THE "SHAB" DISEASE OF LAVENDER

By C. R. METCALFE

(With Plate VII and 6 Text-figures)

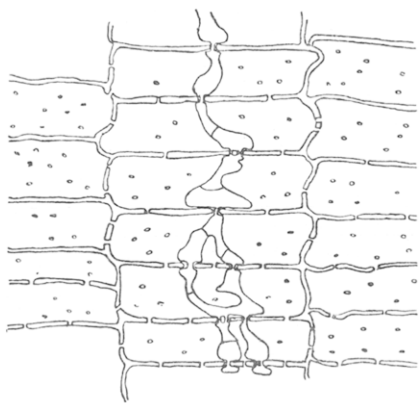
From about 1830 until immediately before the Great War certain parts of England were famous for the cultivation of high grade lavender for the manufacture of perfume. However, of recent years the industry has been crippled by the import of French lavender oil at a much lower price than that at which it can be produced in this country, and by a serious disease which has sometimes caused the death of all the bushes in plantations, several acres in extent. The first record of any trouble was in 1860 when many plants in the Hitchin district were killed following a severe frost, and from thenceforth it seems to have been present in most seasons to a greater or less extent. It has been attributed to over-manuring, to frost injury, and to the presence of too much essential oil in the plant; a water-logged soil was also held responsible. The possibility that the disease might be due to fungal attack was first considered in 1892 when a brief description in Sawyer's *Odorographia* recorded that a "white fungus" developed on the roots of infected plants.

The disease, which now commonly passes under the name of "Shab," was first investigated scientifically by Brierley (1) who proved that it was due to the fungus *Phoma Lavandulae* Gabotto, and the present investigation has confirmed this, although other causes may sometimes give rise to symptoms that might readily be confused with those resulting from true "Shab" attack. Since then diseased lavender has been recorded in France by Chevalier in 1922, who, on very insufficient evidence, attributed the disease to *Pholiota praecox*, and in 1924 Lazare also recorded rotting of lavender in France in fields which had suffered from drought or in which there had been heavy applications of nitrogenous manure.

Following complaints about the disease received by the Ministry of Agriculture and Fisheries from a grower at Hitchin, I began a re-investigation of the disease in 1926, at the suggestion of Dr G. H. Pethybridge. Detailed observations were made at Hitchin on the disease as it occurs in the field, and other commercial lavender plantations in different parts of the country were visited. Thanks are due to Mr F. T. Brooks under whose supervision the work was carried out, as well as to the lavender growers who co-operated in the investigations.

Early Symptoms of Disease

The earliest symptoms of the disease can be seen between May and August when certain of the young shoots wilt and die, usually following a preliminary yellowing. The disease develops downwards from the newly infected shoots; lower branches become infected at their bases, and from these the disease spreads upwards into other branches which subsequently die in the same way; lastly, the roots are invaded. The general appearance of plants killed by the disease is shown in Pl. VII, fig. 2, the small dead plants in the foreground being in marked contrast to the background of healthy bushes.



Text-fig. 1. Thick hyphae in the medullary ray cells. × 300.

It is common for one side of a plant to die before the disease is seen in the remainder, because the rootstock becomes infected before the fungus is able to invade the other side. When the healthy part of such a plant is infected it succumbs very rapidly.

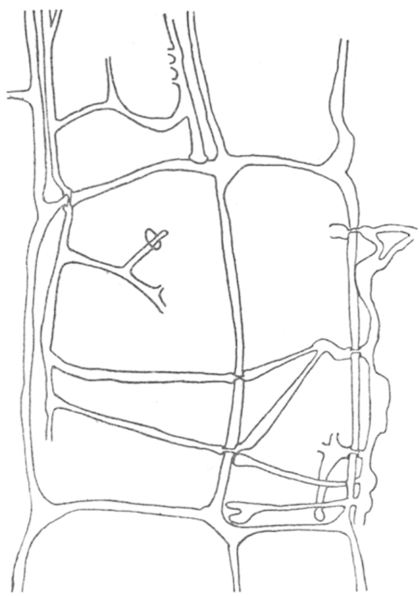
Densely crowded pycnidia are formed at a late stage of the disease chiefly on young twigs, and especially on those destined to bear, or which have borne, flower heads. The fungus is identical with the one Brierley called *Phoma Lavandulae* Gab. The average size of the spores is $4 \times 2\,\mu$. Other *Phoma* spp. with larger spores have also been found on lavender but these have proved to be saprophytes.

Pycnidia of *Phoma Lavandulae* are sometimes produced on old lavender stems, more especially when the bark has been removed by some mechanical agency. They are also formed on the leaves but are rendered inconspicuous by the stellate hairs; they are clearly seen if the infected leaves are moistened with water or immersed in Eau-de-Javelle for a few moments. Although pycnidia are not commonly produced except on tissues that have actually been killed by the disease they have been met with from time to time on newly infected tissues.

The tissues of a diseased stem are brown or almost black, and where diseased and healthy tissues are continuous there is a distinct line of demarcation.

For microscopical examination freehand sections were stained with cotton blue in lacto-phenol, Delafield's haematoxylin, or gentian violet and congo red. All these stains were useful in differentiating the mycelium from the tissues. Usually cotton blue was the most satisfactory.

A branching septate mycelium ramifies in all the diseased tissues, but is most abundant in the vessels of the older stems where it passes



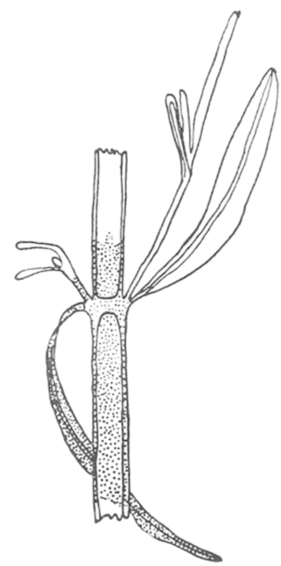
Text-fig. 2. Thin branched hyphae in the cells of the pith. × 300.

from one vessel to the next only through pits in the walls. In the medullary ray cells, very thick, dark coloured hyphae are found (Text-fig. 1) which are connected with the mycelium in the vessels, and also with a mycelium of thin branched hyphae in the pith which also passes through pits in the walls (Text-fig. 2).

The brown appearance of the infected tissues is due to a discoloration of the cell walls. In transverse sections of young diseased stems, however, a considerable amount of gum is visible, especially in vessels in which the mycelium is first established. Sometimes a few isolated pith cells also become filled with gum.

Mode of Infection

Extensive field observations were made to determine the mode of infection by the fungus. A large number of twigs which were suspected to be infected were observed at frequent intervals; the results show that there are two ways in which infection can occur. In the first the earliest symptoms of disease are seen when the tissues at or near a leaf axil on a young stem turn brown. Later the leaf turns bright yellow, usually only one leaf of a pair at a node becoming infected. From the infected leaf axil the yellowing extends up and down the stem frequently without passing to the other side. This leaf now becomes brown, curls round, and dies (Text-fig. 3). Although infections of this type are frequent in leaf axils, they may occur anywhere on the lamina of a leaf, or sometimes on an internode of a young stem. The yellowing extends rapidly and leaves at successive nodes wilt and die (Pl. VII, fig. 1).



Text-fig. 3. A late stage of an infection through a leaf axil on a young stem.

The second method of infection is through wounds. These are made very extensively when the crop is harvested and also as a result of clipping. Here no disease symptoms can be seen until the young shoots immediately below the wound develop.

Once wilting has started the disease develops in the same way. Usually a period of from three weeks to a month or so elapsed between the first appearance of the disease and the death of the twig. About two weeks later abundant pycnidia of *Phoma Lavandulae* were formed. The speed with which the disease developed from this stage onwards varied in different plants. Some were killed within a few months, but in others the disease appeared to become retarded, and occasionally plants that were known to be diseased, during the winter, exhibited no symptoms that could be recognised with the naked eye. In the following season, however, they succumbed to the disease very rapidly. No evidence that the fungus becomes held up by a gum barrier or similar obstruction has been found, and it is thought that the phenomenon is due merely to the slow growth of the fungus during winter.

Growth of *Phoma Lavandulae* in Pure Culture

Phoma Lavandulae has been repeatedly isolated in pure culture from sections taken from tissues at the junctions of diseased with healthy parts of lavender stems of different ages, and also from pycnospores from pycnidia on diseased lavender bushes.

Media

The first medium used was lavender agar, prepared by stiffening a strong aqueous infusion of lavender leaves with 2 per cent. agar. For initial isolations this medium was found to be most satisfactory, since in it bacterial contamination is reduced, whilst the mycelium, when isolated, has a characteristic appearance at an early stage, by which it can readily be distinguished.

Dox's agar has been used extensively. On this medium the mycelium grows more actively, and pycnidium formation can be induced whereas under no circumstances were fructifications produced on lavender agar.

The preliminary attempts to isolate the fungus were frequently unsuccessful; it was found later that many attempts were made with twigs which had the appearance of being affected with "Shab" but which in reality were suffering only from the effects of frost. Another difficulty was that in spite of careful surface sterilisation it was almost impossible to avoid contamination with *Dematium pullulans* which concealed the relatively slow growing *Phoma Lavandulae*. In later isolations, made at a time of year when frost damage was almost impossible, *Phoma Lavandulae* was successfully obtained in a high proportion of the isolations attempted. This is shown in Table I.

Table I

Source	No. of isolations attempted	No. of isolations successful
Young stems	27	19
Old stems	5	3
Inoculated plants	11	4

Although attempts were made to isolate the fungus from diseased roots none of these was successful. This is probably because the root is the last part of the plant to succumb to the disease and by the time this happens numerous secondary organisms are present which may well conceal the relatively slow growing *Phoma Lavandulae*. On the other hand, from the young stems, which are first infected, the fungus was isolated practically in pure culture from the start.

Other fungi isolated from diseased tissue were: a *Phoma* differing from *P. Lavandulae* in having larger spores, *Botrytis* spp., an unidentified fungus characterised by the production of pycnidia containing brown spores, and a fungus allied to *Diaporthe*. Although repeated inoculations were made with all these fungi none of them proved to be pathogenic to lavender.

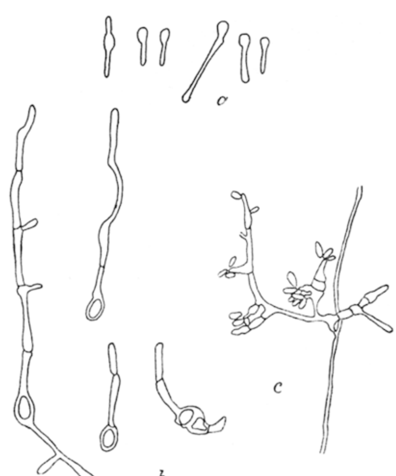
Fructification of *Phoma Lavandulae* in Pure Culture

At first considerable difficulty was experienced in obtaining fructifications of *Phoma Lavandulae* in pure culture. The fungus was grown on a series of media ranging from natural substrata such as lavender twigs and potato chunks to relatively complex media such as asparagin and Dox's agar. The fungus grew on all the media tried both at room temperature and at 25° C. It was eventually discovered that if cultures on Dox's agar were kept in a room where they were exposed to bright sunshine abundant pycnidia were formed within about five weeks. Occasionally a few abnormal compound pycnidia were formed at an earlier date under these conditions, and similar pycnidia were occasionally produced in old dried up cultures even when they were not exposed to sunshine.

The *Phoma* with larger spores isolated from lavender formed pycnidia as readily in dull as in bright light.

The Germination of Pycnospores

Spores both from natural material and pure culture germinated in hanging drop cultures on films of Dox's agar with few exceptions. Within twelve hours the spores became swollen and put out one or two germ tubes (Text-fig. 4*a*). These grew in length, and became



Text-fig. 4. Stages in the germination of the spores of *Phoma Lavandulae*. × 450.

branched and septate within a few days (Text-fig. 4*b*). From the third to the fifth days short lateral branches of limited growth were put out, and from these, groups of conidia were abstricted (Text-fig. 4*c*) which agreed very closely in size and shape with the pycnospores. The formation of similar conidia was described by Brierley.

Resistance of Pycnidia to External Conditions

Numerous experiments were made to determine the effect of certain adverse conditions on spore germination while the spores were still in the pycnidia. Freshly gathered material was kept (1) under ordinary laboratory conditions, (2) in an incubator at 25° C., and (3) in a paraffin oven at 50° C. Hanging drop cultures of pycnospores were made at intervals during a period of fourteen days. Exposure for this period to laboratory conditions or 25° C. had no effect on viability, but of those kept at 50° C. only about 50 per cent. remained viable.

No pycnidia were subjected to a known low temperature over a long period, but it was found that spores from pycnidia collected after very hard frosts or snow germinated as readily as at midsummer.

Finally, in December 1927, twigs bearing pycnidia were buried in the soil at depths of one foot and one foot six inches respectively. At intervals of one month they were dug up and the pycnospores tested. The experiment was continued until April 24th, 1928, when it was found that although the twigs were becoming decomposed the pycnospores were still as viable as at first.

Experiments on the Retention of Viability by Spores after Exudation from the Pycnidia

The spores of many species of *Phoma* are exuded in mucilaginous drops or tendrils in a moist atmosphere. It might be expected that the spores would retain their viability so long as the mucilage is not dissolved by rain or any other agency. Attempts have been made with *Phoma Lavandulae* under different moisture conditions to induce the exudation of mucilaginous masses, but the spores of this fungus emerge from the pycnidia only when these are in contact with free water. Any mucilage that is present is immediately dissolved and the spores become separated from one another.

To determine for how long the spores of *P. Lavandulae* can retain their viability when once they have left their pycnidia, pycnospores from fresh lavender twigs were teased out in drops of sterile distilled water on sterile coverslips which were then placed in separate watch-glasses, with other watch-glasses inverted over them. The coverslips were then treated in one of the following ways:

(1) Left at room temperature.

(2) Left at room temperature but with a drop of sterile distilled water introduced into the watch-glass so that the spores were kept in a moist atmosphere.

(3) Left at 26° C. in an incubator.

(4) Left under moist conditions as (2), but in an incubator at 26° C.

At intervals of an hour, one or two coverslips were taken from each set, and the spores covered with a film of Dox's agar at about 40° C., mounted in hanging drops and left for observation. The first experiment was continued so that the longest period of desiccation was forty-eight hours, but during this time there was no great loss of viability by the spores. Accordingly similar experiments were made at room temperature in which spores were subjected to much longer periods of desiccation, and fresh cultures were made at intervals of twenty-four hours instead of one. The results obtained may be summarised as follows:

(1) There is a general decrease in viability as the period of desiccation is prolonged.

(2) Viability is lost more rapidly in a moist than in a dry atmosphere.

(3) There is a marked loss of viability in a moist atmosphere between sixteen and forty hours.

(4) In a dry atmosphere pycnospores retain their viability for sixty-four hours, after which they germinate more slowly than when fresh; if kept for 114 hours under these conditions only very few spores are capable of germinating.

It is thus clear that pycnidia are the chief form in which the fungus can tide over unfavourable periods, whereas isolated spores are of little importance in this connection.

Inoculation Experiments

Inoculations, except where specifically stated to the contrary, have been made almost exclusively on what commonly passes under the name of "Old English" lavender—a variety of *Lavandula spica* Linn. which is usually cultivated in this country for the manufacture of perfume. There is, however, considerable confusion in the nomenclature of the different varieties, and the same variety is often known by different names to different growers. What is called here "Old English" is a tall variety, with dark blue flowers arranged in interrupted spikes, usually consisting of eight to ten "whorls" of flowers. The consecutive "whorls" of flowers are sufficiently far apart for the stem to be visible between them. The heads do not taper to a point at the top. Small subsidiary flower spikes often arise in the leaf axils low down on the stem bearing the main spike.

The first inoculations were made exclusively with pure cultures of

Phoma Lavandulae, but when it was established that this fungus is the primary cause of the disease, spores from pycnidia on diseased lavender stems were employed. The preliminary inoculations were made both with mycelium and spores on wounded and unwounded plants through both young and old tissues, and both out of doors and in a greenhouse. The inoculations with spores were made with a brush or an atomiser, whilst those with mycelium were done by means of sterilised scalpels or needles. Usually where plants were inoculated at some particular point lead foil was wrapped round it and tied on securely. In addition, freshly inoculated plants were usually covered with bell jars for a period of about forty-eight hours, but this does not appear to have been essential except when plants were inoculated out of doors on dry days. Successful inoculations were also made by attaching small portions of twigs bearing pycnidia to healthy bushes.

Preliminary Experiments

Thirty-eight plants were inoculated in one or other of the ways mentioned above. Most of these inoculations were carried out in a greenhouse between October 26th, 1926 and January 21st, 1927. All the plants inoculated through freshly made wounds subsequently became diseased, but a striking feature was the long interval which elapsed between the date of inoculation and the appearance of the first disease symptoms. Thus, in a typical example, a plant inoculated with mycelium through freshly made wounds on young shoots on October 26th showed no symptoms of disease until January 12th, about two and a half months after the inoculations were made. At this date, three of the six inoculated shoots had wilted. No extension of the wilt was to be seen until the following July when the young developing shoots wilted as the fungus grew into them from the points of inoculation. By August 15th the plants were dead. When plants were inoculated with spores there was a similar long interval before the disease appeared and no rapid development took place until the young shoots succumbed very rapidly. Spore and mycelium inoculations carried out at the same time of year but out of doors, either failed, or the disease symptoms developed even more slowly than those showing in the greenhouse. For instance, a plant inoculated on October 26th remained healthy until the following June when one of the inoculated twigs wilted. By December 8th, fourteen months after inoculation, this twig was dead, but the rest of the plant was healthy.

Comparison of results with those obtained by Brierley

These experiments showed conclusively that *Phoma Lavandulae* is one primary cause of "Shab" disease, thus confirming the results of Brierley. However, they differed appreciably from them in the long lapse of time between the inoculations and the first appearance of disease symptoms. Brierley's results indicated that plants began to die back about ten days after inoculation, whereas in the present investigation a period of at least two months normally elapsed before any wilting was seen. It was thought at first that this long interval would occur only during the winter months, but this is not so. The shortest interval noted during the present investigation was in six plants growing out of doors, inoculated on June 9th, through wounded leaf axils on young shoots which became diseased one month after they were inoculated. Moreover, the period during which the disease is not apparent when plotted against the time of year when the inoculations were made takes approximately the form of an optimum curve.

Inoculations of different varieties of lavender made with strains of *Phoma Lavandulae* isolated from lavender obtained from different sources, also failed to discover any combination of a virulent strain of the fungus and markedly susceptible lavender variety which resulted in a more rapid appearance of the disease.

Another possibility was that a lavender plant growing under adverse environmental conditions might succumb to the disease more rapidly. Observations made in lavender plantations showed that the disease was usually most prevalent in low lying, badly drained areas, suggesting that excess of water at the roots favoured the disease. (The disease is by no means confined to waterlogged areas; the suggestion is merely that in such a position the plants are affected more severely. Actually the worst example of "Shab" met with was on a light, well-drained soil.)

Attempts to compare the rate of development of the disease in inoculated plants in pots kept in a bath of water with that in similarly inoculated plants in pots kept under ordinary outdoor conditions gave inconclusive results. This was because waterlogging alone is capable of causing unhealthy symptoms, and consequently it was never certain to what extent that or the fungus was individually responsible for the unhealthy symptoms noted. However, in no instance was there any evidence of the disease developing within a time that was in any way comparable with the ten days recorded by Brierley.

The only possible explanation of the long interval is that during this period the fungus is latent within the tissues of the host. It will be seen later that the latent period is longest amongst plants inoculated in autumn and winter out of doors when development appears to be retarded until the following spring. This has been borne out by microscopical examinations of tissues at varying intervals after inoculation which have shown that fungus mycelium becomes established within a few days, but that it develops very slowly until the young shoots begin to grow.

Spores of *Phoma Lavandulae* were seldom seen actually germinating in the tissues, probably on account of their small size, but they have been met with in the pith cells near freshly inoculated wounds. They sometimes germinate several millimetres from the surface of infected wounds owing to the fact that they become embedded in cracks in the pith formed in the process of making the wound.

Large Scale Inoculation Experiments carried out between October 1927 and September 1928

During the period October 1927 to September 1928, large scale inoculation experiments were started in order to obtain information on the following points:

(1) At what time of year infection most readily takes place.

(2) Whether infection occurs more readily in wounded than in unwounded plants, and if so whether there is any variation in the readiness with which infection occurs according to the time of year.

(3) To compare the time of year at which most infection takes place with that at which artificial inoculations are most successful.

(4) To determine whether, if wounds are made at different times of the year, for how long they remain liable to infection and whether there is any variation dependent on the season at which the wounds are made.

Experiments on Inoculation of Wounds of different Ages

It has been shown in "Silver Leaf" disease of fruit and other trees (5) that there is considerable variation in the ease with which infection takes place by spores of *Stereum purpureum* depending on the time of year at which the wounds are made, and the time that elapses between making the wounds and the introduction of the spores.

During 1926 preliminary experiments, in which lavender stems that had been wounded and left for varying periods not exceeding fourteen days and were subsequently inoculated, showed that wounds of that age were as liable to invasion as when freshly made.

Wherever it is grown on a commercial scale lavender is liable to be severely wounded (1) when the crop of flowers is cut in August, (2) in September or October when some growers make a practice of trimming the plants with shears, (3) early in March when the plants may be trimmed with shears—a practice suggested as a means of keeping the disease in check. Consequently in the following experiment wounds were made in August, October and February respectively, and inoculated at successive intervals of one month to determine whether such wounds were equally liable to invasion, and if so, for how long they were likely to remain so.

A. *August wounds*

Seventy-two plants were divided into groups of three so that one set could be inoculated each month throughout the year, and a similar set could be kept as a control. Three plants, wounded on August 4th by cutting off pieces of the younger branches with scissors, were immediately inoculated with a spore suspension of *Phoma Lavandulae*, and successive sets were inoculated on August 28th, October 18th, November 11th, December 9th, January 18th, February 6th, March 14th, April 4th and May 26th respectively. Each wound was covered with a cap of lead foil tied on with wool immediately after it had been inoculated.

All three of the plants inoculated on August 4th, when the wounds were fresh became diseased, the first symptoms being noted on November 12th. During the following summer the three plants became badly diseased and by August 11th one was nearly dead. This corroborated the conclusion already reached, viz. that infection can occur through freshly made wounds.

The plants inoculated on August 28th, when the wounds were about three weeks old, showed by December 12th rather uncertain disease symptoms which underwent no further development and were confined to one shoot.

Up to October 1928 none of the plants inoculated after August 28th became diseased and the controls likewise remained healthy. For this reason these inoculations were discontinued after May 26th.

B. *October wounds*

The wounds made in October did not become infected even when they were freshly made, probably because owing to the very small size of the plants it was almost impossible to make wounds in living tissues without cutting most of the plant away. In consequence the wounds were made in young twigs which were already dying back naturally at the end of the summer as is customary in all lavender. Other experiments described later show that wounds made in October are actually liable to infection when fresh.

C. *February wounds*

A third set of plants were wounded on February 28th, 1928. Six of these were inoculated on March 4th, when the wounds were five days old, and further groups of six were inoculated at intervals of approximately one month until June. Six uninoculated plants were marked as controls on each occasion.

Of the plants that were inoculated through wounds five days old, two showed early disease symptoms on July 17th and by August 7th four were diseased. By November 17th, two of the plants were continuing to die back slowly and two others were nearly dead. The remaining two plants kept free from disease as did also the control plants except one that was killed by frost.

Six plants inoculated on April 25th through wounds that were three and a half weeks old remained healthy. Of six plants inoculated on May 26th one was dying back rapidly on November 17th, and of those inoculated on June 16th, when the wounds were three and a half months old, two were badly diseased by November 17th and one less severely. The control plants for each month remained healthy. It thus appears as if wounds made in March may remain liable to infection for several months, but this is probably not really so, the results depending on the fact that from May onwards the plants were growing rapidly and that consequently in attempting to gain access to the wounds in order to inoculate them fresh wounds were made unintentionally through which infection probably took place. If this explanation is correct the conclusion may be drawn that fresh wounds made in March are liable to be invaded by *Phoma Lavandulae*, in the same way as those made in August and October, and that in all three months this liability to invasion is lost after an interval of four weeks.

Monthly Inoculation Experiment

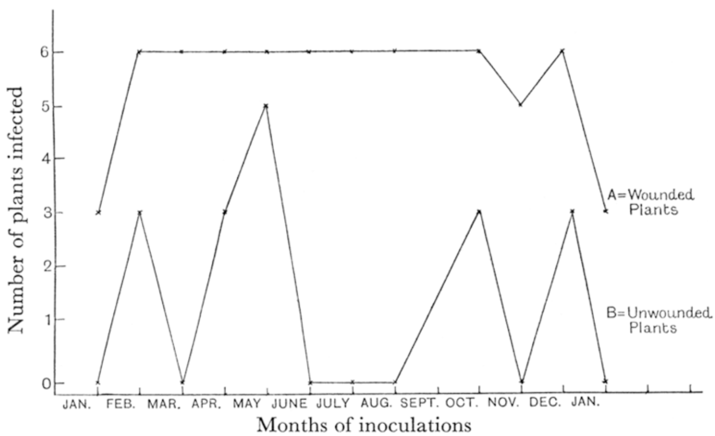
Starting in October 1927, three sets of six plants each were treated at intervals of approximately one month as follows: (*a*) six plants were wounded by trimming them with scissors, and sprayed with a spore suspension of *Phoma Lavandulae* immediately afterwards; (*b*) six unwounded plants were sprayed in the same way; (*c*) six unwounded plants were sprayed with sterile distilled water and left as controls.

Immediately after inoculation these were covered with bell jars for a period of about forty-eight hours, or longer during some of the winter months. No bell jars were placed over the control plants as there were not sufficient available for the purpose.

Up to September 30th, 1928, no control plant showed any disease symptoms. However, by November 17th, 1928, eight control plants had become diseased—a result which is scarcely surprising since by this date the disease was rampant amongst the adjoining plants that had been inoculated.

The result of the experiment is shown in the form of a graph in Text-fig. 5. Certain important points have been made clear. Thus it is shown that infection can take place, under suitable conditions, during any month. The lowest infection recorded was amongst the plants inoculated in January, of which only two that were freshly wounded developed the disease, and none that was unwounded. From February until May there is a steady increase in liability to infection both amongst wounded and unwounded plants, and finally in May, six wounded and five unwounded succumbed. From May onwards during the summer, whereas all the freshly wounded plants that were inoculated became diseased the unwounded ones remained healthy. It is of interest that the maximum infection of unwounded plants was in May, when the young shoots were developing, which agrees well with what was observed in the field. When the young shoots become hardened as they develop they become less liable to invasion unless they are wounded.

Another important feature is the long interval that elapses between the time of inoculation and the first appearance of disease symptoms. Thus, when plants were inoculated at the beginning and middle of November respectively, a period of seven months elapsed before the



Text-fig. 5. *A* = number of infections during successive months in wounded plants. *B* = number of unwounded plants successfully inoculated during successive months.

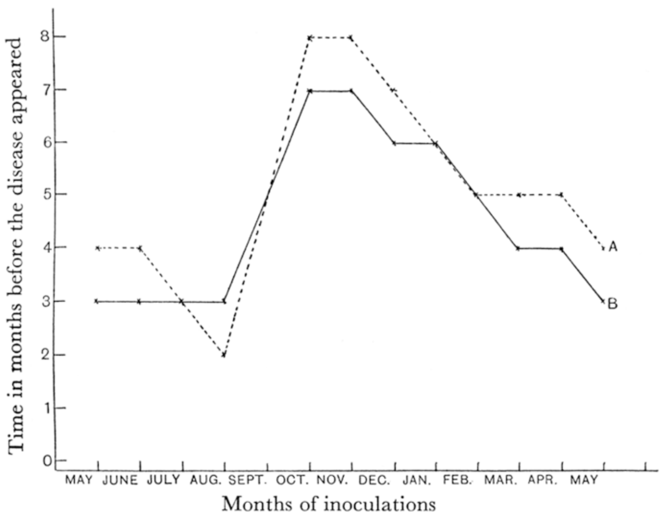
disease could be discerned. This period gradually diminished amongst the plants inoculated during consecutive months until May to August, when there was an interval of three months only. These results are expressed graphically in Text-fig. 6.

The successful inoculations of October, which took more readily in wounded than in unwounded plants, show that freshly made wounds are liable to invasion at that time of year. This is contrary to the results obtained in the experiment dealing with the inoculation of wounds of different ages, and supports the suggestion there put forward to account for the failure then experienced (p. 161).

Experimental Inoculation Trial by attaching Twigs bearing Pycnidia to plants at monthly intervals throughout the year

Starting in early November 1927, small portions of diseased lavender stems bearing pycnidia of *Phoma Lavandulae* were attached to the upper branches of healthy plants by means of fine copper wire.

Twenty-five plants (sometimes twenty-four) were subjected to this treatment each month. After the first month the pycnidia-bearing twigs were removed from twelve of the plants to which they had been attached one month previously. In this way the plants were exposed to a source of infection for long and short periods respectively, starting at different times of the year. Each month twenty-five plants were left untreated as controls, and during the course of the experiment only four out of about three hundred became infected.



Text-fig. 6. *A* = time during which the fungus is latent within the host amongst plants inoculated by attaching twigs bearing pycnidia to them at intervals of one month. *B* = ditto in plants inoculated with spores.

The detailed results are shown in Table II. The most interesting points brought out are (1) that infection can occur at any time of year; (2) that, generally speaking, exposure to a source of infection for a prolonged period is more effective than exposures of not more than four weeks; (3) that there is a period ranging from two to nine months during which the fungus is dormant within the host tissues according to the time of year when the inoculations are made. The duration of this latent period is in very close agreement with that found when inoculations with spores were carried out at monthly intervals as described in a previous experiment. This is brought out very clearly in Text-fig. 6 in which the duration of the latent period in these two experiments is seen to approximate very closely.

Inoculations of different varieties of Lavender and Other Plants

Experiments in which as many different varieties of lavender as could be obtained were inoculated with *Phoma Lavandulae*, both out of doors and in a greenhouse, have led to the conclusion that most varieties are about equally susceptible to invasion. A notable exception is the variety "Dwarf French" which failed to become diseased under any circumstances, and indeed, it seems probable that this variety is immune from the disease. The oil obtained by the distillation of the flowers of this variety was very promising when freshly distilled, but was not suitable for lavender water.

Attempts have also been made to inoculate *Lavandula dentata*, *Rosmarius officinalis*, *Lamium purpureum*, and *Chenopodium album*, all of which were unsuccessful.

Table II

Date of inoculation	Long or short exposure	Time in months before disease appeared	No. of diseased plants in consecutive months				Killed by frost
			June	July	August	Sept.	
Nov. 2nd	L.	8	6	7	8	8	1
	S.	9	0	1	1	3	4
Nov. 18th	L.	8	4	5	6	6	3
	S.	8	1	2	2	3	1
Dec. 12th	L.	7	5	7	9	9	2
	S.	8	0	7	7	8	2
Jan. 14th	L.	6	2	8	8	9	1
	S.	7	0	2	2	3	1
Feb. 8th	L.	5	4	7	9	10	—
	S.	5	1	7	7	8	1
Mar. 15th	L.	5	0	6	8	10	—
	S.	5	0	3	3	7	3
Apr. 23rd	L.	5	0	0	1	4	4
	S.	5	0	0	1	3	4
May 25th	L.	4	0	0	1	6	1
	S.	3	0	0	1	6	1
June 12th	L.	4	0	0	0	2	—
	S.	4	0	0	0	5	1
July 17th	L.	3	—	0	0	3	—
	S.	No disease	—	0	0	0	—

Further Observations on the mode of Spread of the Disease

A feature of the disease that is frequently very striking is that it is often confined to localised areas in the field. This has been thought in the past to indicate that some soil factor played an important part in the causation of the disease, lime deficiency especially having been held responsible. During the present investigations it has been noted that the trouble is often most severe in low lying places where water tends to accumulate in winter, and there is no doubt that excess of water at the roots of itself can induce unhealthy symptoms in the crop, and in conjunction with *Phoma Lavandulae* the disease would have the appearance of being especially well developed in waterlogged areas. The disease has also been seen on soils throughout which there is known to have been a good lime content, so that lime deficiency cannot always be held responsible. The worst case of "Shab" met with was on a light, well drained, calcareous soil, but here also localised disease centres were met with, showing that the distribution must be accounted for in some other way.

Detailed observation extending over several years made in a number of lavender plantations have led to the conclusion that the uneven distribution of the disease exists only at an early stage before the fungus has become widely distributed. The areas in fact represent the random positions in which the first diseased plants were established and from these infection spreads in a centrifugal manner, resulting first of all in the formation of disease centres which later on coalesce and lose their individuality. This mode of spread accords very well with what would be expected from the manner in which the fungus is dispersed. The pycnospores are very small and thin walled. Moreover, when once they have been exuded from the pycnidia they cannot remain long alive. Such spores are clearly not well adapted for wide dispersal by wind. At the same time the spores are incapable of emerging from the pycnidia except when the latter are in contact with water. When it rains heavily, newly exuded spores are splashed about and so spread over short distances. After a heavy storm it has been noted that soil particles are frequently splashed to the top of large lavender plants, and if it be assumed that spores may be splashed to the same height it is clear that they may in this way gain access to leaf axils on young developing shoots and so establish infection. This mode of spore dispersal probably accounts for the centrifugal extension of the disease.

Sometimes a single plant, or two or three in a group at some distance from any diseased plants, will themselves become infected, and observations have been made to determine whether the pycnidia themselves rather than the spores can become disseminated over wider areas, and considerable evidence has been found in support of this suggestion.

Cultivation in lavender plantations is normally carried on by horse-hoeing and it is largely as a result of this practice that the fungus is distributed over wide areas. As the hoe passes between the rows of plants small fragments become detached. The young pycnidia-bearing twigs of diseased plants being very brittle are especially liable to be broken off, and after the hoe and the driver have passed by there is an elastic rebound of the bush which results in hurling into the air fragments which fall on or near healthy bushes in the neighbourhood of the diseased ones. In addition, twigs bearing pycnidia may be carried a considerable distance attached to the horse's hoofs, the hoe, and the driver's boots.

Further, it is common, especially during the winter, for the outermost tissues to break away from young twigs, and to fall off subsequently in small particles, and if the twig is a diseased one the pycnidia sometimes come off also. Experiments were made to determine whether these pycnidia-bearing particles become distributed by the wind. This was done by exposing to the wind pieces of American cloth coated with vaseline, in a field near diseased bushes. The cloth was held in a more or less vertical position by means of a wooden framework. Small particles of all kinds adhered to the surface of the cloth which was subsequently examined. After examination, the cloth was cleaned with xylol, recoated with vaseline and used for repeated exposures. Most of the experiments were unsuccessful, but on a few occasions small particles of lavender bark bearing pycnidia of *Phoma Lavandulae* were caught and identified under the microscope. These particles were caught at a distance of about two feet from a diseased plant. It is therefore considered that pycnidia may be distributed in this way at least for short distances, although probably to a somewhat limited extent.

Factors other than *Phoma Lavandulae* which may cause Symptoms similar to "Shab"

The symptoms of "Shab," especially at an advanced stage, are such that any factors which adversely affect the lavender plant would simulate those resulting from invasion by *Phoma Lavandulae*. It is believed that this does happen, and the death of lavender resulting from such causes has undoubtedly led to confusion in the past.

The most important of these adverse factors are thought to be frost, shading by or dripping from trees, and possibly invasion by a species of *Botrytis* either alone or in conjunction with the other factors.

Frost can damage lavender plants in either of two ways. A severe frost in winter may cause large branches to die back or even result in the death of the plant. Newly established plants are especially liable to this type of injury, as are also those that have been clipped severely in late summer or autumn. On the other hand less severe frosts in late spring may cause the young shoots to turn yellow and subsequently to die back. This type of damage might readily be mistaken for an early stage of *Phoma* attack. Indeed, the damage resulting from these two causes was finally distinguished only by making detailed periodical observations on a large number of twigs. Generally speaking, the yellowing due to the late frosts appears earlier in the season than the similar symptoms induced by *Phoma*. Injury from late frosts is seldom serious as fresh shoots develop which replace the damaged ones, and the worst that may happen is that the time of flowering may be somewhat delayed.

Lavender plants have sometimes been seen showing symptoms similar to those of "Shab" but the cause is uncertain. Large branches die, and their foliage sometimes turns yellow before they succumb. Infected branches become covered with a *Botrytis*, and hyphae, which may belong to the same fungus, are found in the tissues. In the absence of successful attempts to inoculate lavender with the *Botrytis* this cannot be held responsible for the disease, but it is possible that it may act as a weak parasite in plants that have been previously weakened by some such cause as frost.

Finally it may be pointed out that in old lavender bushes, as in other woody plants, a certain amount of die back appears to be normal even when they are growing under ideal circumstances.

Occurrence of *Phoma Lavandulae* on *Chenopodium album*

While searching on the ground in a lavender field for old diseased stems bearing pycnidia of *Phoma Lavandulae*, a number of pycnidial fungi were seen on decaying weeds. Among these a *Phoma* morphologically indistinguishable from that on lavender was found on decaying stems of *Chenopodium album*, a common weed in most lavender fields, and extremely abundant in some. Further collections of decaying *Chenopodium album* were examined on which the fungus was found to be quite common, especially in those parts of the field in which the lavender disease was most abundant. Careful search was made for the fungus on other weeds, but without success.

The fungus was isolated and grown in pure culture and agreed in its growth characters with *Phoma Lavandulae* and, moreover like it, could be induced to fructify only in a bright light. The fungus has been isolated from *Chenopodium album* several times during two successive seasons, but only from one field. However, no serious search for the *Phoma* on *Chenopodium album* was made in any other lavender plantations.

Inoculations of lavender plants were made in a greenhouse with mycelium and spores. Seven plants in all were inoculated, four of which developed typical disease, two being killed; the remaining three plants remained healthy while under observation. The *Chenopodium* fungus thus appears to be identical with *Phoma Lavandulae*.

Phoma Lavandulae has not been found on living plants of *Chenopodium album*, nor have inoculations of living specimens met with any success.

Another species of *Phoma* has been found on living and dead plants of *Chenopodium album*, but this fungus has larger spores and smaller pycnidia than *Phoma Lavandulae*. Furthermore, its growth form in pure culture is quite distinct. On dead stems of *Chenopodium album* the pycnidia of both *Phoma* species have been seen growing together, but generally speaking *Phoma Lavandulae* has been found on *Chenopodium album* only when the latter was in a fairly advanced stage of decomposition, whereas the large spored *Phoma* tends to disappear at that stage. No evidence of a genetical connection between the two species has been established. Inoculations of lavender plants with the large spored *Phoma* were unsuccessful.

Control Measures

Since the only variety of lavender found to be immune to the "Shab" disease is of no use in the manufacture of perfume, the disease cannot be controlled by growing resistant varieties. From the nature of the disease no satisfactory cure can be effected, and it is best controlled by general methods of sanitation. Attempts to control the disease along the lines described below have already been introduced into some plantations and show considerable promise, and if continued may lead to the complete extermination of the disease.

(1) *Change of land*

Lavender has been cultivated in this country on a commercial scale in strictly localised areas, chiefly by growers who confine themselves almost exclusively to this one crop. With the natural desire to obtain the maximum yield from the land, lavender crops have been grown continuously on the same ground for seventy years or longer, and crop rotation has been almost unknown. This is undoubtedly the chief reason why the "Shab" disease has become so firmly established.

It has been shown that dead branches bearing pycnidia become detached from diseased lavender bushes, and may remain on the ground until they undergo decomposition. Hence, if the ground in a diseased field is replanted with healthy bushes immediately after the previous crop is removed the fresh plants will be subjected to a source of intense infection. Further, successive crops on the same ground will become progressively worse, and, indeed, the ground would soon become lavender "sick" and unfit for the cultivation of this crop until it had had a rest. It is strongly urged that before any area is replanted with lavender, whether the disease is present or not, it should have a change of crop for at least one year, or if necessary it should be left fallow.

Lavender cultivation on a heavy, waterlogged soil should be avoided. If this is impossible all measures conducive to good drainage and "lightening" the soil should be practised.

(2) *Clean cultivation*

Lavender plantations should be kept in clean cultivation. In recent years, however, weeds have become all too common in the plantations in some districts, rendering the fields unsightly and resulting in a great weakening of the plants. Hand hoeing is the ideal method of keeping a lavender plantation clean, and even in large areas where horse-hoeing is the only commercial possibility weeds immediately surrounding the plants must be removed by hand. Neglect of this last precaution has been the cause of severe epidemics of weeds in some districts, resulting in a great weakening of the bushes which were rapidly overcome by the fungus as a result.

Special care should be taken to remove all plants of *Chenopodium album*, the dead remains of which may become infected with *Phoma Lavandulae*, and so assist in carrying over the fungus to a more favourable period for its development. This weed may also serve as a means of keeping the fungus alive between two successive crops.

(3) *Taking cuttings*

In the past the usual methods by which lavender has been propagated are: (1) By dividing a large plant into a number of small ones with the aid of a chopper, in such a way that each of the fresh plants is provided with a portion of the root system of the parent. (2) By breaking off branches at least two or three years old, and planting them deeply in the soil where they develop roots and grow into fresh plants. (3) By burying plants in the soil to such a depth that only the young branches are above ground. Adventitious roots grow out from all parts below the soil, and when these are well developed the original plant is dug up and divided into a number of small ones. This method of propagation is common in nurseries.

All these methods are unsatisfactory where the "Shab" disease is present, and should be discontinued, because by any of them the mycelium of *Phoma Lavandulae* may be distributed in a high percentage of the young plants. Even if care is taken to avoid propagating from diseased bushes this may, nevertheless, be done quite inadvertently, since the fungus may be established in a latent condition in an apparently healthy plant.

If possible a fresh start should be made with a healthy stock planted in clean ground. Clean stocks of good oil-yielding varieties are not easy to obtain, however; hence growers who are unable to start afresh may propagate their plants in the following way.

Small cuttings are less liable to be diseased than large ones. It is, therefore, suggested that small cuttings should be used exclusively for propagation. The cuttings should be only two to two and a half inches long and should consist only of "green wood." It has been found that the cuttings root most readily if started in a light soil in a warm greenhouse, but if this is not practicable they may be grown in cold frames or even in open ground in a sheltered place, but here growth is slower. One grower has taken many thousands of cuttings in this way from a badly diseased stock with most promising results, a small percentage only of the cuttings becoming diseased. However, the diseased plants were destroyed as soon as they appeared, and one year after the cuttings were taken many thousands of strong young plants were obtained which were planted out in their permanent quarters.

When propagating lavender in this way allowance must be made for the fact that some of the cuttings fail to root. If reasonable care is taken the percentage is not a high one, but it is always advisable to take a few thousand more cuttings than the number required.

(4) *General sanitation*

As soon as a diseased plant is seen in an otherwise healthy plantation it should be destroyed without delay. The four plants nearest to it should also be destroyed, since the fungus may be established in them in a latent condition.

(5) *Distance between the plants*

When lavender was first cultivated in this country it was customary to plant the bushes further apart than the three feet or less which is the present custom. As a result of inspecting plantations in which the bushes were at different distances apart, it has become clear that the greater these distances are, so much the more do the plants flourish. An excessive distance between the plants is clearly not economical as a great deal of ground is wasted, but a distance apart that has much to commend it is four feet in each direction. In a young plantation this allows room for the horse-hoe to move diagonally through the field, as well as in directions at right angles to one another. Furthermore, since the branches of neighbouring plants do not grow in contact with one another, spores are not so liable to be splashed from plant to plant.

(6) *Spring clipping*

A promising means of controlling the disease is to clip the plants drastically with shears at the end of February or the beginning of March. This is based on the consideration of the fact that the fungus develops slowly during the winter. Furthermore, since the plants are wounded most severely when the crop of flowers is harvested in August, and in some plantations additional wounds are made by trimming the plants with shears in the autumn, it is considered that the plants are especially liable to infection immediately after these operations. Moreover, since the fungus develops only slowly during the winter months it was hoped that if the plants were trimmed drastically with shears in the spring most of the newly infected portions would be removed, and in consequence a clean start would be made during the summer. This method of control would be ineffective in a plantation that is already badly diseased, or if the clippings are not carefully collected and burned as soon as the trimming has been carried out. When the experiments to test this idea were started it was hoped that wounds made in the spring would not be so liable to infection as those made in August or September, but this possibility was later conclusively disproved by the inoculation experiments already described.

Apart from any consideration of the disease the practice of spring clipping renders the plants more liable to be damaged by late frosts in May, when the young shoots turn yellow and later die back. However, they recover from this injury and the main consequence is that the time of flowering may be delayed by about three weeks. This delay is a serious drawback in many instances, and where early flowering is important the practice is not recommended.

The first important experiment was started on March 19th, when four rows, each consisting of about seventy plants, were trimmed drastically with shears. Four similar rows alternating with the clipped ones were left untreated as controls. No disease was apparent in any of the plants before clipping. The results are shown in Table III.

Table III

Date	No. of diseased plants in clipped rows	No. of diseased plants in unclipped rows
July 6th	4	20
July 19th	5	24
August 2nd	11	37

In the autumn of 1927 the diseased plants in six of the eight rows were removed, and the plants in three of them trimmed again on March 6th, 1928, the behaviour of the bushes thus being kept under observation for two consecutive seasons. The results are shown in Table IV.

Table IV

Date	No. of diseased plants in clipped rows	No. of diseased plants in unclipped rows
March 5th	5	20
May 21st	1	20
June 14th	13	49
July 17th	30	85
August 5th	41	105

In another experiment, twelve groups of six rows of four-year old plants each extending the whole width of a field were treated as follows. Two rows were trimmed drastically with shears on August 20th–26th, 1927, two were trimmed on March 5th–6th, 1928, and the remaining two were left untreated as controls. This arrangement was adopted because the disease was principally situated in localised areas. Most of the badly diseased bushes were dug up and destroyed at the end of August 1927, but those that were only slightly affected were left.

By November 1927, a great many branches in the plants clipped between August 20th and 26th had died, and many more succumbed during the winter, chiefly following intense frost or heavy rain. Finally, by the spring of 1928 most of these plants were dead, and during the summer only a few of the remainder recovered sufficiently to produce flowers. The wood of the moribund plants was brown, and infested with fungal mycelium. Attempts to isolate the fungus in pure culture were made, but only *Dematium pullulans* and other common saprophytes were obtained.

The remaining plants were studied individually. The first record was made immediately before the spring clipping, those plants on which pycnidia of *Phoma Lavandulae* were present being marked as diseased. The number of plants thus kept under observations was 3443, of which 1723 were clipped and 1720 were kept as controls. There were 435 diseased plants before clipping, and 1747 were diseased on August 5th, when the last observations were made—an increase of 1312 during the summer. Furthermore, comparison shows that whereas there was an increase of 445 diseased plants in the clipped rows the increase in those that were unclipped was 887. The incidence of the disease in clipped and unclipped rows during successive months is shown in Table V.

Table V

Date	Diseased plants in clipped rows	Diseased plants in unclipped rows	Total change in clipped rows	Total change in unclipped rows
8. iii. 28	219	216	—	—
17. v. 28	77	239	Decrease of 142	Increase of 23
12. vi. 28	173	595	Decrease of 46	Increase of 379
9. vii. 28	468	903	Increase of 249	Increase of 687
2. viii. 28	644	1103	Increase of 425	Increase of 887

The increase in the number of diseased bushes in clipped and unclipped rows respectively during successive months is shown in Table VI

These figures show conclusively that spring clipping may lead to a very marked reduction in the spread of the disease. Moreover, it is considered probable that if the practice is carried out regularly the result would be even more satisfactory, since clipped and unclipped rows would not then be intermingled as they were in this experiment. Most of the later infections in the clipped rows were undoubtedly due to the close proximity of the pycnidia in the control rows, for which reason the small units used were unsatisfactory.

Table VI

Month	Change in clipped rows	Change in unclipped rows
March 31st–May 17th	decrease of 142	increase of 23
May 17th–June 12th	increase of 96	„ 356
June 12th–July 9th	„ 315	„ 356
July 9th–August 2nd	„ 176	„ 200

It will be seen from the figures in Table V that to begin with there was actually an apparent decrease in the number of diseased plants in the clipped rows immediately after the clipping had been carried out, which might be thought to indicate that certain of the plants were "cured." Although this may have been so in certain instances, the effect in others may have been only an apparent one due to the fact that all those parts of the plants that were obviously diseased were removed; but the fungus may have been established below the points of abscission and have undergone further development afterwards, the plants thus becoming obviously diseased a second time. On the other hand a bush that was only slightly diseased may well have been "cured," and it is almost certain that many such "cures" were masked by the plants becoming infected a second time after being trimmed.

Further experiments on the same lines were conducted in another field about one and a half acres in extent. No disease was present in this field, and the plants were young, one acre being planted with second year bushes and the remainder were in their first year. Although no disease appeared in this plantation certain interesting features were noted, of which the most important was that the time of flowering was not delayed by spring clipping. Indeed, very little difference could be seen between the plants that were clipped in spring and those that were not trimmed at all—a feature which indicates that if spring clipping is started when the plants are sufficiently young the drawback of late flowering may be avoided. The second interesting result shown by this experiment is that a high percentage of the plants clipped in late summer (September 6th) were killed by frost, thus corroborating the result obtained in the previous similar experiment with older bushes.

Observations were also made in a small commercial lavender plantation where drastic spring clipping had been practised regularly for many years. This plantation contained no diseased plants. Furthermore, the time of flowering was not seriously delayed, the plants displayed strong and vigorous growth, and the flower heads were remarkably fine. All these facts tend to show that in competent hands the practice of spring clipping is advantageous.

Other Diseases of Lavender

Two other diseases of lavender have been met with that are distinct from "Shab." These diseases do not cause much damage to the crop and are of no economic importance. No detailed work has been done on either of them.

A. Circular black spots a few millimetres in diameter are formed on the leaves, often in great numbers. The centres of the spots sometimes become white as the tissues are killed, and pycnidia of *Septoria Lavandulae* are formed on the spots. Usually the older leaves are attacked. If the attack is a severe one some of the leaves fall off prematurely, but otherwise very little harm results.

B. The stems bearing the flower heads frequently become constricted and twisted usually an inch or two below the actual flowers. Later the tissues at the lesions become partially decomposed and the heads then fall over. The lesions never extend very far down the stems, seldom attaining a length of more than a few centimetres. The diseased tissues are frequently packed with fungal mycelium, and in damp weather a species of *Botrytis* fructifies over the surface of the lesions. The cause of this disease, which is most prevalent in old bushes, especially if the weather is wet, is unknown.

Discussion of Results

"Shab" disease is a very serious one and if lavender had been cultivated in this country on a larger scale it would undoubtedly have commanded more attention at an earlier date. The species of *Phoma* which are of economic importance are chiefly associated with rots, such as "dry-rot" of swedes caused by *Phoma Lingam*. *Phoma Lavandulae* is of especial interest in that it is capable of growing throughout the tissues of a lavender plant in which it can induce a wilt and die back —a mode of parasitism unlike that so far recorded for any other member of the genus.

There are very few plant diseases in which inoculations have been made at monthly intervals throughout the year. This, in the main, is doubtless due to the fact that many agricultural crops are comparatively short lived and hence do not lend themselves to this type of experiment. However, in recent years very extensive work on these lines has been carried out in connection with the "Silver Leaf" disease of fruit and other deciduous trees by Brooks and his colleagues. In lavender large deposits of gum are not formed in association with wounds, and in correlation with this fact it has been shown that fresh wounds in lavender stems are liable to invasion at any time of the year under suitable conditions. It is true that old wounds in lavender stems cannot be invaded by *Phoma Lavandulae*, in the same way as old wounds in plum wood are not liable to invasion by *Stereum purpureum*; but whereas in plum wood this is usually due to the deposition of gum, in lavender it results from some other as yet undetermined cause.

The factors governing the fructification in pure culture of members of the Sphaeropsidales is little understood. It has been found in a general way that such factors as light intensity and temperature play a part in this connection, but no general rules applicable to more than a few isolated species within the group have been discovered (8, 9). The problem of pycnidium formation is a complex one, which, if more fully understood, would greatly assist plant pathologists.

The discovery of *Phoma Lavandulae* growing saprophytically on *Chenopodium album* indicates the possibility that as yet the biology of fungi of the *Phoma* type is but little understood. Members of the Sphaeropsidales have hitherto been studied chiefly from the standpoint of the crop plants on which they are known to be parasitic, and it is sometimes assumed that fungi of this type are relatively specialised parasites. *Phoma Lavandulae* will not grow on *Lavandula dentata* and other Labiatae, nor even on the "Dwarf French" variety of *Lavandula spica*, although it will grow saprophytically on *Chenopodium album*.

Summary

1. It has been shown conclusively by inoculation experiments that the primary cause of the "Shab" disease of lavender is the fungus *Phoma Lavandulae* Gab. Symptoms similar to those of "Shab" may, however, be due to adverse climatic and environmental factors of which the chief are frost and waterlogged soils. A species of *Botrytis* may also cause a die-back at times.

2. The early symptoms of the disease are that the young shoots turn yellow and wilt from about May onwards. Later the branches die back, and the disease spreads throughout the plant which ultimately dies. Pycnidia of *Phoma Lavandulae* are formed in great numbers on the young diseased shoots after these have been killed.

3. Infection of healthy lavender plants can take place either through or near leaf axils on young shoots in summer, or through freshly made wounds. From the points of infection the fungus grows downwards invading all the tissues, and killing the branches. Wounds are liable to invasion when freshly made at any time of the year under suitable conditions, but when more than four weeks old they appear no longer to serve as paths of infection.

4. A long period elapses between the time when a plant is inoculated and the first appearance of clear disease symptoms. During this period, which ranges from two months to a year or more, the fungus is latent within the tissues of the host.

5. The disease is spread (1) by raising plants from cuttings in which the fungus is already established, (2) by the distribution during cultural operations of branches or leaves bearing pycnidia, (3) by the distribution by wind of small particles of bark bearing pycnidia, and (4) locally by the splashing of spores from plant to plant by rain.

6. *Phoma Lavandulae* has been isolated repeatedly from diseased lavender plants and grown in pure culture on a variety of media. It failed to produce pycnidia except on a few media of which the chief was Dox's agar in bright sunlight.

7. Pycnospores of *Phoma Lavandulae* lose their viability within a few hours of being exuded from the pycnidia. On the other hand, they can remain alive within the pycnidia for long periods under a wide range of environmental conditions.

8. Whilst *Phoma Lavandulae* can infect most varieties of lavender the variety "Dwarf French" appears to be immune. This variety is of no use in the manufacture of perfume. *Lavandula dentata* is likewise immune. On the other hand, *Phoma Lavandulae* can grow saprophytically under field conditions on *Chenopodium album*.

9. Measures for controlling the disease based on the principles of plant sanitation have been devised and have met with considerable success wherever they have been put into operation.

DESCRIPTION OF PLATE VII

Fig. 1. A freshly wilted lavender twig showing its attachment to a branch that is still healthy. × ½.

Fig. 2. A group of lavender plants that were killed by "Shab" disease, with a background of healthy bushes of the same age.

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Fig. 1.

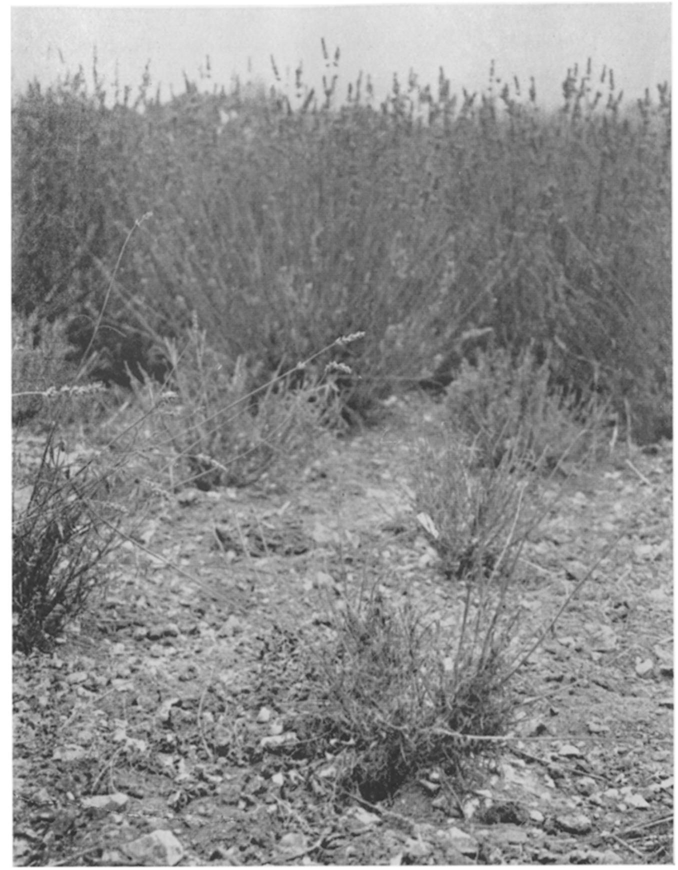

Fig. 2.