The relationship between the white powdery scale, *Cribrolecanium andersoni* (Hemiptera : Coccidae) and sooty mould and the effect on photosynthetic rates of citrus.[1]

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THE RELATIONSHIP BETWEEN THE WHITE POWDERY SCALE, *CRIBROLECANIUM ANDERSONI* (HEMIPTERA : COCCIDAE) AND SOOTY MOULD AND THE EFFECT ON PHOTOSYNTHETIC RATES OF CITRUS.

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ABSTRACT - The white powdery scale, *Cribrolecanium andersoni* (Newstead) (Hemiptera : Coccidae) is a pest of citrus in South Africa and Swaziland. *C. andersoni* feeds on the leaves and secretes honeydew which serves as a substrate for sooty mould fungi. The impact of sooty mould on net photosynthesis was determined on *Citrus paradisi* leaves by using a LI-COR LI-6200 photosynthetic system. The degree of blockage of photosynthetically active radiation was evaluated by placing a portion of mould over the quantum sensor of the LI-COR LI-6200 photosynthesis system. Infested leaves and *C. andersoni* adults were monitored for a period of one year in a *Citrus reticulata* orchard. Photosynthetic activity recovered after removal of mould indicating that it screened out sunlight and did not cause permanent damage to the leaves. This was supported by the observation that the mean photosynthetically active radiation as measured through the mould was significantly less compared to the full sky reading. The sooty mould infestation was highest during April to September. During October 1988 to April 1989 there was a linear relationship between the number of adult scales present in a tree and the percentage of sooty mould infested leaves.

EFFET DEPRESSIF OCCASIONNE PAR LE DEVELOPPEMENT DE FUMAGINE LIE A LA PRESENCE DE LA COCHENILLE FARINEUSE *CRIBROLECANIUM ANDERSONI* (HEMIPTERA : COCCIDAE), SUR L'ACTIVITE PHOTOSYNTHETIQUE DES AGRUMES.

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RESUME - La cochenille farineuse *Cribrolecanium andersoni* Newstead) (Hemiptera : Coccidae) est un ravageur des agrumes rencontré en Afrique du Sud et au Swaziland. *C. andersoni* s'alimente sur les feuilles et excrète du miellat sur lequel se développe la fumagine. L'effet dépressif de la fumagine sur l'assimilation photosynthétique a fait l'objet d'une évaluation sur *Citrus paradisi* à l'aide d'un appareil de mesure LI-COR LI-6200. Les perturbations entraînées sur la radiation photosynthétiquement active ont été mesurées en plaçant un écran de fumagine sur le lecteur optique LI-COR LI-6200. Par ailleurs, les feuilles présentant des encroûtements de *C. andersoni* ont été contrôlées pendant une période d'un an dans un verger de mandariniers.

L'activité photosynthétique a repris un niveau normal après élimination de la couche de fumagine, indiquant que celle-ci constitue un écran à la lumière sans causer de dommage durable pour la feuille. La quantité de radiation active qui filtre au travers d'une couche de fumagine est sensiblement plus faible que la normale.

C'est entre avril et septembre que sont enregistrés les encroûtements les plus conséquents. D,octobre 1988 à avril 1989 nous avons observé une relation linéaire entre le nombre de cochenilles adultes attaquant le feuillage et le pourcentage de surface foliaire recouverte par la fumagine.

MOTS CLEFS : *Cribrolecanium andersoni*, cochenille farineuse, Citrus, fumagine, activité photosynthétique.

KEYWORDS : *Cribrolecanium andersoni*, white powdery scale, Citrus, sooty mould fungi, photosynthetic rates.

INTRODUCTION

The white powdery scale, *Cribrolecanium andersoni* (Newstead) (Hemiptera : Coccidae), is a soft scale which has acquired pest status in some citrus producing areas of South Africa and Swaziland (Brink and Bruwer, 1989). The adult *C. andersoni* is completely covered with a dense white

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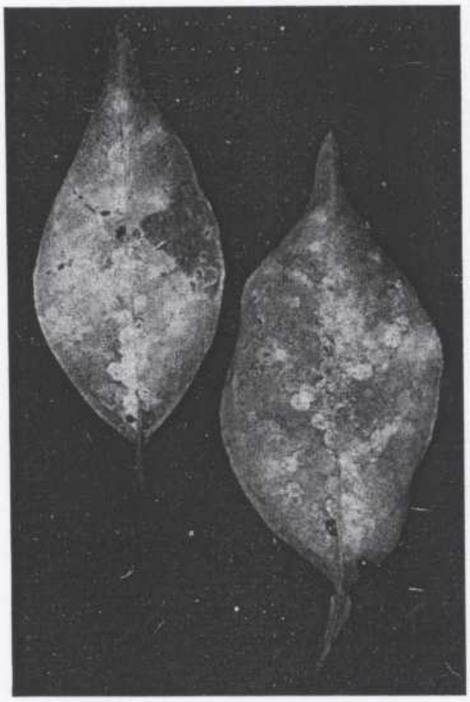

Photo 1 - *C. andersoni* infested citrus leaves.

powdery secretion which also spreads over the surrounding parts of the host plant giving infested leaves an almost uniform powdery appearance (Photo 1). *C. andersoni* feeds on the leaves while fruit and branches are not colonized. *C. andersoni* secretes honeydew which serves as a substrate for sooty mould fungi of the genus *Capnodium*. Leaves and fruit become infested with sooty mould. Honeydew attracts ants which result in coincidental infestation by other scale pests due to reduced pressure by natural enemies (Buitendag, 1987). Although natural enemies are present and biological control is in some cases satisfactory, producers are often forced to control the pest chemically.

C. andersoni was originally described from Kenya (Newstead, 1917) and has since been recorded in Zimbabwe, Uganda (Hall, 1937) and Angola (De Lotto, 1968). *C. andersoni* was first encountered on citrus in South Africa during 1944. The transition from chemical towards biological control for red scale, *Aonidiella aurantii* (Maskell) has resulted in increased population levels of *C. andersoni* in citrus orchards (Kamburov, 1986 ; Buitendag, 1987).

This study reports on the effect of sooty mould fungi (due to the presence of *C. andersoni*) on net photosynthesis and photosynthetically active radiation.

MATERIALS AND METHODS

Effect of sooty mould on net photosynthesis and photosynthetically active radiation.

The impact that sooty mould has on net photosynthesis was studies on *Citrus paradisi* Macf. trees that had been planted in 1979 and cultivated under micro-irrigation on the Institute for Tropical and Subtropical Crops experimental farm situated at Nelspruit (25°27'S, 30°58'E). One heavily *C. andersoni* infested tree was selected. There was great variation in the levels of sooty mould infestation and leaves were therefore divided into the following classes : 1) leaves with heavy mould, 2) leaves with light mould and 3) leaves without mould. The light mould class consisted of a discontinuous layer of mould and in the heavy mould class the mould covered the entire surface of the leaf.

Net photosynthesis measurements were made on five leaves for each of the various mould classes. The net photosynthetic rate was determined using a LI-COR LI-6200 portable photosynthetic system with a 1 litre leaf chamber. The net photosynthetic rate was determined between 10h30 and 11h30 on 19 June 1990 under conditions of saturated light and atmospheric CO_2 levels of 340 to 370 ppm. Measurements were at relative humidities of 30 to 42% and leaf temperatures were between 23 and 27°C. Although there are many factors, such as age and sink status which influence photosynthesis of a leaf (Salisbury and Ross, 1978), this was only a relative study and the same leaves were used to determine the ability of leaves to recover photosynthetic activity after the removal of sooty mould. The dorsal surfaces of mould-infested leaves were wetted with water and the mould gently rubbed off. Leaves were allowed to acclimatise for three days and the net photosynthetic rates re-measured on 22 June 1990 between 11h00 and 12h00. The CO_2 levels were between 340 and 370 ppm and the leaf temperature between 24 and 29°C. Measurements were at relative humidities of 27 to 32%.

The degree of blockage of photosynthetically active radiation by sooty mould was evaluated as follows : leaves which were heavily infested were used and a portion of approximately 100 mm² of the mould layer was gently lifted from the leaf surface with a pincette and placed exactly over the quantum sensor of the LI-COR LI-6200 portable photosynthesis system. The photosynthetically active reading obtained through the mould disc was then compared against the full sky reading. Measurements were made through mould collected from ten leaves between 11h00 and 12h00 on 23 July 1990. These methods were used by Wood *et al.* (1988) in determining the effect of pecan aphids on tree productivity.

Mould infestation.

Leaf samples were collected monthly on the Cairn Trust Estate near Nelspruit (25°27'S, 30°58'E). The orchard on the Cairn Trust Estate consisted of 160 *Citrus reticulata* Osbeck trees that had been planted in 1981, grown under flood irrigation and was heavily infested with *C. andersoni*. Ten trees were selected randomly and served as sampling trees. Twenty leaves were sampled monthly per tree. Five leaves were picked randomly from each aspect (north, south, east and west) of the tree and only adult scales counted with a stereo microscope. Live, dead and parasitised scales were included. The number of sooty mould infested leaves was also recorded. The experimental period extended from August 1988, when the first sampling commenced, until July 1989.

TABLE 1 - The effect of sooty mould on the net rate of photosynthesis.

Sooty mould level	Net photosynthesis (μmol $m^{-2} s^{-1}$) 19 June 1990 Before removal	22 June 1990 After removal	Percentage of pre-removal level
Heavy mould	0.256 a	2.083 d	813
Light mould	2.732 b	3.374 de	123
No mould	5.045 c	4.419 e	88
	CV = 52%	CV = 28%	

Means followed by the same letter do not differ significantly from one another (p = 0.05)

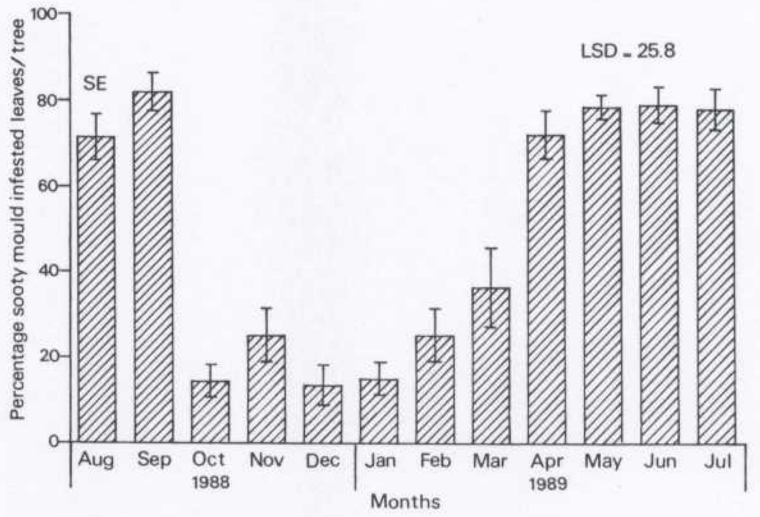

FIGURE 1 - The percentage of sooty mould infested leaves per tree in a *C. reticulata* orchard near Nelspruit ; 10 trees and 20 leaves per tree were sampled

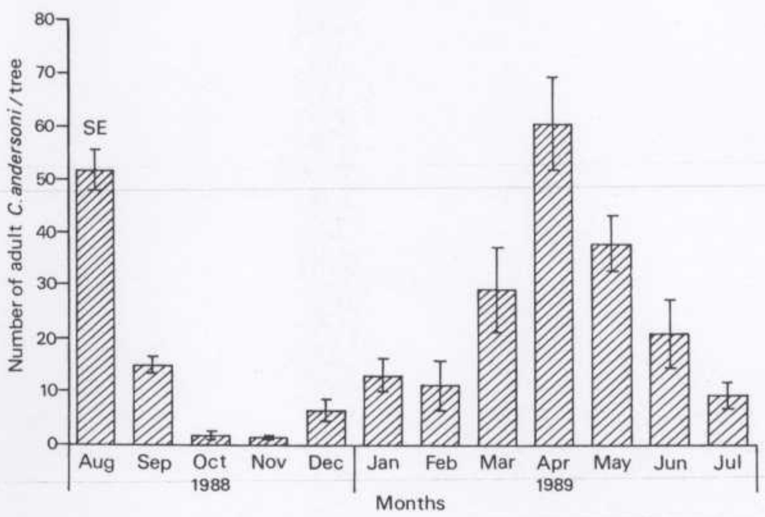

FIGURE 2 - The number of adult *C. andersoni* per tree in a *C. reticulata* orchard near Nelspruit ; 10 trees and 20 leaves per tree were sampled

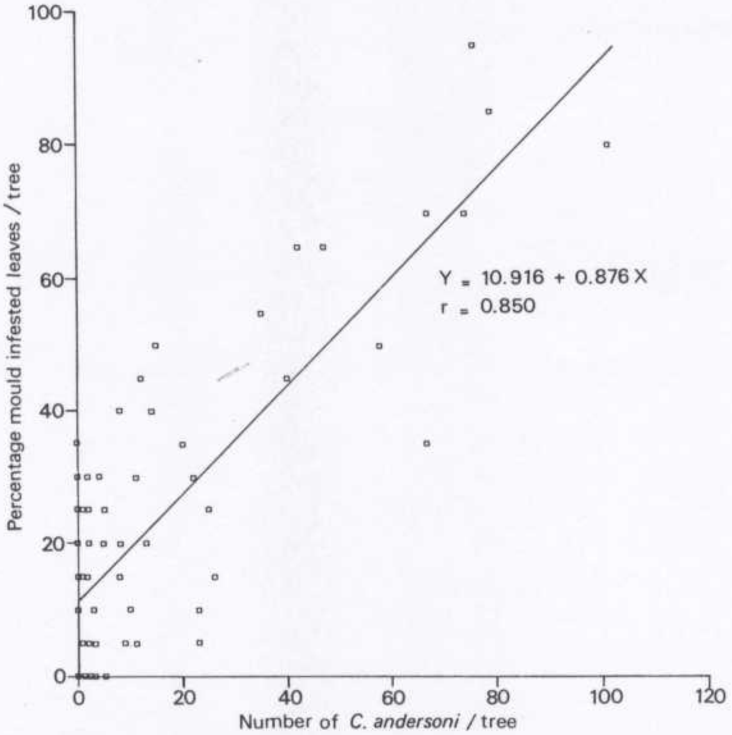

FIGURE 3 - The relationship between the occurrence of sooty mould and *C. andersoni* between October 1988 and April 1989.

Analysis of results.

Unless otherwise stated a completely randomised experimental design was used and data were subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

On 19 June 1990 there were significant differences in the net rate of photosynthesis between heavily infested leaves, leaves which were not infested and lightly infested leaves (Table 1). Some of the heavily infested leaves had no measurable photosynthetic activity. After the removal of the fungal layer the photosynthetic activity of the heavily infested leaves recovered to the level of the lightly infested leaves and there was no significant difference (Table 1). The lightly infested leaves recovered to the same level as the leaves with no mould and there was no significant difference in photosynthetic activity (Table 1). Recovery of photosynthetic activity after removal of the mould indicated that it merely screened out sunlight and did not cause permanent damage to the leaves. This was supported by the observation that the mean photosynthetically active radiation as measured through the mould was 129,5 μmol $m^{-2}s^{-1}$ as against the full sky reading of 1395,0 μmol $m^{-2}s^{-1}$.

The sooty mould infestation in a *C. reticulata* orchard was highest during April, May, June, July, August and September with no significant differences in infestation levels between these months (Fig. 1). After September the infestation declined and remained low until March. In October the level of sooty mould infection dropped because more old leaves were shed during the flowering period. During October and November the adult scale population (live, dead and parasitised) was low in the orchard (Fig. 2). During this period the *C. andersoni* population consist mainly out of the nymphal instars. Thereafter it increased to its maximum in April, declined once again and then increased to a second peak in August (Fig. 2).

Low *C. andersoni* numbers during in Spring (September to October) can rich high infestation levels later in the season causing considerable amount of sooty mould infested leaves. Sooty mould also infested the fruit and despite washing and brushing, infested fruit can often not be satisfactory cleaned and therefore were culled or downgraded in the packhouse. During the period October 1988 to April 1989 there was a linear relationship between the number of adult scales present in a tree and the percentage of sooty mould infested leaves (Fig. 3).

It is known that *C. andersoni* can cause considerable crop reduction in the season following its initial appearance (Kamburov, 1986). Factors that decrease carbohydrate reserves decrease yield. Carbohydrate reserves are primarily influenced by the plant's ability to produce them photosynthetically. Factors affecting photosynthesis are therefore of major importance to production (Wood *et al.*, 1983, 1988). A reduction in net photosynthesis provides evidence for subsequent decline in tree productivity.

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EFECTO DEPRESIVO OCASIONADO POR EL DESARROLLO DE LA FUMAGINA ASOCIADA CON LA PRESENCIA DE LA COCHINILLA HARINOSA *CRIBROLECANIUM ANDERSONI* (HEMIPTERA : COCCIDAE), SOBRE LA ACTIVIDAD FOTOSINTETICA DE LOS CITRICOS.

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RESUMEN - La cochinilla harinosa *Cribrolecanium andersoni* Newstead (Hemiptera : Coccidae) es una plaga de los cítricos que encuentra en Africa del Sur y en Swaziland. *C. andersoni* se alimenta sobre las hojas y excreta miel sobre la cual se desarrolla la fumagina. El efecto depresivo de la fumagina sobre la asimilación fotosintética a propiciado una evaluación en *Citrus paradisi* con el auxilio de un aparato de medición LI-COR LI-6200. Los disturbios provocados sobre la radiación fotosinteticamente activa fueron medidos colocando una capa de fumagina sobre el lector óptico LI-COR LI-6200. Por otra parte, las hojas que presentan encostramientos de *C. andersoni* fueron controladas durante un período de un año en un huerto de mandarinas.

La actividad fotosintética recupera un nivel normal después de eliminar la capa de fumagina, indicando que la misma constituye una barrera para la luz, sin provocar daños durables para la hoja.

La cantidad de radiación activa que filtra a través de una capa de fumagina es sensiblemente más baja que la normal.

Es entre abril y septiembre que se registran los encostramientos más consecuentes. De octubre 1988 a abril 1989 observamos una relación linear entre el número de cochinillas adultas atacando el follaje y el porcentaje de superficie foliar cubierta por la fumagina.