THE CONTROL OF ALTERNARIA BLIGHT OF SUNFLOWERS IN EASTERN AUSTRALIA.

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ABSTRACT

Alternaria blight causes significant yield reductions in sunflower crops grown in Queensland. Surveys of the diseases present in commercial sunflower crops throughout eastern Australia showed that alternaria blight was present in New South Wales and Victoria but only at very low levels. The disease was most common on the central coast and central highlands of Queensland. The conditions required for the rapid development of epidemics of alternaria blight included (i) warm temperatures (optimum 26°), (ii) extended periods of wet weather and (iii) maturing plants (after the commencement of anthesis). These conditions were frequently met in spring sown sunflower crops in Queensland, which matured during the summer months when mean daily temperatures were between 25°C and 30°C and when the chance of rainbearing cyclonic depressions was high. It is suggested that sunflower crops in the central coast and central highlands of Queensland should be sown in summer so that they mature during the cooler and dryer autumn months when environmental conditions are less likely to favour the development of alternaria blight. A strategically timed application of the fungicide captafol was shown to provide adequate control of the disease under glasshouse conditions.

INTRODUCTION

Alternaria helianthi (Hansf.) Tubaki and Nishihara was first described by Hansford (1943) as *Helminthosporium helianthi* Hansf. from diseased sunflower leaves collected near Kampala in Uganda. The presence of disease symptoms caused by this pathogen was subsequently reported in Tanzania in 1950 (Wallace and Wallace, 1950), Japan in 1963 (Takano, 1963), Yugoslavia in 1964 (Acimovic, 1969), India in 1971 (Narain and Saksena, 1973), Brazil in 1971 (De Aquino, Bezerra and Lira, 1971), Iran in 1971 (Acimovic, 1975), Australia in 1971 (Alcorn and Pont, 1972) and the U.S.A. in 1979 (Shane, Baumer and Sederstrom, 1981). *A. helianthi* is now regarded as a major pathogen of sunflower, particularly in Yugoslavia (Acimovic, 1969; Islam and Maric, 1978) and India (Abraham, Menon and Nair, 1976) Kolte and Tewari, 1977).

In Australia the pathogen was first isolated from diseased material collected in north Queensland (Alcorn and Pont, 1972). Delaney (1978) reported that *A. helianthi* spread quickly to all other sunflower growing areas of Queensland and had become important in the wetter areas of the state. Losses in sunflower yield caused by *A. helianthi* in Queensland have been reported by Williamson (1979) and Allen, Kochman and Brown (1981). Alternaria blight has also been recorded in New South Wales (Anon, 1979).

The effects of environmental factors on growth and development of *A. helianthi* have been investigated by several authors. Islam and Maric (1978) found that growth of *A. helianthi* on artificial media occurred at temperatures ranging from 4 to 32°C with the optimum being 26°C. They also found that sporulation was poor at temperatures below 16°C and abundant at temperatures between 20 and 28°C. Anilkumar, Urs, Seshadri and Hegde (1974) noted that alternaria blight was very severe on plants in the later stages of their growth. Islam, Cuk, Maric and Skoric (1976) also observed that the development of disease caused by *A helianthi* was greatest on senescing plants. Islam *et al.*, (1976) found that the disease occurred only sporadically on the older leaves of plants before flowering and that the heaviest infections occurred during the seed development stage of growth. Free water or dew on the leaf surface was found to be essential for the infection of sunflower by *A. helianthi.* However, reports vary as to the minimum dew period required for infection to take place. Acimovic (1969) reported that the minimum dew period required was one to two hours whereas Islam and Maric (1976) found that a minimal dew period of twelve hours was required. Several authors have related the severity of alternaria blight to the incidence of wet or humid weather conditions (Tubaki and Nishihara, 1969; Acimovic, 1975; Delaney, 1978; Kolte, Balasubrahmanyam, Tewari and Awasthi, 1979).

Efforts to determine effective control practices for alternaria blight of sunflower have mainly concentrated on the screening of various fungicides and the evaluation of sunflower cultivars for the presence of resistance to the pathogen. Several cultural practices have also been recommended to reduce the incidence of the disease. Hedjaroude (1973) suggested that the elimination of alternative weed hosts, destruction of crop residues and crop rotation were possible cultural measures that could be used to control alternaria blight of sunflower in Iran. Disease escape was recommended for the control of the disease in India by Kolte and Tewari (1977). They found that alternaria blight was most severe in sunflower crops that were planted in June, July and August and was least severe in crops planted in October, November, December and January. Maximum disease severity was correlated with the monsoon season. Several authors have screened various fungicides for the control of *A. helianthi* on sunflower (Islam *et al.*, 1976; Reddy and Gupta, 1976; Abraham *et al.*, 1976; Bhaskaran and Kandaswamy, 1979). Dithiocarbamates and copper fungicides have generally proven to be the most effective although Islam *et al.*, (1976) recommended benomyl for the control of alternaria blight of sunflower in Yugoslavia. In most cases the spray programme used to evaluate the fungicides has involved two to five spray applications at seven to fifteen day intervals. Despite some variation in the susceptibility of different sunflower cultivars to alternaria blight, complete resistance to the pathogen has not been identified (Islam *et al.*, 1976; Acimovic, 1976; Shane *et al.*, 1981).

The objectives of the studies reported in this paper were (i) to investigate the distribution and severity of alternaria blight of sunflower in eastern Australia, (ii) to determine the effects of dew period and temperature on the growth and development of *A. helianthi* (iii) to investigate the possibility of using fungicides to control alternaria blight and (iv) to develop recommendations for the control of alternaria blight in eastern Australia.

EXPERIMENTAL

The Distribution and Severity of Alternaria Blight of Sunflower in Eastern Australia.

The diseases present in commercial sunflower crops growing in central and southern Queensland, New South Wales and Victoria were surveyed during the 1978 — 1979, 1979 — 1980 and 1980 — 1981 seasons. The severity of alternaria blight was recorded as the percentage of leaf area showing symptoms of the disease. The location, date of survey, cultivar (if known), previous cropping history and the growth stage of the crop (based on the scale of Siddiqui, Brown and Allen, 1975) were recorded for each crop examined. Over 500 crops were examined during the three seasons during which surveys were made.

These disease surveys showed that alternaria blight was most prevalent in central and southern Queensland, particularly during summer months. Although alternaria blight was present in New South Wales and Victoria, very few crops were infected and disease severity was generally well below one per cent. The disease was most severe in crops growing on the central highlands and central coast of Queensland.

One crop that was observed in this area had been subjected to an epidemic of alternaria blight during ten days of wet weather in February 1979. All leaves had dried off before petal fall and the crop yielded approximately 0.25 tonnes/ha compared with 0.78 t/ha which was the average yield for sunflower grown in Queensland during the 1978 — 1979 season (Bureau of Agricultural Economics).

The Effects of Dew Period and Temperature on the Growth and Development of *A. helianthi.*

Sixteen sunflower plants (six weeks old, in 15 cm pots) were uniformly inoculated in an inoculation chamber (Brown and Fittler, *in press*) and then placed in a dew chamber at 25°C to determine the length of dew period required to give maximum infection. Four plants (replicates) were removed after nine hours incubation in the dew chamber and placed in a glasshouse. Plants were also removed at twelve, fifteen and eighteen hours after inoculation. Treatments were assessed one week after inoculation by determining the number of lesions/cm^2 of leaf area using leaves, 3, 4, 5 and 6 (from the base of the plant).

Table 1. The effect of dew period (hours of leaf wetness) on the infection of sunflower leaves by *A. helianthi.*

	dew period				
	9 hours	12 hours	15 hours	18 hours	LSD (P = 0.05)
lesions/cm^2	4.00	6.15	6.40	6.50	0.50

The length of the dew period required to give maximum infection of sunflower leaves by *A. helianthi* was found to be twelve hours at 25°C (Table 1). Longer dew periods did not significantly increase the level of infection by this pathogen. Previous reports on alternaria blight in Australia (Delaney, 1978; Williamson, 1979; Anon, 1979) have indicated that the disease was most prevalent in Queensland. Temperatures in New South Wales and Victoria are generally lower than those in Queensland. To determine the extent to which temperature influenced the development of *A. helianthi* a comparison was made between the germination of conidia, growth of colonies on artifical media and the degree of infection of sunflower leaves by *A. helianthi at 20 and 26*°C. Germination was studied by brushing dry conidia onto filter paper disks (15 mm diameter) that had been moistened with sterile distilled water and placed on a large wet filter paper in a petri dish. After inoculation the plates were incubated in darkness for six hours at 20 and 26°C. Several drops of lactophenol trypan blue were then added to each petri dish and allowed to soak into the inoculated filter paper disks. This prevented further germination of conidia and stained both conidia and germ tubes. One hundred conidia in each of four replicates were counted and the percentage germination at each temperature was calculated. The effect of temperature on colony growth was investigated by culturing *A. helianthi* on Potato Dextros Agar (P.D.A.) supplemented with a sunflower seed extract. After seven days in darkness at 20 and 26°C (six replicates at each temperature), the mean colony diameter was determined by measuring the mycelial growth along each of five radii marked on the bottom of each petri dish. The effect of a cooler temperature on infection of sunflower plants by *A. helianthi* was studied using glasshouse grown, five week-old sunflower plants growing in 15 cm pots. Eight plants were uniformly inoculated in the inoculation chamber and four plants were them placed in a dew chamber kept at 26°C. The remaining four plants were placed in a dew chamber kept at 20°C. After twelve hours incubation all plants were transferred to a glasshouse. The leaf area and the number of lesions per leaf were recorded for leaves 3, 4, 5 and 6 on each plant, at ten days after inoculation.

Table 2. A comparison between the germination of conidia, the growth of colonies on artificial media and the infection of sunflower by *A. helianthi* at optimal (26°C) and sub-optimal (20°C) temperatures.

	Per cent reduction at 20°C as compared to germination, growth and infection at 26°C
germination of conida on wet filter paper — after 6 hours	15
Growth of colonies on artificial media — after 7 days	29
Infection of sunflower leaves — after a 12 hour dew period	80

A comparison between the germination of conidia, the growth of colonies on artificial media and the infection of sunflower leaves by *A. helianthi* at optimal and sub-optimal (26°C and 20°C)temperatures is presented in Table 2. The growth and development of the pathogen was found to be considerably reduced at 20°C when compared to that at 26°C.

The Application of Fungicide for the Control of Alternaria Blight of Sunflowers.

The use of regularly repeated fungicide applicaitons for the control of alternaria blight of sunflowers would be commercially uneconomical under Australian conditions. The large areas sown to sunflowers (up to 400 hectares in some fields on the central highlands of Queensland) and the habit of the crop would necessitate the application of any fungicide treatment from an aircraft. In the sunflower producing areas of Queensland the extended periods of wet weather during summer are usually associated with cyclonic rain bearing depressions moving down from the tropics along the coast. Daily synoptic weather charts produced by the Bureau of Meteorology generally provide advance warning of these weather conditions. The purpose of the investigations reported in this section was to determine the effect of one strategic application of fungicide just prior to an extended wet period on the development of a simulated epidemic of alternaria blight in a glasshouse. Glasshouse grown sunflower plants (eight weeks old, in 15 cm pots) were sprayed to run-off with captafol (2.0 gm Difolatan per litre), benomyl (0.5 gm Benlate per litre) and water (control). Six days after the fungicide application, the plants were placed in a glasshouse bay with a "Walton SW5" humidifier and six plants that were severely infected with *A. helianthi.* There were six replicates of each fungicide treatment. As a result of the warm, humid conditions and long dew periods (12 to 16 hours) produced in the glasshouse bay the lesions on the diseased plants sporulated and an 'epidemic' developed. Eleven days after the application of fungicide treatments (including five days in the humid glasshouse bay), the number of lesions per leaf and the mean diameter of lesions were determined for leaves 5 and 6 on each plant. After fifteen days of exposure to the artificial epidemic in the glasshouse (21 days after the application of fungicide treatments), the number of lesions per cm^2, the mean diameter of lesions and the amount of senescence were determined.

Table 3. The effect of captafol and benomyl on the development of an artificially induced epidemic of alternaria blight of sunflower.

	captafol	benomyl	control	LSD (P = 0.05)
First assessment (11 days after fungicide application)				
No. of lesions per leaf (leaves 5 & 6)	3.0	37.2	44.2	14.73
mean lesion diameter (mm)	1.00	1.15	2.13	0.19
Second assessment (21 days after fungicide application)				
No. of lesions/cm^2 (leaves 7 & 8)	1.19	1.41	1.71	0.23
mean lesion diameter (mm)	2.87	2.93	2.93	0.27
No. of senesced leaves	2.50	4.83	5.83	1.42

The results of the fungicide experiment (Table 3) show that the application of captafol to sunflower plants six days prior to the start of an epidemic significantly reduced the number and size of lesions at five days after the commencement of an artificial epidemic and the number of lesions per cm^2 leaf area and amount of 'senescence' at fifteen days after the start of an artificial epidemic. Benomyl was less effective than captafol under the conditions of this experiment.

DISCUSSION

The results obtained, together with those of other authors indicate that the development of epidemics of alternaria blight of sunflower is favoured by warm temperatures (optimum 26°C), extended periods when free water is present on the plant surface (associated with extended periods of wet weather) and host plants that are in the post-flowering stages of development (when plants are most susceptible to disease). The distribution and severity of alternaria blight of sunflower in eastern Australia can be related to the environmental requirements of the pathogen. The dryer summers in Victoria and southern New South Wales and the cooler temperatures during wet weather periods in Victoria and New South Wales do not favour the development of epidemics of alternaria blight. In contrast, sunflower crops that are planted in spring in Queensland mature during the warm summer months when the probability of rain-bearing cyclonic depressions is high. These conditions favour the development of epidemics of *A. helianthi*. It is suggested therefore that the incidence of disease in Queensland crops (especially those grown on the central coast and central highlands) would be reduced if crops were sown in late summer so that the crop matured during the cooler and dryer autumn and early winter months. This practice would ensure that plants were at the most susceptible stage of growth when environmental conditions were least favourable for the development of epidemics.

The strategic application of a fungicide prior to the commencement of an epidemic of alternaria blight would only be considered if (i) *A. helianthi* was present on crop debris or on the lower leaves of plants (to provide inoculum of the pathogen), (ii) during summer months (when temperatures favoured disease development), (iii) in spring sown sunflower crops that are approaching maturity at a time when (iv) the approach of a rain-bearing cyclonic depression was imminent. Under current Australian conditions the cost of one application of captafol (as Difolatan flocol at 3 litres/ha) would be between $25 and $30 per hectare. However, before recommending that fungicides be used to control alternaria blight further evaluation of their effectiveness under field conditions is required. It is suggested that the strategic use of fungicides could be of value for the control of alternaria blight in seed production crops and experimental plots.

The use of crop rotations that avoid sowing sunflowers in areas that contain contaminated residues from previous crops (Hedjaroude, 1973; Islam *et al.,* 1976) might contribute towards reducing the incidence of alternaria blight in sunflower crops, especially in spring sown crops in central Queensland.

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SOME FACTORS AFFECTING THE INCIDENCE AND IMPORTANCE OF SUNFLOWER RUST IN AUSTRALIA.

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ABSTRACT

The incidence of rust (caused by *Puccinia helianthi* Schw.) in commercial sunflower crops in eastern Australia was monitored during the period 1972 to 1982. The incidence of rust has decreased in recent years due primarily to an increase in the use of rust resistant hybrid cultivars. Wholly or partially resistant hybrids became commercially available in Australia in about 1975 after it was found that yield could be increased by 70% when rust was controlled in susceptible, open pollinated cultivars grown in New South Wales and Queensland. Glasshouse studies showed that the effects of simulated rust epidemics on growth and yield parameters depended on the stage of plant growth when the epidemic occurred and on the duration and intensity of the epidemic. Laboratory studies designed to investigate the mechanisms by which rust infection reduced yield showed that healthy plants exported between 42 to 70% of the photosynthate they produced to other parts of the plant. In contrast to this, infected leaves retained about 97% of the photosynthate they produced. Only about 3% of the photosynthate produced was exported to other plant parts. Rust infection also increased the water requirements of plants that were subjected to conditions of moisture stress. Studies on the infection process showed that the fungus gained entry into its host through stomata. The optimal temperature for infection and disease development was 20°C. At this temperature a dew period of 8 h enabled maximal infection by the rust fungus. A longer dew period was required at temperatures above or below the optimum. Light inhibited development during the pre-penetration phases of infection. Under optimal environmental conditions, the time taken for pustules to erupt was 11 days.

INTRODUCTION

Rust caused by *P. helianthi* is a common disease of sunflower in most countries of the world. The disease has been shown to cause serious loss of yield in Russia (Eremeyeva and Karakulin, 1929), Kenya (Nattrass, 1950; Singh, 1975), Argentina (Muntanola, 1954), Canada (Putt and Sackston, 1955) and Hungary (Kurnik and Meszaros, 1962). Some workers in the United States however, consider rust to be of minor importance (Culp and Kinman, 1965; Robinson, Johnson and Soine, 1967) while others consider it to be important on susceptible cultivars (Cobia and Zimmer, 1975; Zimmer and Hoes, 1978).

Middleton (1971) and Stovold and Moore (1972) discussed the incidence and importance of diseases of sunflower in Queensland and New South Wales respectively. They considered that rust caused by *P. helianthi* was the most important disease present in commercial sunflower crops at that time. Middleton and Obst (1972) and Brown, Kajornchaiyakul, Siddiqui and Allen (1974) showed that when sunflower rust was controlled, yield increased by over 70% in open pollinated, rust susceptible cultivars in Australia. The significance of the losses resulted in rust resistant hybrid cultivars being released and used by sunflower farmers.

During the period 1971 to 1981 there has been a marked change in the relative importance of different diseases of sunflower. During the early to mid 1970's, when open pollinated rust susceptible cultivars were grown *P. helianthi* rust was observed in all crops examined and was regarded as being the most important disease in the sunflower areas of eastern Australia. In subsequent surveys the incidence of the disease was very variable as a result of genetic differences between commercial sunflower lines. The disease occurred in all open-pollinated cultivars examined with a usual level of infection of between 19 and 20%. Rust was also common in most inbred A lines ("female parent") which were usually susceptible to the disease. Most of the hybrid cultivars observed were resistant to rust although some showed some disease. However, the rust levels in these latter cultivars were usually about three times less than that observed in open pollinated cultivars. The relative importance of other diseases of sunflower in eastern Australia has been discussed by Allen, Brown and Kochman (1980).

The objective of this paper is to review the research that has been undertaken on sunflower rust in Australia during the past 10 years. Much of this work has been done by past and present members of the Botany Department's Plant Pathology Laboratory at the University of New England. Although a considerable amount of the work referred to in this paper has been published elsewhere, it is summarised here together with previously unpublished work in order to give an overall perspective of the sunflower rust situation in Australia.

Effect of natural rust epidemics on sunflower yield during the 1972 and 1973 seasons.

Field trials were conducted in the Gwydir Valley of N.S.W. to investigate the effects of rust infection on the yield of the rust susceptible sunflower cultivar Peredovic. (Brown *et al.,* 1974).

An irrigated trial (trial 1) was hand sown on 24 February 1972 in rows 15m long and 76cm apart at the rate of 74,000 plants/ha. Commencing at 5 weeks after sowing, the fungicide mancozeb (80% a.i. at 200g/100 1) was applied to the foliage of plants to control rust. Rust was allowed to develop on untreated control plots. The trial was designed