FACTORS INFLUENCING THE DEVELOPMENT OF BROWN PATCH IN LAWNS OF *SAGINA PROCUMBENS* L.

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Summary

The meteorological conditions necessary for the appearance of brown patch caused by *Pellicularia praticola* (Kotila) Flentje in *Sagina* lawns in Adelaide have been determined. They are:

(i) A minimum temperature between 63·5 and 68°F, and

(ii) Free moisture or very high humidity at the lawn surface.

The time necessary for infection to take place was determined at one temperature only (77°F) and was 8–12 hr.

Results indicate that the causal fungus is able to grow as a saprophyte beneath the surface of a well-watered lawn, but that intensive saprophytic growth is dependent on an adequate nutrient supply which, under natural conditions, is provided by a previous period of parasitic growth.

I. Introduction

Brown patch disease of lawns was first described by Piper and Coe (1919) who isolated the casual organism and determined it as *Rhizoctonia solani* Kühn (*Pellicularia filamentosa* (Pat.) Rogers). This fungus has a wide host range and may infect many lawn grasses (Howard, Rowell, and Keil 1951). In South Australia, *Sagina procumbens* L. (pearlwort) has been commercialized as a lawn plant, its chief merit being that it does not require cutting. It has been planted in several gardens in Adelaide and has proved very susceptible to brown patch. The disease occurs in two forms: firstly, as more or less circular patches of dead lawn, 6–12 in. in diameter, or secondly, it may appear as "smoke rings", also more or less circular, but only those plants in a strip 2–3 in. wide round the perimeter of the ring are killed (Plate 1, Fig. 1). A smoke ring may be 1–8 ft in diameter or even larger. Where the disease is serious, strips of dead lawn from several patches may meet and it is then difficult to recognize their circular nature. Plants killed by the fungus are at first dark green, almost black in colour, due to the water-soaked character of the infected tissues which later dry out and become light brown.

The influence of environmental conditions on brown patch has been noted by several workers who, in general, agree that the appearance of the disease is dependent on warm, moist weather, but who disagree as to the relative importance of temperature and humidity on it. Dickinson (1930) stated temperature was the important factor, humidity influencing the disease only by its effect on air and surface soil temperature. He defined the optimum temperature conditions for the development of brown patch as:

(i) A temperature of 64–68°F for 45 min to stimulate germination of resting sclerotia, followed by

(ii) A rise in temperature to between 80 and 85°F.

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Dahl (1933) did not agree with the findings of Dickinson. Working with several strains of the fungus he found that the minimum temperature for germination of sclerotia was between 46 and 54°F, and the optimum temperature between 82 and 90°F. The sclerotia did not require any drop in temperature to stimulate germination. Monteith and Dahl (1932) stated that the conditions most favourable for the development of brown patch are a temperature between 80 and 90°F and "the presence of ample water". Because of the conflicting evidence on the exact conditions which favour the occurrence of brown patch, the appearance of the disease in *Sagina* lawns in Adelaide has been studied in relation to weather conditions.

The fungus used in the present work was Waite Institute strain St 3 which was isolated from a smoke ring in a *Sagina* lawn. It differs from most isolates of *P. filamentosa* from other hosts in having a faster rate of growth and a typical white mealy appearance in culture (potato-dextrose-agar); it has been designated *P. praticola* by Flentje (1956).

II. Experimental

(a) *The Relation between the Occurrence of Brown Patch in* Sagina *Lawns in Adelaide and Weather Conditions*

Brown patch in a *Sagina* lawn was first recorded in Adelaide on February 11, 1952. During the following summer (1952–53) 12 lawns within a radius of 3 miles of

Table 1

Days on which brown patch appeared and the meteorological records for the 24 hr ending 9 a.m. on these days

Days on which Brown Patch Appeared	No. of Lawns Affected	Air Temp.		Soil Temp. (1-in. depth)		Rainfall (in.)	R.H. (at 9 a.m.)
		Max.	Min.	Max.	Min.		
11.ii.52	?	72·8	57·8	93·6	58·2	0·160	68
15.xi.52	2	85·3	61·2	70·5	58·5	0·265	86
5.xii.52	2	74·2	60·1	99·5	61·5	0·075	66
26.xii.52	8	78·6	58·2	107·2	62·3	0·040	54
5.i.53	4	93·2	59·5	81	66	0·390	95
25.i.53 }		95·1	67·8	98	65·8	1·0	80
26.i.53 }	9	92·5	68·8	107·2	67·2	0·1	50
27.i.53 }		90·7	76·4	101·0	72·8	0·025	64
5.ii.53	7	87·0	61·2	82	61·3	0·495	79
16.iv.53	1	91·2	73·5	87·3	64·5	Lawn watered	43

the Waite Institute were visited regularly, and the appearance of patches in these lawns was noted. The days on which patches appeared are given in Table 1, together with the Waite Institute meteorological records for the 24 hr ending 9 a.m. on these days. The weather in each instance was warm or hot, and rain was recorded on each occasion except one, when only a single lawn was affected. Enquiries were made and it was found that that lawn had been watered on the evening before the patches appeared.

This suggested that free water was necessary for the appearance of brown patch, and to test this the parasitic activity of the casual fungus, with and without free moisture present, was studied in the laboratory. Constant relative humidity was maintained in a growth cabinet by means of an automatic humidifier controlled by a cellulose acetate–mercury hygrometer (Ballard 1949). A relative humidity of 93 per cent. was maintained with a variation of $\pm$ 2 per cent. R.H. Six inoculated and six control plugs of a *Sagina* lawn, 3 in. in diameter, were sprayed with water, placed in 4-in. diameter glass jars, and transferred to the growth cabinet at a temperature of 77°F. Half of the jars were covered with plastic to prevent evaporation of water. After 2 days the controls at both humidities and the inoculated plugs at 93 per cent.

TABLE 2

TEMPERATURE AT TIME OF RAINFALL ON DAYS WHEN BROWN PATCH APPEARED

Days on which Brown Patch Appeared	Rainfall (in.)	Time of Rainfall (hr)	Air Temp. at Time of Rainfall (°F)	1-in. Depth Soil Temp. at Time of Rainfall (°F)
11.ii.52	0·160	1200–1600	—	76–75
15.xi.52	0·265	0400–0730	76–65	66–67
5.xii.52	0·075	0530	68	65
26.xii.52	0·040	1400–1600	70–72	75–78
5.i.53	0·390	0100–0900	66–61	72–66
25.i.53	1·0	1600 0830	94–70 79	80 68
26.i.53	0·1	1700	92	90
27.i.53	0·025	1700	88	104
5.ii.53	0·495	1700–1800	80–74	81–76
16.iv.53	Lawn watered	1920–2030	83–84	80–78

R.H. remained healthy. In the inoculated lawns with free moisture present, the fungus had grown out radially from the inoculum and killed the lawn in a circle 2 in. in diameter. This experiment shows that a relative humidity higher than 93 per cent. is necessary for the parasitic activity of *P. praticola*, but in Adelaide there are very few days with a temperature around 77°F and an air humidity above 93 per cent. without free moisture being present on the surface of a lawn.

If free moisture is essential for the development of brown patch, the maximum and minimum temperature for the previous 24 hr are not so important as the temperature of the lawn when the free moisture is present. The time of rainfall during the 24 hr prior to the appearance of brown patch was determined from a Julien Friez continuous rain recorder, and this is compiled with the corresponding air temperature and soil temperature at 1 in. depth in Table 2 (a continuous grass temperature record was not available). The air temperature varied between 61 and 94°F and the soil temperature between 65 and 104°F. Although temperature at time of rainfall was determined, it was not known how long free moisture remained on the lawn surface after the rain, and so a complete record could not be obtained for the period when moisture conditions were suitable for parasitism by the fungus. The evidence suggests that the minimum temperature for the appearance of brown patch is between 60 and 70°F.

For more precise information the pathogenicity of *P. praticola* to *S. procumbens* was studied in the laboratory at 59, 68, and 77°F. Three replicates of inoculated and control lawn plugs in glass jars were placed in Wisconsin tanks at these temperatures, sprayed with water, and covered with plastic. After 3 days there were diseased patches in the inoculated plugs at 68 and 77°F whereas the inoculated lawns at 59°F and all the control lawns were healthy. The six lawn plugs at 59°F were examined again after 1 week, but there was still no infection.

A further experiment was carried out, using the same methods but at temperatures of 59, 63·5, and 68°F. At 59 and 68°F the result was as before. At 63·5°F a typical patch was not formed, but the fungus had grown out and a few leaves were infected, so that this temperature must be very near the minimum at which *P. praticola* will infect *S. procumbens*, but it is too low for the fungus to cause a typical brown patch.

The infection period, or the measure of time required for the establishment of the parasitic relationship had yet to be determined. With this object in view, 4-mm discs of inoculum were floated on sterile water in Petri dishes until hyphae grew from the discs which were then carefully transferred to plugs of *Sagina* lawn. This ensured that there was no delay in the growth of the fungus after inoculation. The plugs were sprayed with water and covered with plastic. Three plugs were removed after 4, 8, 12, 16, and 24 hr and carefully examined for infection. Owing to scarcity of material the infection period could be determined only at one temperature, 77°F. Occasional infection was observed after 8 hr and infection was common after 12 hr.

It can be stated, therefore, that the conditions of temperature, moisture, and time necessary for the appearance of brown patch in a *Sagina* lawn are:

(i) A minimum temperature between 63·5 and 68°F,

(ii) Free moisture or very high humidity at the lawn surface, and

(iii) An infection period of 8–12 hr at the one temperature tested (77°F).

(b) *Saprophytic Activities of the Brown Patch Fungus*

The character of a smoke ring suggests that the initial growth of the fungus is saprophytic because the centre of the patch remains healthy. To test this, two circular plugs of *S. procumbens* lawn, 10 in. in diameter, were inoculated at the centre and half an inch below the surface of the lawn with 1 g of sand-maize-meal inoculum of *P. praticola* and placed in a growth room at 72°F and watered regularly. After 7 days there was no sign of parasitic activity and the extent of saprophytic growth of the fungus was determined by planting on to tap-water-agar pieces of lawn plants taken from below the surface and at half-inch intervals along four radii from each plug. *P. praticola* had grown to the edge of the plugs.

The result of this experiment indicates that the fungus is capable of extensive saprophytic growth beneath the surface of a well-watered lawn where there is always free moisture or a very high humidity. When it rains, or the lawn is watered, the fungus will be able to grow to the surface and parasitize the leaves of the lawn plants if the temperature is above 63·5°F. The size of the patch will depend on the extent of saprophytic growth and the duration of conditions suitable for parasitism. If the saprophytic growth is limited a small brown patch will be formed; if extensive, a smoke ring patch will result, the width of the ring being determined by the duration of conditions suitable for parasitism.

An attempt was made to produce a smoke ring in the laboratory. A plug of *Sagina* lawn, 10 in. in diameter, was placed in a glass dish of the same diameter. The plug was inoculated at the centre and 1 cm beneath the surface, with 1 g of sand-maize-meal inoculum, and placed in a constant temperature (72°F) growth room at approximately 50 per cent. relative humidity. It was watered regularly for 8 days and the lawn showed no sign of disease. The lawn was then sprayed with water, covered with clear plastic to prevent evaporation, and examined after 24 hr. The plug of lawn was diseased except for a strip, approximately 1 in. wide, round the periphery (Plate 1, Fig. 2). A smoke ring was not formed. The result confirms the hypothesis except for the formation of the smoke ring. It is likely that the extent of saprophytic growth was not sufficient for a ring to be formed.

The factors which stimulate very dense saprophytic growth of the fungus are not yet known. It does not grow intensively during the winter because the first patches that appear in the early summer are always small, 6 in.–1 ft in diameter. As the summer advances and conditions suitable for parasitism occur, larger patches appear, and by the end of the summer patches 6–8 ft in diameter or even larger are formed. Brown patch may occur as a double ring (see Plate 1, Fig. 1), the outer ring appearing after the inner. For five such double rings from separate lawns, the radial difference between the inner and outer rings was measured, and, as the days on which these appeared were known, it was possible to calculate the rate of growth of the fungus in the lawns. The size of the rings was also known and therefore the day on which growth started could be estimated (radius of patch/rate of growth). It was calculated that in three patches growth commenced on December 6, 1952 and, in the remaining two, on December 22, 1952. Such an estimation must necessarily be approximate since it assumes that the fungus grows at a constant rate, but it is interesting to note that brown patch was recorded on December 5, 1952, and December 26, 1952 (see Table 1). This suggests that the saprophytic growth of the fungus in a patch, or in a potential patch, starts after an initial period of parasitic activity. To test this, 1 g of soil, known to be infected with *P. filamentosa*, was placed in the centre of each of two plugs of *Sagina* lawn 8 in. in diameter. The plugs were sprayed with water and one was covered with clear plastic; both were kept at a temperature of 72°F. The plastic cover was removed after 24 hr and it was seen that the leaves in the centre of the plug were parasitized. Both lawns were left for a further 6 days without covers and watered regularly. There was no sign of parasitism during this time. The lawns were then sprayed with water and covered with plastic for 24 hr, after which they were examined again. That which was infected during the initial period of 24 hr had now a diseased patch 6–7 in. in diameter, while the other had a patch approximately 1 in. in diameter. Intensive saprophytic growth appears to depend on an initial period of parasitism.

III. Discussion

From the above results the probable behaviour of the brown patch fungus, *P. praticola*, in a lawn can be described. During winter when temperatures are too low for parasitic activity the survival of the fungus must be limited, otherwise a patch formed one year would reappear the following year in the same spot, and with a diameter as great as, or greater than, that of the original patch. This does not occur and probably the fungus survives as a saprophyte or as dormant mycelium or sclerotia in isolated spots either in the lawn or in the soil beneath the lawn. In the early summer when conditions suitable for parasitism prevail, the fungus grows to the surface of the lawn, and parasitizes the leaves of the lawn plants. This initial period of parasitism provides the fungus with nutrients which enable it to grow intensively and extensively as a saprophyte beneath the lawn surface where there is always high humidity or free moisture (nutrients may be provided artificially by using high nutrient inoculum such as sand-maize-meal). When conditions suitable for parasitism again occur, the fungus will once more grow to the lawn surface and become parasitic. If the previous saprophytic growth was extensive the disease will be in the form of a smoke ring because of the greater hyphal activity at the growing edge of the colony than behind it; if the previous saprophytic growth was limited, the disease will be in the form of a brown patch. This alternating parasitic and saprophytic growth may continue throughout the summer with the result that patches formed towards the end of summer will, in general, be much larger than those formed at the beginning.

Very high humidity or free moisture is essential for the development of brown patch, its influence being direct and not indirect by its effect on temperature as stated by Dickinson (1930). This confirms Shurtleff (1953) who found that the sclerotia of *P. filamentosa* would germinate only at relative humidities of 98 per cent. or higher.

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V. References

Ballard, L. A. T. (1949).—A simple device for controlling relative humidity. *Aust. J. Sci.* **12**: 76.

Dahl, A. S. (1933).—Effect of temperature on brown patch of turf. Abstr. in *Phytopathology* **23**: 8.

Dickinson, L. S. (1930).—The effect of air temperature on the pathogenicity of *Rhizoctonia solani* parasitising grasses on putting green turf. *Phytopathology* **20**: 597.

Flentje, N. T. (1956).—Studies on the fungus *Pellicularia filamentosa* (Pat.) Rogers. I. The formation of the perfect stage by different strains. *Trans. Brit. Mycol. Soc.* **39**: (in press).

Howard, F. L., Rowell, J. B., and Keil, H. L. (1951).—Fungus diseases of turf grasses. Bull. R.I. Agric. Exp. Sta. No. 308. 56 pp.

Monteith, J., and Dahl, A. S. (1932).—Turf diseases and their control. *Bull. U.S. Golf Assoc.* (*Green Section*) **12**: 85.

Piper, C. V., and Coe, H. S. (1919).—*Rhizoctonia* in lawns and pastures. *Phytopathology* **9**: 89.

Shurtleff, M. C. (1953).—Factors that influence *Rhizoctonia solani* to incite turf brown patch. Abstr. in *Phytopathology* **43**: 484.

Explanation of Plate 1

Fig. 1.—Brown patch in a *Sagina* lawn showing a typical smoke ring. $\times \frac{1}{8}$.

Fig. 2.—Brown patch produced by *P. praticola*, after saprophytic growth for 8 days followed by parasitic growth for 1 day. $\times \frac{2}{5}$.

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