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The effect of site preparation and fertilization on the severity of Phaeoseptoria eucalypti on Eucalyptus species

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Abstract

The effect of site preparation and fertilization on the susceptibility of *Eucalyptus* species to *Phaeoseptoria eucalypti* was examined. There was no significant difference in disease rating between plough and terrace treatments which consistently yielded trees that attained greater heights and possessed a denser foliage. These trees were also less susceptible to *P. eucalypti* than those associated with other forms of site preparation. Trace element application reduced the incidence of disease as did the application of 50 % fertilizer at planting and 50 % when trees were 6 months old as opposed to the second half being applied when trees were 3 months old.

Key words: Trace elements – Stress – Water – Light – Nutrition.

1 Introduction

Phaeoseptoria eucalypti (Hansf.) Walker is a leaf pathogen of many *Eucalyptus* species capable of causing severe defoliation of mature trees. It was first recorded in South Africa by Wingfield (1987) and is now one of the three most commonly occurring *Eucalyptus* leaf pathogens in the country. *P. eucalypti* has also been reported in Australia (Hansford 1957; Walker 1962; Heather 1967a, b), Brazil (Ferreira 1989), Hawaii (Gardner and Hodges 1988), India (Padaganur and Hiremath 1973; Sharma et al. 1985), Malawi (Chipompha 1987) and Zambia (Shakacite 1991).

Very little is known about the biology of *P. eucalypti*. Heather (1967a) found that the mature leaves on lower branches of *Eucalyptus* species were more susceptible to the pathogen than younger leaves higher up in the crown. The glaucous wax layer afforded the leaves a certain amount of protection. This was, however, not the only factor determining disease susceptibility as even in non-glaucous *Eucalyptus* species, the lower leaves were twice as susceptible as the younger leaves (Heather 1967a).

Infection of mature leaves on the lower branches of trees will cause defoliation late in the growing season (Chipomopha 1987; Crous et al. 1989). However, in certain cases *P. eucalypti* has been found to cause infection of younger leaves and of seedlings (Chipompha 1987; Gardner and Hodges 1988). This infection was originally thought to be caused by a more virulent strain of *P. eucalypti* although there is no evidence to support this hypothesis. An alternative explanation for the high degree of susceptibility was that trees severely infected by *P. eucalypti* were usually suffering from stress as a result of adverse conditions (present authors, unpublished data). This stress was often associated with the root zone, and was caused either by the effects of other pathogens and insects or physiological factors. Physiological factors usually included root deformation resulting from root strangulation. Colhoun (1979) and Yarwood (1959) noted that unsuitable soil conditions, weed competition, frost and drought could also cause stress. These observa-

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tions and the fact that *P. eucalypti* is more prevalent on mature leaves, suggest that adverse conditions increase the susceptibility of trees to *P. eucalypti*.

In the present study, various factors thought to contribute towards stressful conditions in *Eucalyptus* species were evaluated to identify those causing an increase in susceptibility to *P. eucalypti*. Trees growing under different site preparation treatments were rated for the incidence of the pathogen. The effect of fertilization on disease susceptibility as well as the relationship between the height of fertilized trees and the incidence of disease was also examined.

2 Methods

2.1 Effect of site preparation

A trial planted at Bloemendal Field Experiment Station near Pietermaritzburg, South Africa, included four methods of site preparation, namely pitting, ripping, terracing and ploughing. Pitting involved digging pits that were 50 cm in diameter and 25 cm deep and planting seedlings within the pit. Ripping was done with three tines, (the outside two to a depth of 60 cm and the centre one to a depth of 90 cm) and the trees were planted along the centre line. Bench terraces were 4 m wide on the contour, and they were then ripped as above. Ploughing was done to a depth of 15 cm followed by secondary tillage. The trial was a split plot design consisting of two main treatments, one situated on a warm slope (north facing) and the other on a cool slope (south facing). The trial was planted to *Eucalyptus grandis* Hill ex Maid. and trees were rated for disease incidence at 7, 11, 13 and 17 months of age. The ratings were made during the months May, September, November 1990 and March 1991, respectively. Disease ratings were made with the aid of a rating scale (NICHOL et al. 1992). The rating scale was used to estimate the percentage leaf area diseased. A shoot containing six leaves was randomly chosen and picked from the lowest leafbearing branch on each tree and given a rating. Fifteen trees were rated per plot and the average percentage disease for each plot was calculated by first converting the rating score to percentage infection.

Heights of trees were measured and the average height per plot was calculated. The incremental height (the increase in height from one measurement to the next) rather than the absolute height was recorded to reduce the effect that good early growth would have on subsequent height measurements.

Since the experiment was designed as an unreplicated split plot, the replications were over time as opposed to space. Thus measurements at four different ages of the trees yielded four replications. Statistical analysis of the data performed after 11, 13 and 17 months, therefore comprised two, three and four replications respectively.

Treatments were not consistent between the two slopes. The pitting treatment on the warm slope was incorrectly prepared as the pits were twice the size of those on the cool slope. The pits on the cool slope represented the size of the pits used in commercial plantings. The ripping treatment did not produce the desired soil disturbance. The depth of the soil disturbance was only 75 cm as opposed to the 90 cm desired. The top layer of soil was not disturbed at all and root growth was therefore restricted.

2.2 Effect of fertilization

A fertilization trial planted to *E. grandis* was rated for susceptibility to *P. eucalypti*. The trial was established with a 2^5 factorial design and confounded blocks of 8+2. The experiment consisted of 2 replications with treatments incorporating nitrogen, phosphorus, potassium and trace element applications. Nitrogen [LAN(28)] was applied at 250 and 500 kg/ha, phosphorus at 380 and 760 kg/ha in the form of superphosphate (10,5), and the potassium [K_2SO_4(40)] at 50 and 120 kg/ha. The trace elements were added at 60 and 120 kg/ha and consisted of boron, molybdenum, copper, manganese, iron and zinc.

Two different methods of fertilizer application were used. In the first method, half the total amount of fertilizer was applied at planting and half when the trees were 3 months old. The second method entailed applying half the fertilizer at planting and half when the trees were 6 months of age. Eight trees were rated per plot and the rating was converted to percentage disease. The total percentage disease per plot was then calculated. A two-way analysis of variance (ANOVA) was performed using the accumulated data as well as a regression analysis with average tree height per plot.

3 Results

3.1 Effect of site preparation

In the 11 and 13 month analyses (Fig. 1), pitting was found to result in trees being significantly (P = 0.05) more susceptible to *P. eucalypti*. There was, however, no significant (P = 0.05) difference between pitting and ripping at the last analysis at 17 months tree age. At each rating, trees in the ploughing and terracing treatments were least susceptible to *P. eucalypti*, and analysis at all ages showed no significant difference between the two treatments (Fig. 1). There was a substantial increase in the percentage disease of trees planted on the terraced plots from the November to the March rating (Fig. 1). Due to the increase in disease there was no longer a significant difference in disease (P = 0.05) between the terracing and ripping methods of land preparation at the last analysis.

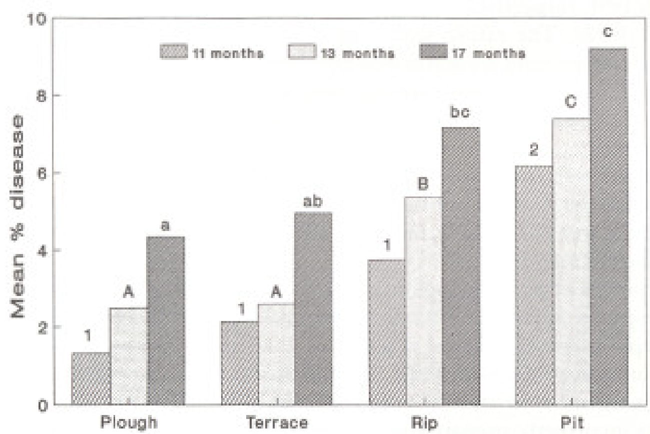

Fig. 1. Mean percentage disease for each method of site preparation after rating at 11, 13 and 17 months. Bars designated the same numbers, lower or upper case letters are not significantly (P = 0.05) different according to Student's least significant difference (LSD)

Significant differences (P = 0.05) between the mean percentage disease on the warm and the cool slope could only be detected after analysis of the data from the first three ratings, namely May, September and November. Analysis of the data from only the first two ratings showed no significant differences. Significant differences of P = 0.01 were obtained when all four ratings were analysed using analysis of variance. At each rating, however, the trees on the cool slope were more susceptible to *P. eucalypti* than those on the warm slope (Fig. 2). The percentage disease recorded on the cool slope increased uniformly during the experimental period (Fig. 2). In contrast, trees on the warm slope showed the greatest increase in percentage disease at the last rating.

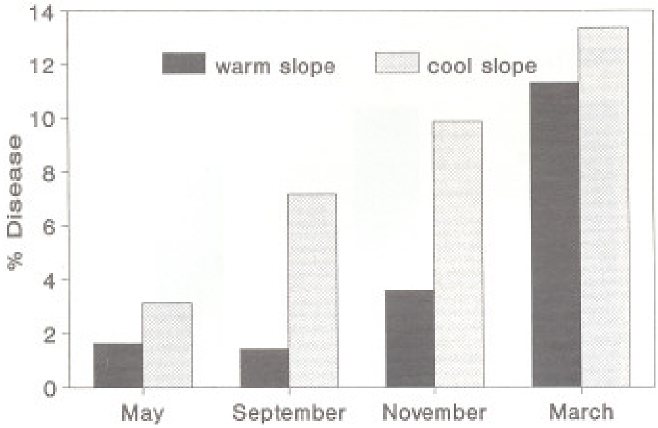

Fig. 2. Percentage disease recorded on the warm and the cool slope from May 1990 to March 1991

Height of trees was inversely proportional to the disease rating obtained for both slopes and all land preparation methods (Fig. 3). The difference in tree height on the different slopes became less evident over time. At the last analysis there was no significant (P = 0.05) difference between height of trees planted in sites prepared by the different methods.

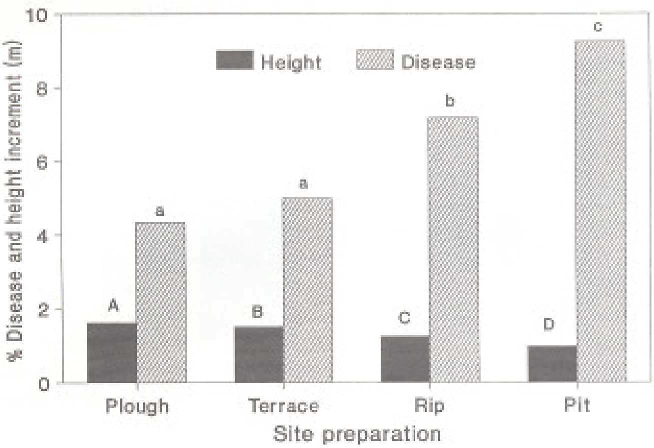

Fig. 3. Mean percentage disease recorded and the height increment for each method of site preparation for March 1991. Bars designated the same lower or upper case letters are not significantly (P = 0.05) different according to Student's least significant difference (LSD)

3.2 Effect of fertilization

Significant differences (P = 0.05) between treatments were only evident with respect to trace element application and the time at which the second application of fertilizer was applied. A higher trace element application reduced the incidence of disease significantly (P = 0.05) when interacting with a high potassium, low nitrogen and low phosphorus application (Fig. 4). Results from the other fertilizer interactions, including nitrogen, were not significantly different.

Significantly less disease occurred when 50 % of the fertilizer was applied at 6 months after planting as opposed to 3 months after planting (Fig. 5). The two consistent findings

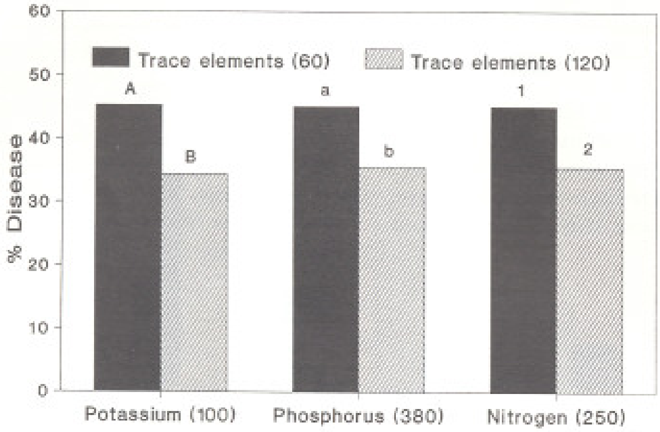

Fig. 4. Effect of the application of trace elements on the mean percentage disease recorded in conjunction with potassium, phosphorus and nitrogen (Values in brackets indicate the application rate in kg/ha). Bars designated the same numbers, lower or upper case letters are not significantly (P = 0.05) different according to Student's least significant difference (LSD)

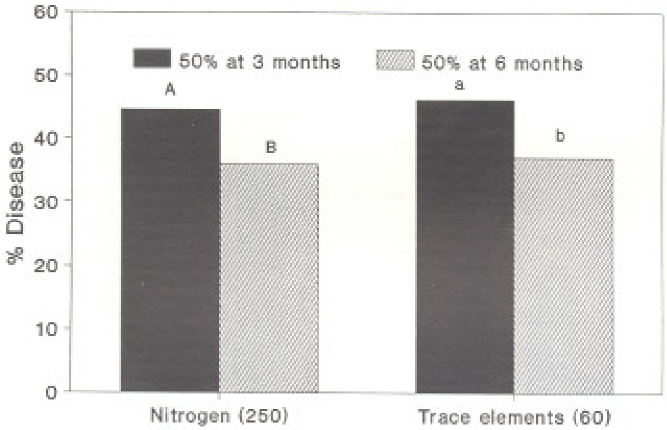

Fig. 5. Effect of the time of application of 50 % of the fertilizer on the mean percentage disease recorded in conjunction with nitrogen and trace elements (Values in brackets indicate the application rate in kg/ha). Bars designated the same lower or upper case letters are not significantly (P = 0.05) different according to Student's least significant difference (LSD)

were therefore that trace elements and the application of fertilizer at 6 months as opposed to 3 months reduced disease incidence. No significant effects were obtained for the phosphorus application.

4 Discussion

The present study has shown that site preparation and fertilization have a significant effect on the incidence of disease caused by *P. eucalypti*. Site preparation has a direct bearing on both the soil volumne available for rapid root growth and the amount of water retained by the soils (NICHOLSON 1990; SMITH 1990), which will influence the degree of stress experienced by *E. grandis*. Pitting resulted in the least amount of soil breakup and consequently the smallest area available for root penetration. Ripping provided a larger area but only in the direction of the rip-line. The terrace and plough treatments resulted in a far more comprehensive soil breakup which therefore allowed for greater root penetration. Soil breakup has a definite effect on root growth. A restriction in root growth results in fewer roots being available for water uptake and thus greater host stress.

The increased disease severity on trees planted on the terrace and plough site preparations at the last rating could be ascribed to the moist conditions experienced between the last two ratings, namely November and March. The greatest increase in the incidence of disease should occur during this period because increased temperature and rainfall provide optimal conditions for disease development. An additional reason for the increase in susceptibility of the trees planted on terraced land could relate to canopy formation. When the final rating was made at 17 months, the trees growing on the plough and terrace site preparations had begun to form a canopy, whereas trees on the pit and rip site preparations were still small and showed no sign of canopy formation. Canopy formation provides shading of the lower leaves and also serves to increase the humidity by reducing air movement. Both these conditions would enhance disease development (READ 1968).

Trees growing on the cooler slope were consistently more susceptible to *P. eucalypti* than those on the warm north facing slope. These results are consistent with the observations of READ (1968) who, in studying the effect of shade on the susceptibility of Corsican pine to *Brunchorstia pinea* (Karst.) v. Höhn., found that more disease occurred on cool north facing slopes (northern hemisphere). These slopes only received diffuse light as opposed to the direct light experienced on the south facing slopes. The reduction in light was found to cause a reduction in soluble carbohydrate concentration which correlated with increased susceptibility (READ 1968). Similarly, BENEDICT (1971) also found that light intensity was an important factor in the determination of symptom expression of *Septoria tritici* Desm. on various wheat cultivars. Apart from the effect of light, warm dry slopes result in reduced turgor pressure of leaves and therefore increased respiration which can lead to the closure of stomata (RAVEN et al. 1981). *P. eucalypti* penetrates the leaves via stomata (HEATHER 1967b) and the closure of stomata could result in increased resistance. Both light intensity and stomatal closure could therefore explain the increase in susceptibility of trees growing on the cooler south facing slope.

Trace elements reduced susceptibility of *Eucalyptus*species to *P. eucalypti* whereas the application of nitrogen gave variable results. Nitrogen has frequently been found to increase susceptibility of plants to various pathogens (YARWOOD 1959; HUBER and WATSON 1974). HUBER (1980) found that the form rather than the amount of available nitrogen was important. One form of nitrogen might increase the incidence of a particular disease while reduce the incidence of another (HUBER and WATSON 1974). In general, a disease that is increased due to nitrate is decreased due to ammonium (HUBER and WATSON 1974). LAN(28), however, provides nitrogen in the form of both nitrate and ammonia which could explain the variable results obtained here. Nitrogen has been found to reduce the osmotic water potential of leaves and this, therefore, increases the susceptibility of the plants that favour low osmotic potentials (COOK and PAPENDICK 1972). In most cases, it appears that trace elements reduce the incidence of disease (ISMAILOV 1954; YARWOOD 1959; HUBER 1980).

This study has shown that the susceptibility of *Eucalyptus* species to *P. eucalypti* is affected by conditions of plantation establishment. Factors found to affect susceptibility, include the method of site preparation and fertilization of the host.

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Summary

The effect of physiological stress, induced by site preparation and fertilization on the susceptibility of *Eucalyptus* species to *Phaeoseptoria eucalypti* was examined. Site preparation by means of pitting was more conducive to infection by *P. eucalypti* than ripping, terracing or ploughing. Trees that were least susceptible to *P. eucalypti* consistently attained greater heights and possessed denser foliage. Fertilization trials entailing trace element application at 120 kg/ha interacting individually with potassium (100 kg/ha), phosphorus (380 kg/ha) and nitrogen (250 kg/ha) significantly reduced the incidence of disease. Significantly less disease also occurred when 50 % of the fertilizer was applied at 6 months after planting as opposed to 3 months after planting.

Résumé

Effet de la préparation du site et de la fertilisation sur la gravité d'infection des Eucalyptus par Phaeoseptoria eucalypti

L'effet du stress physiologique induit par la préparation du site et par la fertilisation sur la sensibilité de *Eucalyptus* spp. à *P. eucalypti* a été étudié. La préparation par trous de plantation était plus favorable à l'infection que par scarification, terrassement ou labour. Les arbres les moins sensibles atteignaient des hauteurs nettement plus grandes et possédaient un feuillage plus dense. Des essais de fertilisation comprenant des oligoéléments à raison de 120 kg/ha en combinaison avec le Potassium (100 kg/ha), le Phosphore (380 kg/ha) et l'Azote (250 kg/ha), réduisaient significativement l'incidence de la maladie. Une réduction également significative de la maladie avait lieu quand 50 % de la fertilisation était appliquée 6 mois après la plantation au lieu de 3 mois.

Zusammenfassung

Auswirkung von Bodenbearbeitung und Düngung auf die Intensität des Phaeoseptoria eucalypti-Befalles bei Eucalyptus-Arten

Die Auswirkungen von physiologischem Stress durch Bodenbearbeitung und Düngung auf die Anfälligkeit von *Eucalyptus*-Arten gegen *Phaeoseptoria* wurden untersucht. Eine Pflanzung in Gruben führte zu höherer Infektionsanfälligkeit als Bodenlockerung, Terrassierung oder Pflügen. Die am wenigsten gegen *P. eucalypti* anfälligen Bäume waren wüchsiger und hatten eine dichtere Belaubung. Eine Düngung (120 kg/ha Spurenelemente, individuell kombiniert mit 100 kg/ha Kalium, 380 kg/ha Phoshor und 250 kg/ha Stickstoff) reduzierte die Krankheitsintensität signifikant. Die Pflanzen waren auch deutlich weniger anfällig, wenn 50 % des Düngers 6 Monate nach der Pflanzung appliziert wurden, als wenn bereits nach 3 Monaten gedüngt wurde.

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