	300	90	0	320	320	370
	16	20	105	5	290	145	160	25	0	30	0	250	300	390
	17	115	15	65	230	115	15	300	0	0	315	400	310	270
IV	18	0	0	125	190	10	65	0	400	0	135	320	350	380
	19	0	190	10	310	120	0	230	420	230	5	320	290	400
	20	10	0	85	20	185	15	360	0	260	10	370	0	330
	21	160	10	180	320	150	5	410	360	300	455	340	330	270
	22	175	170	60	350	0	15	380	20	380	5	330	280	390
V	23	145	45	250	40	15	0	370	320	300	0	230	310	330
	24	190	0	110	250	60	5	390	340	170	0	220	180	420
	25	55	40	130	110	85	75	400	0	220	190	180	280	375
	Mean	88	49	125	200	97	57	224	211	204	160	284	257	376

	20°C												
4		5		8		AS9		AS15		AS7		Control
Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	
240	0	150	0	185	180	280	240	355	0	0	220	390
10	30	200	20	185	50	5	180	280	380	315	310	270
290	0	220	110	90	0	390	0	10	300	350	300	580
190	20	190	30	250	0	340	0	10	0	340	310	380
10	0	180	70	185	0	305	0	110	380	360	70	295
180	0	260	20	0	0	35	70	75	340	370	0	320
50	0	270	10	85	0	165	165	325	330	360	230	385
140	40	100	90	175	35	35	0	15	5	320	280	510
130	0	130	120	160	0	15	160	60	50	360	10	390
80	30	90	30	0	0	10	130	100	235	370	310	410
260	0	310	150	165	0	380	180	310	0	380	280	350
170	0	200	0	0	0	15	210	380	240	310	10	340
0	0	150	0	125	30	45	0	40	5	300	350	400
0	50	290	20	15	0	275	0	15	0	350	0	380
190	170	30	220	185	25	15	100	15	340	370	0	410
40	0	50	160	10	0	390	95	40	340	0	0	435
190	0	140	90	265	130	125	0	325	0	0	290	360
0	50	90	40	230	35	185	0	20	340	0	360	420
0	160	130	220	170	30	0	0	10	5	150	330	350
0	155	100	190	200	80	55	165	35	10	360	280	490
145	0	180	80	180	190	275	180	0	5	310	110	410
200	40	80	40	230	80	355	160	330	130	300	320	390
210	160	10	30	190	10	345	0	280	330	310	160	300
140	0	20	150	180	0	355	10	510	0	330	170	460
100	90	10	20	0	0	5	10	350	25	370	315	580
119	40	143	76	138	35	176	82	160	152	279	200	400

	15°C												
4		5		8		AS9		AS15		AS7		Control
Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	
30	10	50	15	0	10	350	115	360	225	380	360	480
80	390	50	50	130	200	260	350	360	250	310	360	350
10	5	75	35	190	11	330	115	360	220	340	360	400
95	150	85	50	220	15	125	5	175	10	460	175	380
50	130	75	30	10	10	290	340	310	155	390	310	390
130	240	60	340	240	210	115	380	270	260	340	270	330
350	5	80	60	150	140	280	415	15	0	320	65	485
60	0	75	65	230	260	150	60	380	320	15	380	500
0	300	80	40	200	90	50	375	380	270	430	360	340
0	10	80	150	210	30	230	410	340	300	410	340	300
10	240	210	130	240	60	200	360	390	165	365	380	340
445	90	180	125	290	40	250	65	340	220	430	330	365
10	250	60	100	300	50	270	415	340	265	425	340	290
30	240	310	75	250	25	380	365	350	330	320	350	435
10	260	60	45	0	20	350	10	440	275	435	340	420
190	15	60	100	10	15	320	380	340	270	430	340	400
280	0	45	50	190	10	80	60	10	320	460	30	360
0	40	15	120	140	30	340	10	370	330	430	370	320
50	435	270	110	90	40	140	450	30	340	345	50	375
20	100	100	240	200	150	60	5	320	230	280	320	400
25	10	165	50	160	15	250	440	380	250	240	360	440
10	135	45	310	0	45	330	320	390	0	45	380	490
0	10	100	140	100	15	380	70	380	0	335	360	490
220	120	100	420	20	30	300	300	390	0	420	300	410
110	5	60	65	90	40	320	240	25	190	340	30	400
89	128	100	117	146	62	246	242	286	209	352	284	392

Table 23a. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by three dikaryotic (4, 5, 8) and three monokaryotic (AS9, AS15, AS7) isolates of S. lacrimans after they had been stored on malt agar or on wood blocks at three temperatures for a period of one year.

A. Weight loss as % of original dry weight after 10 weeks incubation.

		24°C										20°C														15°C							
Bottle	Piece	4		5		8		AS9		AS15		AS7		4		5		8		AS9		AS15		AS7		4		5		8		AS9		AS15		AS7	
No.	No.	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood
	1	17	30	12	8	55	52	53	55	12	67	10	13	16	28	6	16	25	68	33	9	29	23	5	17	18	23	8	10	22	9	12	25	11	33	18	8
	2	10	61	13	20	5	57	32	10	6	6	10	8	16	34	49	28	26	17	6	13	21	51	2	15	24	23	13	13	17	12	9	14	7	10	7	6
I	3	20	39	13	9	57	24	14	10	9	8	8	15	38	34	43	31	33	18	29	53	28	3	18	22	21	20	27	11	20	15	9	18	12	17	8	9
	4	21	14	14	34	22	12	8	49	13	9	3	18	45	41	14	26	14	41	23	16	18	62	28	7	22	35	11	7	12	21	30	12	5	7	5	10
	5	21	41	2	21	3	37	11	27	12	19	5	37	30	34	3	19	21	24	2	31	3	24	2	49	27	18	15	8	17	16	9	8	8	13	9	12
	6	20	15	23	24	14	12	16	10	9	38	6	7	13	37	42	15	19	54	26	50	63	30	6	23	23	33	4	21	24	19	11	10	16	16	9	17
	7	19	12	12	42	10	55	13	20	63	9	15	24	7	35	1	23	28	17	40	37	59	18	1	4	18	25	14	6	24	29	9	12	48	46	23	21
II	8	25	30	40	18	9	21	67	10	29	54	6	10	15	38	39	34	26	64	39	9	57	50	1	50	12	37	8	65	37	20	14	28	7	15	4	15
	9	17	28	17	29	10	57	14	45	21	8	16	7	13	32	19	25	29	59	7	25	6	8	1	4	21	36	9	8	25	21	26	14	5	13	5	44
	10	17	23	9	21	10	9	25	15	17	9	4	42	14	43	10	27	35	60	7	59	12	36	3	42	25	44	28	17	21	28	36	41	7	44	3	13
	11	20	49	7	28	13	60	44	51	15	20	5	14	49	40	12	18	28	55	18	31	20	55	4	15	20	21	27	53	20	26	6	10	8	13	9	60
	12	22	46	12	28	7	29	35	48	20	17	10	40	25	29	9	26	29	26	16	9	6	58	25	7	24	11	10	12	17	29	11	18	5	30	4	5
III	13	33	53	12	21	15	30	14	12	9	15	12	7	5	29	4	20	29	45	5	40	11	5	2	43	17	9	27	24	19	30	65	54	9	11	23	30
	14	29	8	17	23	10	55	17	14	23	12	7	54	21	37	16	25	32	51	31	21	56	52	25	29	17	41	9	14	20	28	11	10	25	38	42	15
	15	31	10	28	21	60	48	15	8	16	37	18	5	26	42	1	32	30	29	31	8	10	59	8	41	12	12	1	8	34	29	12	50	4	16	6	16
	16	31	13	12	22	6	11	13	10	7	24	5	10	16	35	3	31	26	33	4	34	28	18	1	39	11	12	28	18	23	35	9	12	10	10	10	11
	17	17	12	16	16	10	57	15	57	11	23	6	19	4	40	3	19	30	19	39	60	55	22	2	29	10	32	3	1	18	23	6	11	20	49	7	6
IV	18	23	12	15	18	40	57	7	14	27	66	7	14	11	39	40	21	19	29	44	48	40	56	23	15	22	24	28	9	23	29	8	50	3	7	16	11
	19	34	59	15	25	10	16	21	52	68	24	6	10	15	38	5	26	27	64	38	37	6	18	30	4	25	41	24	27	19	24	13	31	19	25	15	8
	20	26	18	14	16	13	13	12	13	10	22	10	17	12	37	10	30	26	27	38	55	11	20	1	7	27	15	9	21	19	21	9	17	7	12	7	19
	21	18	47	41	20	57	45	23	41	6	7	7	11	26	30	22	19	40	60	32	56	24	54	19	13	19	14	4	14	20	37	14	8	27	8	10	15
	22	19	14	19	25	53	10	16	18	8	62	7	18	11	47	8	25	23	45	33	53	15	20	2	7	19	18	6	12	19	23	10	10	9	21	28	9
V	23	16	38	12	16	33	19	16	40	6	27	8	9	33	36	16	23	20	59	25	45	56	53	1	48	24	11	2	19	21	21	7	8	10	16	4	11
	24	20	11	11	17	25	7	18	8	8	23	9	11	47	47	9	21	21	29	5	40	24	61	31	26	20	37	3	16	23	27	7	12	11	46	9	15
	25	14	45	11	32	42	7	18	45	11	63	6	61	27	36	26	32	33	44	18	60	16	22	22	49	27	38	2	14	21	25	12	8	5	14	6	10
	Mean	21.6	29.1	15.9	22.2	23.6	32	21.5	27.3	17.4	26.8	8.2	19.2	21.4	37.5	16	24.0	27.0	41.0	23.6	36.0	27.0	35.1	10.5	24.2	20.2	25.2	12.8	17.1	21.4	23.9	14.6	20.0	11.9	21.2	11.5	15.8

Table 23b. Changes in measurement of decay of pieces of P. sylvestris sapwood decayed by three dikaryotic (4, 5, 8) and three monokaryotic(AS9, AS15 AS7) isolates of S. lacrimans after they had been stored on malt agar or on wood blocks at three temperatures for a period of one year.

B. Breaking strength (Newtons) of pieces after 10 weeks incubation.

		24°C												
Bottle No.	Piece No.	4		5		8		AS9		AS15		AS7		Control
		Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	
	1	250	120	180	220	10	30	0	10	270	0	350	310	450
	2	230	0	200	180	250	10	100	280	290	180	240	310	490
I	3	260	40	240	200	10	180	270	160	370	290	380	200	360
	4	290	205	220	130	130	190	360	35	220	320	410	250	440
	5	310	30	240	160	320	80	340	230	270	270	370	30	380
	6	180	250	260	165	220	200	210	390	200	90	380	290	465
	7	310	260	290	80	220	10	240	120	0	260	220	120	510
II	8	330	170	100	145	320	160	0	275	120	10	330	280	440
	9	280	130	230	130	260	10	290	50	270	290	300	300	400
	10	260	150	350	120	270	250	190	150	280	310	250	60	410
	11	170	10	360	120	280	10	70	15	270	190	360	250	430
	12	180	20	220	130	260	130	100	10	240	340	300	40	500
III	13	80	0	170	125	220	80	240	120	220	220	310	250	280
	14	100	290	220	145	290	20	310	170	220	290	260	0	430
	15	90	280	180	150	5	30	230	400	200	70	400	220	460
	16	70	260	280	170	280	220	220	200	260	210	330	280	420
	17	190	300	210	210	290	15	260	10	170	240	330	200	500
IV	18	200	310	240	185	90	10	310	340	0	0	320	300	430
	19	150	0	250	180	220	250	210	20	250	190	340	260	520
	20	130	170	220	200	170	260	340	290	350	190	370	180	410
	21	230	20	10	220	10	30	240	30	400	310	330	230	500
	22	210	290	270	140	10	320	220	315	340	0	310	230	440
V	23	225	80	280	235	70	190	270	40	280	220	290	210	480
	24	180	285	340	165	180	220	250	150	290	200	310	250	450
	25	210	10	190	190	20	300	260	10	190	0	350	0	480
	Mean	205	147	230	164	176	128	221	153	239	188	326	202	443

		20°C												
		4		5		8		AS9		AS15		AS7		Control
		Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	
		230	160	200	200	170	0	30	200	270	120	330	360	390
		210	90	20	140	160	210	290	180	190	0	330	200	450
		60	180	20	125	195	180	160	0	170	250	190	120	510
		45	60	210	150	230	70	170	200	200	0	120	370	430
		120	190	280	180	220	200	400	85	360	70	250	15	310
		260	140	40	170	235	30	120	15	0	90	340	140	400
		310	120	290	110	110	150	30	20	0	290	310	360	370
		200	80	60	100	100	0	20	200	0	50	220	15	425
		270	170	240	135	80	10	330	90	320	330	360	260	420
		210	40	270	110	70	5	200	10	250	100	340	20	530
		40	40	280	135	130	10	200	60	280	70	350	250	260
		220	120	270	125	165	150	230	360	350	5	170	160	420
		270	190	260	120	110	60	430	55	250	390	380	20	400
		210	60	220	140	70	10	100	170	10	80	190	110	440
		170	60	350	90	120	100	40	310	270	0	320	10	390
		150	120	300	80	140	90	460	50	80	210	320	30	510
		320	30	320	140	150	140	10	0	10	120	400	130	360
		160	90	40	135	170	120	30	10	20	0	170	160	460
		220	20	250	155	90	0	20	60	310	290	120	380	450
		230	190	210	120	75	140	50	10	290	355	340	300	490
		10	130	80	160	60	10	50	0	190	310	200	150	390
		190	10	250	125	90	160	70	20	250	290	280	250	450
		0	140	150	145	135	5	150	15	10	0	370	20	420
		15	0	300	170	115	140	200	10	170	0	80	120	380
		150	125	50	90	70	20	310	5	180	200	120	20	450
		171	102	198	134	130	80	164	85	177	145	264	159	420

		15°C												
		4		5		8		AS9		AS15		AS7		Control
		Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	Agar	Wood	
		290	180	250	240	150	220	170	115	300	120	250	270	325
		130	170	160	280	170	120	210	250	280	330	260	170	480
		190	190	100	290	180	185	130	200	320	140	280	350	310
		120	110	190	130	160	190	140	220	280	210	280	250	485
		180	270	210	200	190	150	380	370	175	280	270	120	460
		195	170	230	230	150	220	410	150	340	160	220	250	500
		220	160	210	210	180	140	220	320	5	15	140	240	240
		145	120	270	0	30	140	140	60	310	350	310	250	480
		150	110	210	270	250	240	110	160	250	350	220	40	270
		120	80	30	170	230	165	100	70	270	50	370	290	490
		135	165	70	10	150	100	210	220	290	120	280	0	440
		160	250	200	250	220	120	370	200	290	110	260	350	415
		260	310	40	150	150	170	10	10	130	340	170	80	500
		175	30	150	190	140	215	250	370	310	80	20	220	420
		180	325	270	250	50	150	220	10	300	250	270	220	390
		220	310	80	200	120	120	380	240	260	220	350	170	480
		250	120	390	300	180	170	270	230	360	20	260	350	460
		210	120	80	310	220	100	360	10	300	320	270	240	495
		160	50	160	120	180	150	160	90	340	130	220	270	420
		180	195	240	140	190	180	170	190	80	250	230	28.	375
		210	270	200	290	190	30	290	410	260	320	260	240	480
		235	295	200	210	170	110	310	220	240	120	150	265	415
		225	300	320	200	170	210	180	210	250	220	300	270	465
		240	90	260	190	130	250	250	150	300	15	380	230	490
		190	70	360	170	200	190	410	230	220	190	310	290	415
		191	178	195	200	166	161	234	188	258	188	253	228	435

Table 24a. Comparison of saprophytic ability of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperatures for different periods of time.

(1) Results of tests of cultures made within 30 days of heat treatment.

(A) Weight loss as % of original dry weight after 10 weeks incubation.

Bottle No.	Culture No. / Piece No.	1	2	3	4	Parent Culture
I	1	19	60	40	19	49
	2	63	20	18	17	19
	3	51	24	20	14	57
	4	12	26	21	6	13
	5	44	12	39	30	53
II	6	13	41	63	64	37
	7	17	6	15	29	12
	8	60	62	39	64	19
	9	56	21	43	12	14
	10	22	37	34	18	64
III	11	53	11	42	15	56
	12	56	20	56	21	13
	13	53	59	53	58	55
	14	28	47	45	61	31
	15	13	32	53	14	22
IV	16	29	11	9	35	51
	17	13	5	21	32	14
	18	12	13	48	32	48
	19	50	6	57	44	54
	20	17	65	37	63	53
V	21	55	9	12	54	20
	22	37	52	21	56	56
	23	44	18	23	46	19
	24	16	33	26	50	59
	25	36	33	62	55	19
	Mean	34.8	28.9	35.9	36.4	36.3

L.S.D. (P =0.05) between means of percent weight losses = 10.13%.

Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

For illustration see text figure 17.

Table 24b. Comparison of saprophytic ability of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperatures for different periods of time.

(1) Results of tests of cultures made within 30 days of heat treatment.

(B) Breaking strength of wood pieces after 10 weeks incubation.

Bottle No.	Culture No. / Piece No.	1	2	3	4	Parent Culture	Control
	1	250	0	110	250	40	350
	2	0	270	320	290	280	430
I	3	10	290	260	310	0	380
	4	10	250	180	320	280	450
	5	60	280	50	190	10	320
	6	340	40	0	0	130	350
	7	320	340	310	110	290	330
II	8	5	0	30	0	180	410
	9	10	270	45	310	150	470
	10	290	90	40	290	5	450
	11	15	320	30	270	10	340
	12	0	350	10	290	320	400
III	13	10	5	10	0	10	330
	14	120	15	10	0	120	380
	15	310	70	10	240	200	390
	16	100	320	340	50	10	380
	17	300	360	260	80	300	400
IV	18	260	320	5	45	40	350
	19	10	260	10	10	5	460
	20	310	0	65	0	10	390
	21	10	400	320	5	200	400
	22	100	10	290	0	5	390
V	23	40	240	200	10	290	420
	24	300	100	150	5	0	390
	25	30	50	0	0	270	460
	Mean	128	185	122	125	125	393

L.S.D. (P = 0.05) between means of breaking strength = 70.5 Newtons

Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

Table 24c. Analysis of variance of data in Appendix Tables 24a and 24b.

A. Percent loss of dry weight

Source of variation	SS	°F	MS	Variance ratio
Between Isolates	1069.0	4	267.3	0.80 *
Between Bottles	8455.0	20	422.8	1.27 *
Within Bottles (error)	33385.0	100	333.9	
TOTAL	42909	124		

B. Breaking strength [exclusive control]

Source of variation	SS	°F	MS	Variance ratio
Between Isolates	75163.0	4	18791.0	1.16 *
Between Bottles	552247.0	20	27612.0	1.71 *
Within Bottles (Error)	1615270.0	100	16152.7	
TOTAL	2242680.0	124		

* Not significant at 0.05 level.

Table 25a . Comparison of saprophytic ability of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperatures for different periods of time.

(2) Results of tests made of cultures which had been stored on malt agar for 6 months after the heat treatment.

(A) Weight loss as % of original dry weight after 10 weeks incubation.

Bottle No.	Culture No. / Piece No.	1	2	3	4	Parent culture
	1	11	15	46	48	58
	2	12	57	23	14	12
I	3	63	38	10	50	40
	4	10	30	40	10	58
	5	32	11	42	7	31
	6	34	33	58	9	10
	7	17	20	18	46	12
II	8	12	23	16	49	54
	9	27	20	16	16	56
	10	33	21	46	52	45
	11	44	11	58	10	39
	12	11	55	28	49	21
III	13	59	11	18	10	38
	14	47	12	31	47	17
	15	34	15	23	7	24
	16	16	14	26	20	56
	17	35	14	26	15	58
IV	18	18	10	57	8	20
	19	15	25	41	23	31
	20	15	48	51	44	11
	21	17	12	13	12	42
	22	15	58	15	28	13
V	23	18	11	40	50	16
	24	17	10	25	11	36
	25	20	50	30	50	15
	Mean	25.3	25.0	31.9	27.4	32.5

L.S.D. (P = 0.05) between means of percent weight losses = 9.5%.

Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had b been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

For illustration see text figure 18.

Table 25b. . Comparison of saprophytic ability of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperatures for different periods of time.

(2) Results of tests made of cultures which had been stored on malt agar for 6 months after the heat treatment.

(B) Breaking strength of wood pieces after 10 weeks incubation.

Bottle No.	Culture No. / Piece No.	1	2	3	4	Parent Culture	Control
	1	340	340	50	10	10	360
	2	280	10	270	200	290	450
I	3	0	170	440	5	140	500
	4	270	310	90	300	20	470
	5	230	340	60	300	165	310
	6	190	90	5	290	250	410
	7	265	270	270	20	250	490
II	8	280	270	340	0	30	470
	9	270	290	300	230	10	395
	10	30	360	30	5	60	500
	11	40	340	10	390	50	500
	12	300	20	150	10	250	300
III	13	5	290	260	300	70	460
	14	5	300	100	10	200	500
	15	150	350	200	360	5	380
	16	370	280	265	300	230	440
	17	50	310	70	310	10	440
IV	18	280	290	10	310	210	400
	19	370	180	260	270	220	380
	20	50	10	20	20	250	490
	21	320	310	270	310	50	450
	22	320	5	320	180	280	460
V	23	370	330	140	30	250	400
	24	240	260	250	320	95	215
	25	340	5	120	10	235	410
	Mean	215	230	172	180	145	423

L.S.D. (P = 0.05) between means of breaking strength = 72.3 Newtons.

Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

Table 25c. Analysis of variance of data in Appendix Tables 25a and 25b.

A. Percent loss of dry weight

Source of variation	SS	°F	MS	Variance ratio
Between Isolates	1291.2	4	322.8	1.11 **
Between Bottles	3614.6	20	180.7	0.62 **
Within Bottles (error)	29026.4	100	290.3	
TOTAL	33932.2	124		

B. Breaking Strength [exclusive control]

Source of variation	SS	°F	MS	Variance ratio
Between Isolates	144083.2	4	36020.8	3.34 *
Between Bottles	215690.0	20	10784.5	0.63 **
Within Bottles (error)	1700210.0	100	17002.1	
TOTAL	2059983.2	124		

* Significant at 0.05 level

** Not significant at 0.05 level

Table 26. Measurement of colony diameter (mm 7 days at 21°C) of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperature for different periods of time.

(1) Results of tests of cultures made within 30 days of heat treatment.

Culture / Replicate	1	2	3	4	Parent* Culture
1	77	71	75	74	80
2	78	75	77	77	83
3	75	72	78	75	84
4	74	74	74	78	85
5	76	73	73	74	83
6	78	76	76	72	79
7	73	70	75	76	86
8	77	73	73	73	82
9	79	75	70	79	84
10	75	74	77	72	87
Mean	76.2	73.3	74.8	75.0	83.3

L.S.D. between means of colony diameters = 2.0 mm (P = 0.05)

Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

* Untreated culture (Strain 8).

Analysis of Variance

Source of variation	SS	°F	MS	Variance ratio
Between cultures	617.1	4	154.3	30.25**
Within cultures	227.4	45	5.1	
TOTAL	844.5	49	17.2	

** Significant at 0.001 level.

For illustration see text figure 17.

Table 27. Measurements of colony diameters (mm 7 days at 21°C) of cultures of S. lacrimans isolated from different parts of colonies which had been subjected to high temperature for different periods of time.

(2) Results of tests made of cultures which had been stored on malt agar for 6 months after the heat treatment.

Culture / Replicate	1	2	3	4	Parent* culture
1	63	59	62	58	66
2	60	55	55	59	67
3	58	57	58	44	66
4	55	55	63	61	61
5	60	52	59	57	65
6	58	58	60	41	60
7	60	57	58	56	66
8	61	54	56	57	61
9	57	59	59	56	66
10	57	54	58	57	59
Mean	58.9	56.0	58.8	54.6	63.7

L.S.D. between means of colony diameters = 3.4 mm (P = 0.05).

Culture 1 Isolated from a fast growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 2 Isolated from a slow growing sector of a colony which had been subjected to 40°C for 15 minutes.

Culture 3 Isolated from a fast growing sector of a colony which had been subjected to 38°C for 25 minutes.

Culture 4 Isolated from a slow growing sector of a colony which had been subjected to 38°C for 25 minutes.

* Untreated culture (Strain 8).

Analysis of Variance

Source of variation	SS	°F	MS	Variance ratio
Between cultures	487.0	4	12.8	8.76**
Within cultures	627.0	45	13.9	
TOTAL	1114.0	49	22.7	

**Significant at 0.001 level .

For illustration see text figure 18.

Table 28a. The comparison of wood decaying ability of three multisporous (8,4,7) and three monosporous (AS9, AS15, AS7) cultures of S. lacrimans incubated for 10 weeks with five different building timbers.

A. Weight loss as % of original dry weight after incubation period.

Bottle	Piece	8					4					7					AS9					AS15					AS7				
No.	No.	N.S.	S.S.	S.P.	B.	O	N.S.	S.S.	S.P.	B.	O	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.
	1	51	44	42	32	9	22	49	30	36	2	1	6	2	1	1	58	16	56	50	2	53	56	34	40	1	33	35	10	41	1
	2	45	45	26	11	4	41	52	3	53	2	3	3	1	1	0	48	43	43	38	3	53	51	42	34	1	47	46	52	35	1
I	3	49	48	30	39	1	54	48	48	21	1	2	2	1	1	1	39	36	61	45	0	59	60	56	39	2	43	40	17	30	1
	4	42	49	44	45	2	26	50	6	3	1	1	4	1	1	0	45	37	50	29	3	57	59	56	44	1	20	25	26	37	1
	5	43	42	17	37	4	50	57	61	47	2	4	2	2	1	0	59	44	52	42	2	46	45	51	39	2	40	37	20	43	1
	6	55	40	33	46	1	43	59	10	46	2	1	1	1	0	0	54	30	48	39	8	54	62	50	36	1	54	33	16	35	1
	7	51	44	31	39	2	51	55	62	25	1	3	5	2	1	0	59	29	55	43	2	54	43	36	39	3	46	49	27	34	1
II	8	49	33	21	31	2	56	50	69	4	1	3	3	2	2	0	55	51	57	33	1	55	60	53	28	2	45	42	47	49	1
	9	55	36	20	27	5	61	40	46	2	2	2	4	1	1	1	42	46	37	46	2	37	30	46	39	1	45	35	28	47	1
	10	43	37	62	38	2	40	49	47	53	1	2	3	1	2	0	49	38	43	45	3	42	67	52	39	2	38	46	23	45	1
	11	60	42	35	25	1	36	55	33	35	1	3	4	2	0	1	55	55	53	84	0	18	40	43	43	2	40	27	54	41	1
	12	51	43	40	34	3	59	50	14	20	0	4	2	1	1	0	33	51	44	18	1	62	48	13	41	1	38	60	48	51	2
III	13	56	39	34	33	2	56	46	55	32	1	1	1	2	1	1	55	51	58	33	0	64	39	60	44	1	50	55	19	49	1
	14	63	37	10	44	2	56	54	80	43	2	2	5	2	1	0	43	48	26	25	3	27	52	47	31	2	32	25	19	36	1
	15	54	39	51	25	2	55	50	44	50	1	3	1	2	1	0	20	50	37	23	1	29	28	57	45	1	50	40	43	48	1
	16	33	55	47	35	1	50	47	22	27	1	1	3	2	0	0	58	57	48	47	3	44	62	28	25	1	60	16	65	23	1
	17	62	44	45	32	5	39	49	43	34	1	3	4	1	1	0	57	48	26	34	5	58	63	24	46	3	9	39	44	28	2
IV	18	20	47	46	41	2	44	57	4	41	1	2	1	3	1	1	49	54	40	37	3	60	60	60	39	1	2	39	12	17	1
	19	38	42	39	20	1	49	53	47	39	1	2	1	1	2	0	41	50	43	45	2	57	38	12	49	2	16	34	63	25	1
	20	38	36	39	27	1	58	55	47	46	1	3	2	3	1	1	57	52	62	42	1	53	59	46	33	1	51	34	64	26	1
	21	55	45	16	40	2	46	49	53	34	1	2	3	1	2	0	58	30	51	43	2	53	55	10	40	2	37	51	24	37	1
	22	52	48	31	45	2	33	55	14	55	1	1	1	2	1	1	58	38	24	45	3	56	32	58	28	1	31	45	6	44	1
V	23	52	39	51	36	2	57	54	55	23	1	5	2	1	1	0	53	42	52	51	1	46	49	42	40	3	47	48	28	36	2
	24	50	45	45	29	5	63	38	24	30	0	3	1	3	1	1	53	41	48	41	3	55	48	58	42	1	29	57	42	37	1
	25	42	39	10	31	5	44	52	42	27	1	1	3	1	1	1	56	43	26	35	1	56	56	58	44	2	37	59	44	36	1
	Mean	48.4	42.3	34.6	33.7	2.7	47.6	50.9	38.4	33.0	1.2	2.3	2.7	1.6	1.0	0.4	50.2	43.2	45.6	40.5	2.2	49.9	50.5	43.7	38.7	1.6	37.6	40.7	33.6	37.2	1.1

Symbols:

N.S. = Norway Spruce
S.S. = Sitka Spruce
S.P. = Scots Pine
B. = Beech
O. = Oak

For illustration see text Figure 19

Analysis of Variance

Source of variance	SS	°F	MS	Variance ratio
Between strains	112988.3	5	22597.7	14.56 *
Between woods	144931.7	4	36232.9	23.34 *
Interaction	31048.2	20	1552.4	16.46 *
Between bottles	13684.6	120	114.0	1.21 **
Within bottles (error)	56563.2	600	94.3	
TOTAL	359216.0	749		

* Significant at 0.001 level

** Not significant at 0.05 level

Table 28b. The comparison of wood decaying ability of three multisporous (8,4, 7) and three monosporous (AS9, AS15, AS7) cultures of S. lacrimans incubated for 10 weeks with five different building timbers.

B. Breaking strength (Newtons) of pieces after incubation period.

Bottle No.	Piece No.	8					4					7					AS9					AS15					AS7					Controls				
		N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.	N.S.	S.S.	S.P.	B.	O.
	1	5	10	20	55	600	170	15	210	40	650	225	150	220	460	460	0	75	0	15	425	15	5	130	60	630	20	50	300	40	610	180	240	390	420	360
	2	10	10	160	75	550	20	10	330	30	480	250	290	355	350	450	20	5	40	45	560	5	5	20	40	590	5	15	10	60	490	270	245	310	600	580
I	3	20	10	150	50	670	0	5	50	80	535	360	290	350	500	490	30	30	5	15	525	10	0	10	35	550	20	50	150	40	610	220	215	240	320	570
	4	10	10	50	40	590	65	5	265	435	600	360	290	350	380	500	25	10	10	60	620	5	0	5	15	470	130	195	140	35	580	270	310	285	430	475
	5	30	15	315	60	640	0	5	5	70	610	300	220	320	390	550	0	5	5	25	590	15	30	10	20	520	30	60	90	40	580	365	275	430	450	580
	6	5	25	80	40	630	45	0	290	40	600	275	260	220	495	470	0	25	20	50	610	5	0	20	40	600	0	60	190	15	650	290	310	275	430	460
	7	5	25	70	55	610	0	10	5	10	610	270	250	350	550	550	0	95	5	20	440	0	60	50	30	590	0	10	95	50	600	300	325	430	530	550
II	8	5	90	160	50	540	0	0	10	400	610	315	240	365	240	580	5	5	5	50	610	0	0	10	95	530	15	55	15	15	600	350	310	310	475	470
	9	5	50	150	65	380	5	65	15	630	630	200	280	285	530	425	5	5	15	30	400	70	230	10	40	365	25	90	100	75	475	260	245	280	350	620
	10	5	65	0	60	530	25	20	10	25	650	230	180	250	530	570	20	10	20	15	560	50	10	5	35	530	65	25	115	325	600	310	250	280	500	500
	11	0	30	70	70	570	50	5	15	40	640	265	130	335	520	530	0	180	5	180	375	170	40	15	20	620	75	0	5	20	450	275	220	320	600	350
	12	5	15	50	40	520	0	20	190	110	630	315	135	335	560	560	50	30	5	150	530	5	5	200	20	600	30	0	5	15	430	350	235	385	475	480
III	13	0	70	70	50	600	5	30	40	70	660	260	300	390	380	370	5	10	0	50	650	0	70	0	20	435	30	0	170	20	620	300	285	395	420	560
	14	0	25	170	60	560	0	10	45	40	320	200	235	375	515	440	40	5	65	165	570	120	10	10	45	610	40	185	190	60	490	330	180	340	470	450
	15	0	20	10	120	610	0	10	70	15	640	230	280	285	475	600	105	5	90	140	560	90	140	5	30	475	0	40	40	10	630	340	210	310	460	570
	16	20	5	10	70	560	5	15	150	50	540	230	210	300	300	465	0	30	0	25	490	30	0	120	60	510	0	240	0	175	495	260	270	385	250	470
	17	0	10	50	35	300	60	15	5	50	640	220	350	390	490	400	15	20	190	30	510	0	0	130	35	515	250	100	30	100	650	235	280	390	600	470
IV	18	250	20	10	70	620	20	5	70	50	530	200	280	310	345	320	10	60	40	50	380	0	0	0	20	600	185	35	240	260	595	250	225	390	350	500
	19	80	15	70	110	570	5	5	50	50	660	255	230	350	540	600	35	120	20	80	620	0	75	315	20	620	140	80	0	100	600	235	335	340	600	510
	20	40	65	60	60	450	0	5	60	30	480	235	325	300	580	560	5	30	0	20	610	5	0	5	30	340	5	90	0	90	530	275	290	320	430	510
	21	0	10	200	40	490	0	10	5	50	650	150	280	375	430	475	5	40	10	60	600	10	5	315	35	390	60	0	60	40	610	200	210	260	300	480
	22	0	15	100	40	450	55	5	190	30	670	290	210	410	570	440	10	100	230	30	620	0	60	5	150	560	110	85	190	20	540	250	260	280	550	350
V	23	5	20	0	50	600	5	5	10	85	500	330	325	295	420	575	5	160	0	20	600	35	5	45	15	460	15	25	80	30	630	200	310	230	410	450
	24	5	10	15	90	450	0	35	90	115	630	300	285	400	450	250	5	10	25	35	660	0	5	0	35	550	35	5	20	40	420	265	190	335	620	510
	25	10	20	170	70	380	0	10	15	120	630	300	310	375	430	480	0	20	80	35	600	0	10	0	25	540	60	0	25	90	480	270	210	340	540	420
	Mean	21	26	88	61	539	21	13	88	107	592	263	253	332	457	484	16	43	35	56	549	26	31	57	39	528	54	60	90	71	559	274	257	330	463	490

Symbols:

N.S. = Norway Spruce
S.S. = Sitka Spruce
S.P. = Scots Pine
B. = Beech
O. = Oak

Analysis of Variance

Source of variance	SS	°F	MS	Variance ratio
Between strains	4589662.4	5	917932.5	7.31*
Between woods	24364865.5	4	6091216.4	48.50**
Interaction	2511704.9	20	125585.3	26.03**
Between bottles	659668.0	120	5497.2	1.14***
Within bottles (error)	2894705.0	600	4824.5	
TOTAL	35020605.8	749		

* Significant at 0.01 level

** Significant at 0.001 level

*** Not significant at 0.05 level