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VINGNANAM
Journal of Science

Publication of Volume 3 is delayed due to circumstances beyond our control and, once again, two numbers had to be combined.

As in previous volumes, in this volume too the papers published deal mostly with regional problems.

Control of pests and diseases constitute a substantial component of the cost of production of our agricultural products. Six out of the seven papers published in this volume are related to research in this field.

The papers by Niranjani Ramanathan and Sivapalan deal with appropriate use of fungicides for the control of a common leaf disease of onion in Jaffna. In a second paper she has published her findings on the effect of environmental factors on the development of the downy mildew disease of grape vine, which poses a serious problem to the grape cultivators in Jaffna.

Padmini Maheswaran and Ganesalingam have provided interesting information on the insecticidal properties of seeds of neem (margosa) which should provide interesting reading to people inclined to organic farming.

Egg development in pests form the subject of two papers. Rajendram and Rajani Rajeswaran describe egg development in a local rice pest. In another paper Sagunthaladevei Ambikaipakan and Ganesalingam report the effect of centrifugation on egg development in an insect pest.

Rajendram with Annette Gunasingam has a second paper on symbiotes in a Sri Lankan rice pest.

Climatology nowadays is a subject of interest to many scientists from diverse disciplines. Puvaneswaran's paper deals with this subject. Many years of meteorological records had been scanned to provide a picture of heat stress over Sri Lanka, which should be helpful for a rational characterisation of seasons in our country.

May 1990

Prof. S. Kandiah,
Chief Editor

VINGNANAM

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CONTENTS

LABORATORY STUDIES ON THE EFFECTS OF ENVIRONMENTAL CONDITIONS AND FUNGICIDES ON THE DEVELOPMENT OF *ALTERNARIA ALTERNATA* (FR.) KEISSLER

NIRANJANI RAMANATHAN & A. SIVAPALAN[1]

(Department of Botany, University of Jaffna, Jaffna.)

Vingnanam — Journal of Science 3 : 1—9 (1988)

ABSTRACT : Field observations indicated that *Alternaria alternata* was constantly associated with senesced leaves of onion with a possible role of causing enhanced leaf senescence. This fungus was isolated and found to have a temperature optimum of 25°C for germination of conidia at 100% relative humidity. However, the growth of mycelium was better at 30°C than at 25°C.

The effects of 2 systemic fungicides (benomyl and baycor) and 9 non-systemic fungicides (cupravit, morestan, pomarsol, sulphur, brassicol, morut, antracol, difolatan and daconil) at concentrations ranging from 0—1000 ppm on the germination of conidia and mycelial growth rate of the fungus, under laboratory conditions, were investigated. All fungicides except cupravit inhibited germination at 10 ppm.

The fungus responded differently to the various fungicides in its mycelial growth rate. Difolatan, daconil, benomyl and pomarsol retarded mycelial growth at concentrations between 10 and 500 ppm and prevented growth completely at 1000 ppm. Morestan, brassicol, morut, baycor and antracol inhibited growth remarkably at concentrations between 10 and 1000 ppm. Cupravit and sulphur permitted a certain amount of growth throughout the experiment.

The fungus was usually killed on media containing daconil, benomyl or pomarsol after 3 days.

This investigation provides evidence that benomyl, daconil and pomarsol could be used to control *Alternaria alternata.*

Introduction

Alternaria alternata (Fr.) Keissler, predominates the pathogens which infect onion scale leaves and cause early leaf senescence. Observation of onion (*Allium cepa* L.) cultivated in Jaffna suggested that the disease caused by this particular fungus was severe after periods of rain.

Disease symptoms appear as blackish brown patches of sporulating structures at the tips of mature scale leaves of onion. Soon they spread down the leaves and cause premature leaf senescence. The photosynthetic area of the onion plants appears to be reduced.

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This pathogenic fungus is a parasite belonging to the group Fungi Imperfecti. The hypha of the fungus, which is dark and pigmented, produces dark conidiophores; these bear chains of conidia in an acropetal manner. Conidia are dark, obclavate to elliptical and muriformed.

Field observations on the severity of the disease under conditions of low temperature and high relative humidity indicated the need for the study of the effects of environmental conditions and fungicides on the development of *Alternaria alternata*.

Materials and Methods

Source of inoculum

Infected onion scale leaves were collected from the field, surface sterilized and then cut into pieces 3 cm in length. A thick conidial suspension was prepared by shaking the infected pieces with sterile distilled water in a McCartney bottle, under aseptic conditions. The source of inoculum thus prepared was diluted to give a concentration of 4.8×10^5 conidia per ml and was used throughout the experiment.

Method of inoculation

To study the germination of conidia under varying temperature and humidity conditions and to evaluate the effects of different fungicides on that, clean sterile cavity slides were used as the substrata. The cavity slides were inoculated with 0.2 ml conidial suspension with the help of a micropipette and were kept over triangular plates in petri dishes containing sterile water. The plates were incubated for 24 h at 25° C and at 100% relative humidity, unless otherwise stated. At the end of the incubation period, the cavity slides were taken out, stained with cotton blue in lactophenol and examined under the microscope. The percentage germination of conidia was determined from counts of germinated and ungerminated conidia while the length of the germ tube of germinated conidia was measured with the help of an eyepiece graticule. These observations were made from counts of about 2000 conidia per treatment. A conidium was considered germinated when the length of any one of the germ tubes exceeded its breath (Manners, 1966).

The effect of temperature on conidial germination and initial growth of germ tube was studied at 10°, 15°, 20°, 25° and 30°C and the mean percentage germination of conidia and mean length of germ tube were measured after 24 h and 48 h of incubation.

For the experiment on the effect of relative humidity on the germination and initial growth of germ tube, humidity maintaining solutions were prepared by diluting conc. H_2SO_4 as given by Solomon (1969). Inoculated sets of cavity slides were allowed to air dry and then kept over triangular plates in petri dishes containing different humidity – maintaining solutions. For 0% and 100% relative humidity, dry $CaCl_2$ and sterile water replaced sulphuric acid solutions respectively. The mean percentage germination and initial growth of germ tube were measured at 0%, 3.2%, 37.4%, 70.4%, 93.9% and 100% relative humidity. A control was set up by keeping one set of inoculated cavity slides wet throughout the experiment.

The effects of two systemic fungicides (benomyl and baycor) and nine non-systemic fungicides (cupravit, morestan, pomarsol, sulphur, brassicol, morut, antracol, difolatan and daconil), which are commonly used by Jaffna farmers, on the germination of conidia at concentrations 0, 10, 100, 500 and 1000 ppm were studied. Sterile cavity slides were inoculated with conidial suspension of the concentration 4.8×10^5 conidia per ml prepared in fungicide solutions of different concentrations. Mean percentage germination was determined after 24 h of incubation at 25° C and at 100% relative humidity.

The rate of growth of mycelia of *Alternaria alternata* was studied on Potato Dextrose Agar (PDA). Mycelial discs of about 0.8 cm diameter were cut from pure 6 day old cultures of the fungus, isolated from infected onion plants, with the help of a sterile cork borer and were used to inoculate fresh sterile PDA plates at the centre. Assessment of the rate of growth of mycelia was made by measuring the increase in diameter of the colony after 3, 6 and 9 days of incubation at 25°C. Each treatment was replicated ten times. For experiment on the effect of temperature, the growth rate of the mycelium was measured after incubation at 10°, 15°, 20°, 25° and 30°C.

The effect of fungicides on mycelial growth was studied on PDA plate already incorporated with different fungicides at the concentrations 0, 10, 100, 500 and 1000 ppm. The increase in diameter of the colony on the above plates was measured after 3, 6 and 9 days of incubation at 25°C.

Results

Effect of temperature on conidial germination and initial growth of germ tube

The mean percentage germination of conidia increased initially with increase in temperature (Fig. 1). Maximum germination occurred between temperatures 20° and 25°C. The value for germination decreased with further increase in temperature above 25°C.

The initial growth of germ tube of germinated conidia varied with temperature in the same manner as in the germination. Optimum growth of germ tube was obtained between 20° and 25°C (Fig. 1). Incubation for 48 h did not have any significant effect on the improvement of germination while it significantly increased the mean length of germ tube.

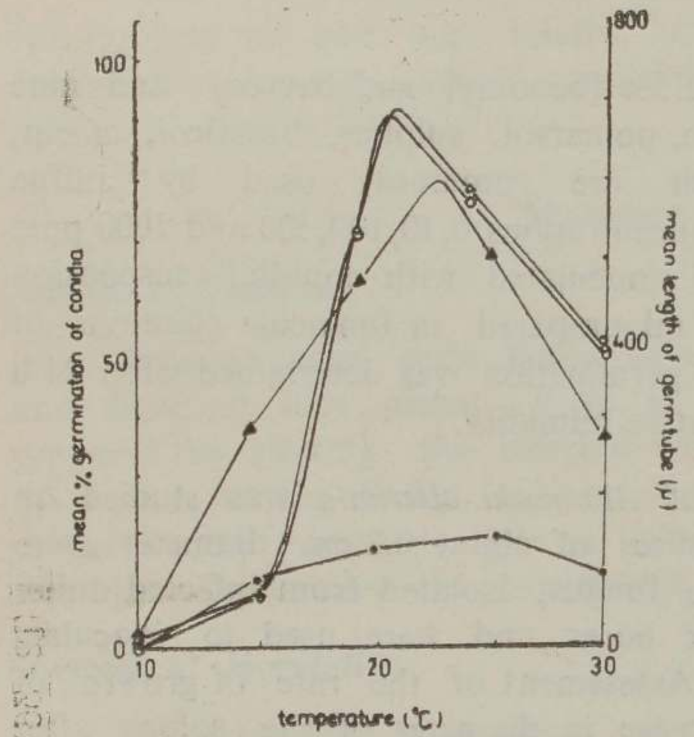

Fig. 1 Effect of temperature on conidial germination and initial growth of germtube of *Alternaria alternata*, at 100% r. h. after 24 h of incubation

- O Mean % germination after 24 h.
- ● Mean length of germtube after 24 h.
- △ Mean % germination after 48 h.
- ▲ Mean length of germtube after 48 h.

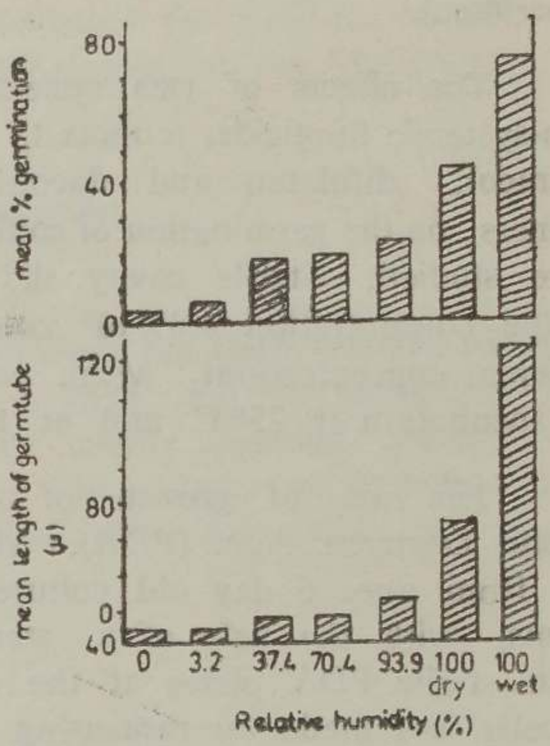

Fig 2 Effect of relative humidity on conidial germination and initial growth of germtube of *Alternaria alternata*, at 25°C after 24 h of incubation.

Effect of relative humidity on conidial germination and initial growth of germ tube

Inoculated sets of cavity slides incubated at different relative humidities at 25°C were examined for germination of conidia and growth of germ tube. It was apparent from the results (Fig. 2) that 100% relative humidity was required for successful germination and luxurious growth of germ tube. Presence of free moisture enhanced germination of conidia as well as the growth of germ tube.

Effect of temperature on mycelial growth

The colony diameter formed on PDA plates increased with increase in temperature (Fig. 3). The growth of the fungus was found to be better at 30°C than at any other temperature used in this experiment.

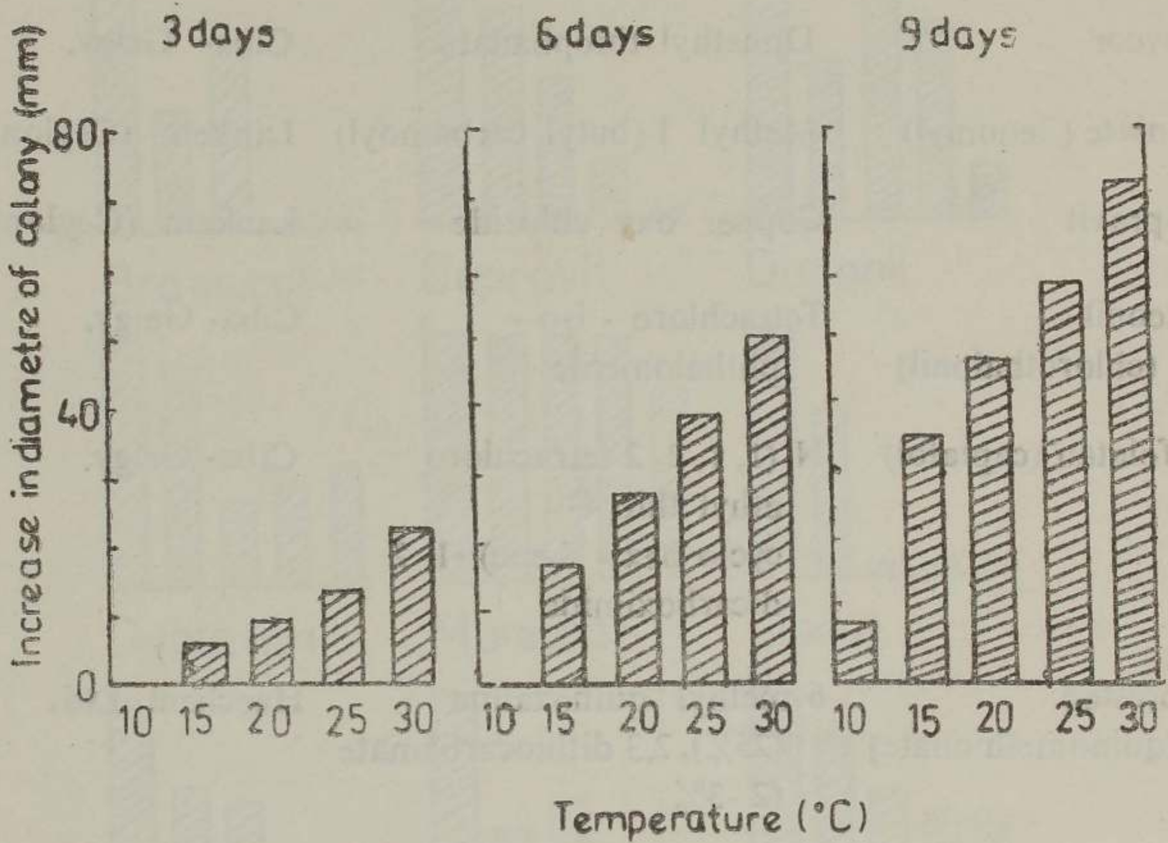

Fig. 3 Effect of temperature on mycelial growth of *Alternaria alternata* at 25°C & 100% r. h. after 3, 6 and 9 days of incubation.

Effects of fungicides on conidial germination

Two systemic fungicides and 9 non-systemic fungicides (Table 1) which are commonly used by Jaffna farmers were used at the concentrations 10, 100, 500 and 1000 ppm.

Table 1 : List of fungicides.

	Product name	Active ingredient	Manufacturer or distributor
1.	Antracol (Propineb)	Zinc propylene–bis–dithiocarbomate	Haechem Ltd.
2.	Baycor	Dimethyl thiophanate	Ciba- Geigy.
3.	Benlate (Benomyl)	Methyl 1-(butyl carbamoyl)	Lankem (Ceylon) Ltd.
4.	Cupravit	Copper oxy chloride	Lankem (Ceylon) Ltd.
5.	Daconil (chlorothalonil)	Tetrachloro - iso - phthalonitrile	Ciba- Geigy.
6.	Difolatan (captafol)	N (1, 1, 2, 2 tetrachloro ethyl thio 4- cyclo hex - 4-ene) -1, 2 dicarboximide	Ciba- Geigy.
7.	Morestan (quinomethionate)	6 methyl quinoxaline (25%), 2,3 dithiocarbamate (2 -3%)	Haechem Ltd.
8.	forut	Feraminosulf +penta-chloronitro benzene	Ciba- Geigy.
9.	Brassicol (quintozene)	Pentachloro nitro benzene	Ciba- Geigy.
10.	Pomarsol (Thiophanate)	1, 2 di (3 –methoxy carbonyl-2 thiordio) benzene	Haechem Ltd.
11.	Sulphur	Inorganic sulphur	Haechem Ltd.

Generally all fungicides except cupravit inhibited germination at very low concentrations like 10 ppm. Benlate and baycor decreased germination (Fig. 4). These two fungicides, however, allowed a certain number of conidia to germinate. Morut, brassicol and sulphur were ineffective against checking germination even at 1000 ppm. Daconil, difolatan, antracol, morestan and pomarsol almost completely retarded germination at and above the concentrations 100 ppm, 500 ppm, 500 ppm, 500 ppm, and 1000 ppm, respectively. Among the tested fungicides daconil could be considered to be very effective in preventing germination of conidia of *Alternaria alternata*.

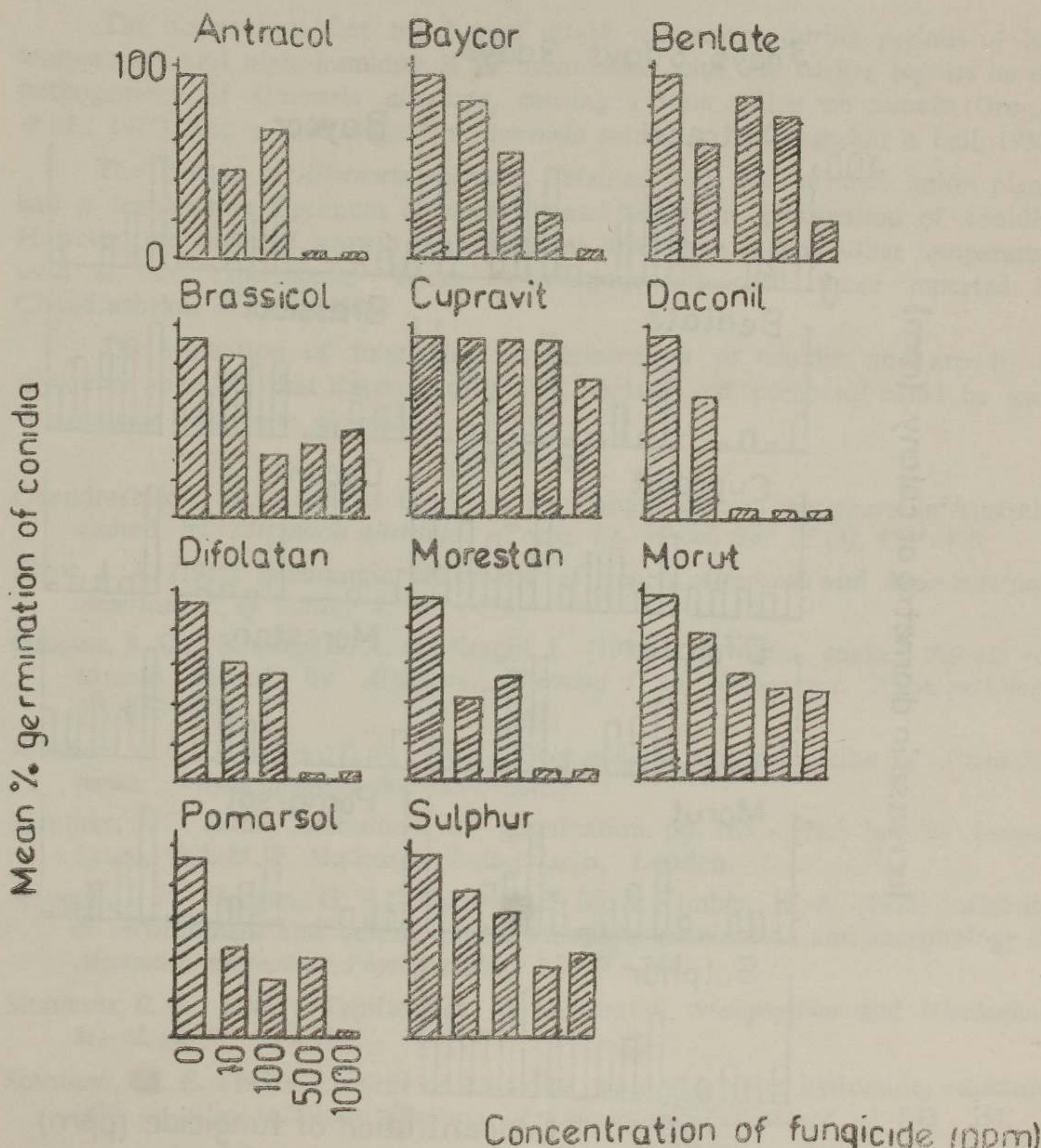

Fig. 4 Effects of fungicides on the germination of *Alternaria alternata* at 25°C & 100% r. h. after 24 h of incubation

Effects of fungicides on mycelial growth

Difolatan, daconil, benlate and pomarsol retarded mycelial growth at concentrations between 10 ppm and 500 ppm. Morestan, brassicol, morut, baycor and antracol retarded growth remarkably at concentrations between 10 ppm and 1000 ppm. Cupravit and sulphur permitted a certain amount of growth throughout the experiment while some fungicides showed stimulatory effects on the radial growth of the fungus at certain low concentrations. The fungus was unusually killed after three days on media containing daconil, benlate or pomarsol (Fig. 5).

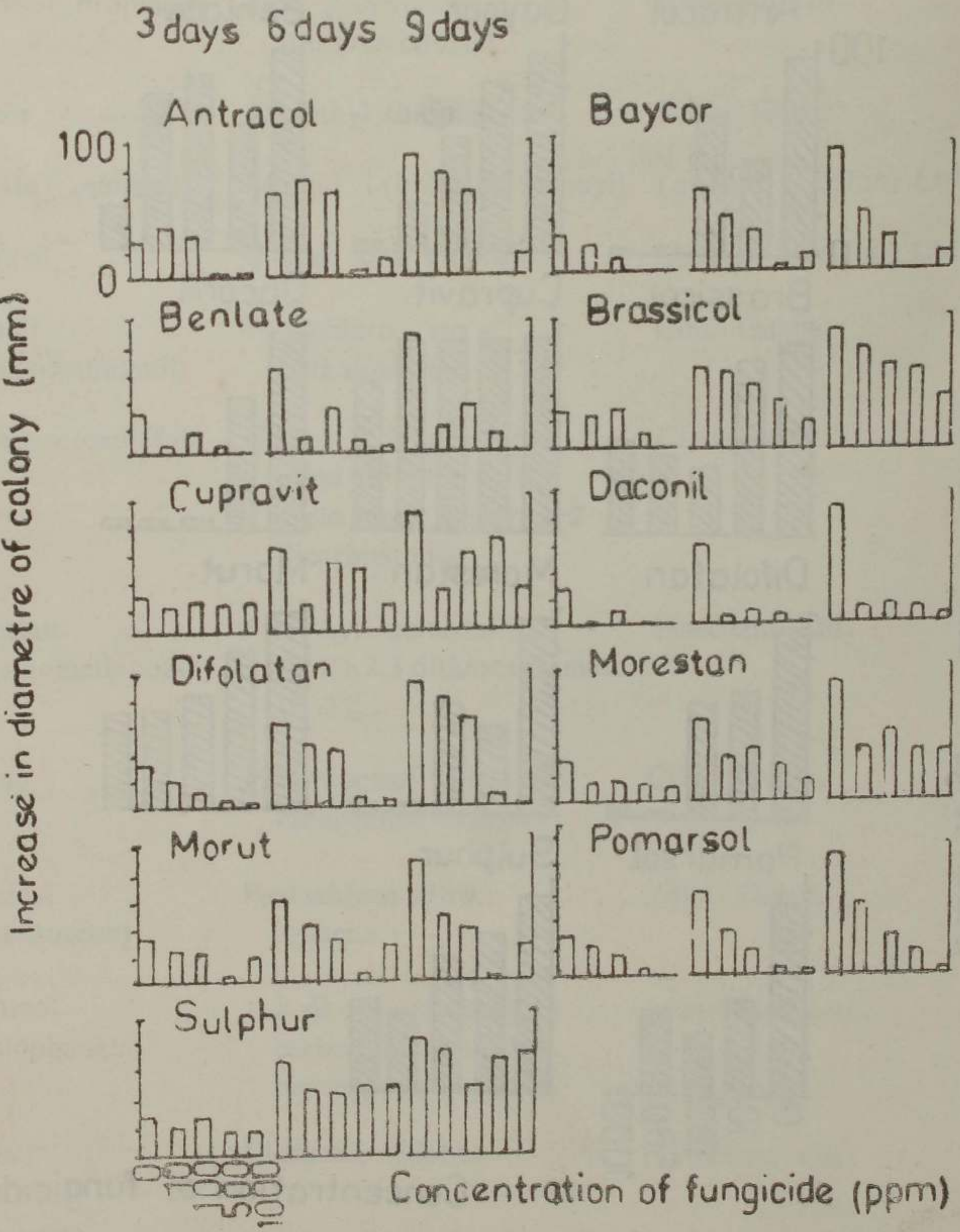

Fig. 5 Effects of fungicides on the mycelial growth of *Alternaria alternata* at 25°C after 3, 6 and 9 days of incubation

Discussion

Field observations in Jaffna indicated that *Alternaria alternata* was the cause of premature leaf senescence of onion. The fungus isolated from naturally infected onion plants was identified and found to be similar in cultural and conidial characteristics to the isolate reported by Simmons (1967). However, the minor morphological variations may be due to the host - environmental effects as described by Elliot (1917), Jimenez & Miller (1966), Grogan *et al.* (1975) and Misaghi *et al.* (1979).

The observation that the fungal attack was severe during periods of low temperature and high humidity is in accordance with the earlier reports on the pathogenicity of *Alternaria alternata*, causing a stem canker on tomato (Grogan *et al.*, 1975) and a leaf blight on *Avicennia marina* (Chandrashekar & Ball, 1980).

The Isolate of *Alternaria alternata* obtained from the infected onion plants had a temperature optimum between 20° and 25°C for germination of conidia. However, the mycelial growth was better at 30°C than at any other temperature used in this experiment. These observations tally with those reported by Chandrashekar & Ball (1980).

The evaluation of fungicides on germination of conidia and growth of mycelium revealed that daconil, difolatan, benlate and pomarsol could be used to eradicate *Alternaria alternata.*

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SOME FIELD OBSERVATIONS ON THE EPIDEMIOLOGY OF DOWNY MILDEW DISEASE OF GRAPE VINE

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ABSTRACT : Incidence of downy mildew disease on grape vine was recorded during the rainy season or during a high humidity, low temperature weather in the presence of dew in Jaffna peninsula. The infection process was initiated by germination of sporangia and the disease cycle from spore landing to spore release was completed in 8 days. The mature leaves first developed infections and later formed the source of inoculum for subsequent infections.

The amount of sporangia released in a vineyard was maximum between 12 noon and 2 pm and was greater in the vertical direction than in the horizontal direction. Maximum capture of sporangia was recorded just below canopy. The incidence of infection and the daily spore release in the rainy season followed the typical pattern of a growth curve with four phases. The building-up of inoculum, the establishment of the fungus and the disappearance of the fungus towards the end of the season were dependent on the weather conditions.

Introduction

The downy mildew disease, the most destructive fungal disease of grape vine (*Vitis vinifera* L.), is caused by the fungal parasite *Plasmopara viticola* (Berk. & Curt.) Berl. & de Toni. The development of the fungus was favoured in a high humidity, low temperature weather in the presence of dew (Ramanathan & Sivapalan, 1982). Symptoms first appeared on the mature leaves and later spread to the other leaves and other parts of grape vine. All green parts of the vine such as berries, inflorescences, tendrils and young shoots were affected by this fungus (Ramanathan, 1985).

The fungus appeared as white downy growth on the lower surface of vine leaves which later became necrotic. All the vineyards in the Jaffna region showed severe defoliation and there was a gradual weakening of the vine plants due to infection. There were instances where the grape cultivation had been completely abandoned due to severe, yearly attacks of the downy mildew fungus (Ramanathan & Sivapalan, 1988).

Overwintering of the fungus is usually either by preservation of mycelia in the bud scales or by production of oospores which are formed during the sexual reproduction of *Plasmopara viticola* as reported by Boubals (1977), Gallet (1977), Lafon & Bulit (1981) and Ramanathan (1985). The infection is initiated at the beginning of the season with the germination of oospores. Inoculum for subsequent infection is supplied by the production of sporangia which are asexual reproductive structures of the fungus. The disease cycle in the field is initiated by air-borne sporangia and is completed in 8 days. Ramanathan (1985) reported that the lesions remain productive upto ten days from the time of appearance.

Sporulation of the fungus takes place at temperatures between 20° and 25°C and relative humidities between 95% and 100% (Istanffi, 1914; Ravaz & Verge, 1914; and Lafon & Bulit, 1981). The aerial liberation of sporangia was found to take place only in the presence of moisture while their transport is ensured by wind (Cobaz, 1972).

The present investigation was undertaken to obtain information on the epidemiology and the seasonal occurrence of the downy mildew disease in the Jaffna district in Sri Lanka.

Methods

Spore release in field

Capture of sporangia was recorded with the help of spore trap ladders as described by Ramanathan (1985). Five spore trap-ladders were hung either vertically or horizontally in the vineyard for experiments on spore release. Each spore trap-ladder consisted of ten pairs of greased slides (2.5×7.5 cm^2) tied together and placed in pairs at 15 cm intervals across two parallel metal wires. The slides were removed periodically, brought to the laboratory and observed under the microscope for deposited sporangia of *Plasmopara viticola*. The number of sporangia deposited over one cm^2 area of the glass slide was taken as the measure of spore release in the field. Counts on deposited sporangia were made on five randomly selected areas (one cm^2) on each of the ten slides per treatment.

The spore deposition on the vertically and horizontally hung ladders will be referred to as vertical deposition and horizontal deposition respectively.

Vertical and horizontal deposition of sporangia were studied by hanging spore trap-ladders both in the vertical and the horizontal direction in the vineyard. Greased slides kept vertically and horizontally on the spore trap-ladders at 15 cm below the canopy from 6 am to 6 pm on a sunny day were removed and examined for deposited sporangia.

Capture of sporangia was also recorded on an hourly basis in a seperate experiment. Spore trap-ladders were kept vertically and horizontally at 15 cm below the canopy. Sets of slides were removed between 6 am and 6 pm, and observed for deposition of spores.

The vertical deposition of sporangia at different heights in the vineyard was studied. Pairs of greased slides tied at 0 cm, 15 cm, 30 cm, 60 cm, 90 cm, 120 cm and 150 cm below canopy level and 30 cm and 60 cm above canopy level on spore trap-ladders hung vertically from 6 am to 6 pm were removed and observed for deposited sporangia.

The vertical distribution of sporangia was also studied in the field over a period of one month. Slides held at different heights from 6 am to 6 pm were removed daily and observed for deposited spores. The mean numbers of sporangia deposited over one cm^2 area of the slide were recorded from 6 December 1982 to 5 January 1983.

In another experiment the spore release and the spreading of infection on 25 randomly selected twigs in a vineyard were studied simultaneously over a period of 4 months starting from 1 December 1982 to 3 April 1983. Pairs of greased slides tied at 15 cm below the canopy on vertically hung spore trap-ladders, from 6 am to 6 pm, were removed daily and the capture of sporangia recorded.

Spreading of infection in field

Twenty five randomly selected twigs were tagged and observed for infection. The number of leaves infected per twig was recorded daily during the period from 1 December 1982 to 3 April 1983.

The development of infection on leaves of different ages was also studied in a vineyard over a period of one month. Leaves of different ages in a twig were denoted as 0, 1, 2, 3 etc. starting from the apex. Twenty five such randomly selected twigs were tagged and observed daily for development of infection. The length measurements of all the leaves in 25 twigs were obtained daily during December 1982. The amount of infection on leaves was assessed with the help of the standard score diagrams prepared by Ramanathan (1985) (Appendix I). The leaves were given scores for percentage area of infection. The disease index for each leaf age group was calculated by dividing the percentage area of infection by the mean length of leaf and this was considered as the measure of disease incidence.

Seasonal occurrence

The general seasonal occurrence of downy mildew disease of grape vine was also recorded during a 3 year - period starting from October 1981 to April 1984.

Results

Vertical and horizontal spore release

The number of sporangia deposited vertically and horizontally from 6 am to 6 pm over one cm^2 area of the slide varied significantly (Table 1). The amount of vertical deposition was greater than that of the horizontal deposition.

Table 1: Vertical and horizontal spore release of *Plasmopara viticola* in the vineyard

Position of spore trap	Mean number of sporangia deposited cm^{-2} area of the slide
Vertical	93 a
Horizontal	5 b

The values denoted by different letters are significantly different (P=0.05).

Hourly spore release

The vertical deposition was higher than the horizontal deposition throughout the day (Fig. 1). No spore release was observed from 6 am to 9 am and 6 am to 12 noon on the vertically and horizontally placed ladders, respectively. The amount of vertical spore deposition started to increase with time after 9 am and reached a maximum level between 12 noon and 2 pm.

Table 2: Vertical spore release of *Plasmopara viticola* at different heights in a vineyard

Height from canopy (cm)	Mean number of sporangia deposited cm^{-2} area of the slide
0 (canopy)	320 a
15 (below)	324 a
30 (below)	14 b
60 (below)	3 c
90 (below)	1 d
120 (below)	<1 d
150 (below)	<1 d
30 (above)	<1 d
60 (above)	<1 d

The values denoted by different letters are significantly different. (P=0.05).

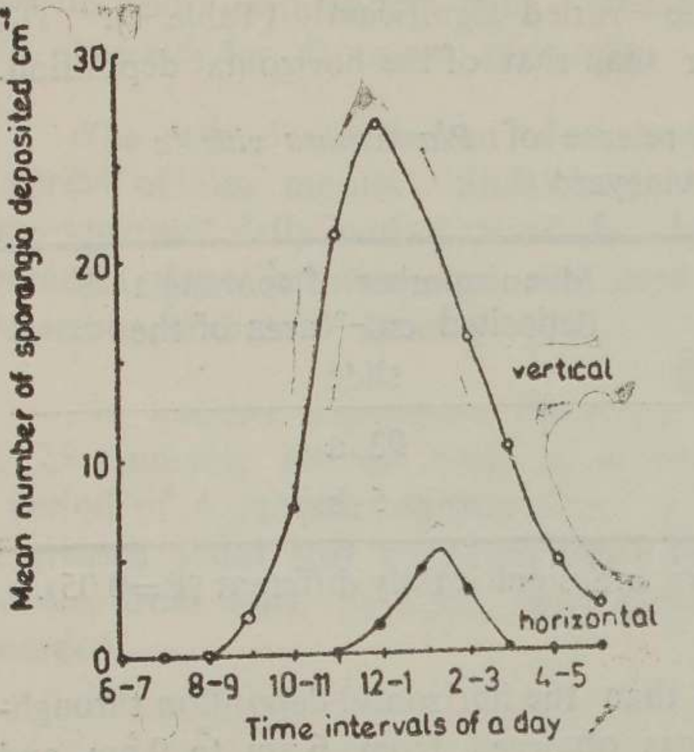


Fig. 1: Hourly spore of *Plasmopara viticola* showing the vertical and horizontal spore deposition in a vineyard.

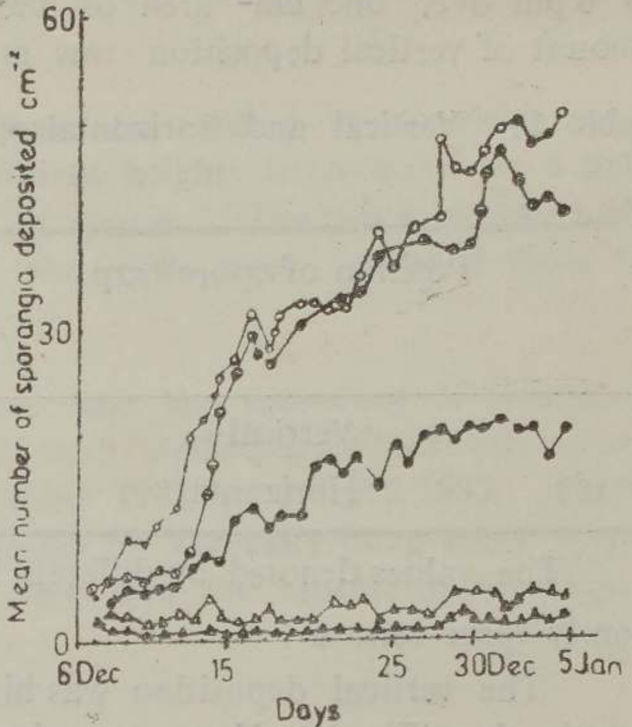


Fig. 2: Vertical deposition of sporangia of *Plasmopara viticola* in a vineyard over a period of one month.

O 15 cm below canopy
∅ canopy level
● 30 cm below
▲ 90 cm below
△ 60 cm below

Spore release at different heights in a vineyard

Maximum captures of sporangia were recorded at 15 cm below canopy (Table 2). The amount of sporangia deposited decreased gradually as the distance below and above canopy increased. The amount of spore release just above the canopy was negligible or very much less than that deposited just below the canopy.

Spore release over a period of one month

The number of sporangia deposited at different heights increased gradually with days from 6 December 1982 to 5 January 1983 showing the building up of inoculum in the field (Fig. 2).

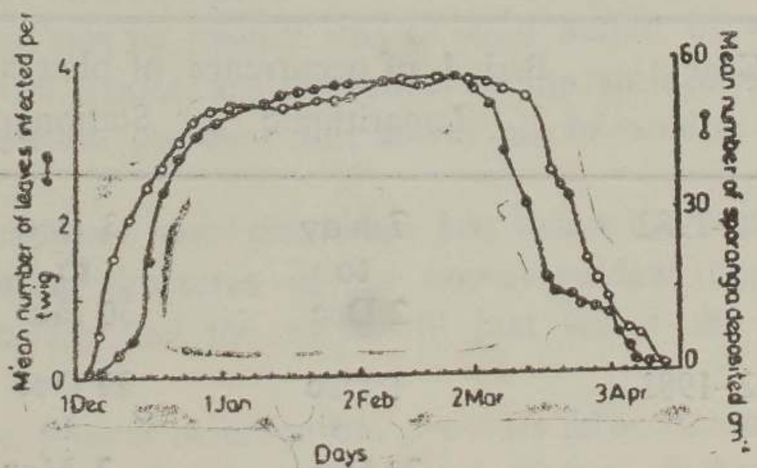
Spore release and spreading of infection over a period of four months

The values obtained for daily spore release and infection in a vineyard from 1 December 1982 to 3 April 1983 were compared with each other. The pattern of spore release was similar to that of infection (Fig 3). Both the amount of spore release and infection followed the pattern of a typical growth curve with four phases during the above study. The first logarithmic phase was observed during December 1982. The spore release and infection increased from 1 December 1982 upto 28 December 1982. They became static from 29 December 1982 and the stationary phase lasted for two months. This was followed by a decline phase when all the infected leaves already dry and brown became crumpled and started to drop from the plants. No spore release was recorded after 15 April 1983 and no new infection was produced on freshly appearing leaves.

Disease incidence on leaves of twenty five twigs over a period of one month

At the beginning of the season the leaves of age 4 developed infections first and subsequently the fungus spread to the younger leaves and leaves of age 5. The amount of infection increased gradually with time (Fig 4) and maximum value for disease incidence was recorded on leaves of age 3 during the experimental period. Infection also spread to the newly-appeared leaves about twenty days after they open.

Fig. 3 Vertical spore release and spreading of infection of *Plasmopara viticola* on twenty five selected twigs in a vineyard over a period of four months (from 1 Dec. 1982 to 15 Apr. 1983).
(Each division in the X axis indicates four days.)



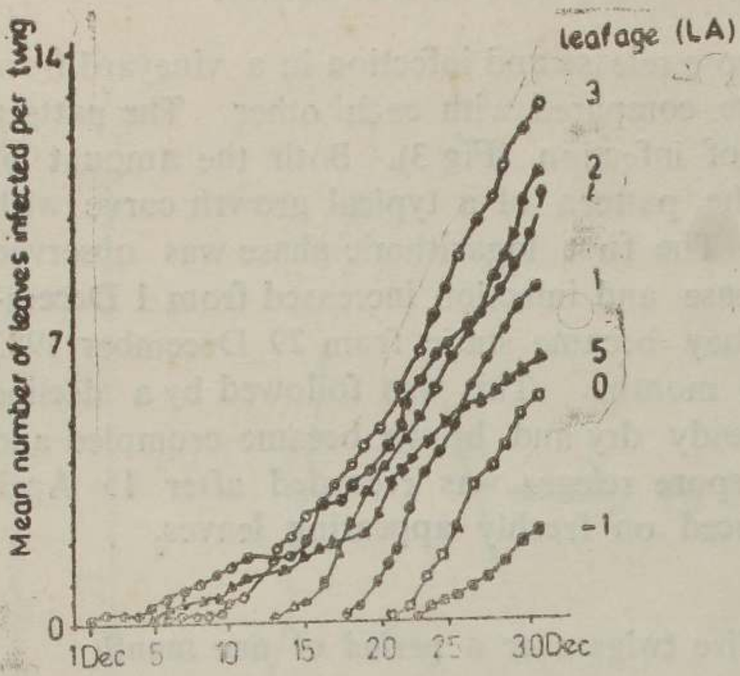


Fig. 4: Disease incidence of *Plasmopara viticola* on leaves of different ages on twenty five selected twigs in a vineyard over a period of one month.

Note : LA=Leaf Age. Leaves of different ages on a twig were numbered as 0, 1, 2, 3, 4 and 5 starting from the apex at the beginning of experiment. LA - 1 refers to the newly appeared leaf.

Seasonal occurrence of downy mildew disease in Sri Lanka

The occurrence of downy mildew disease in the vineyards of Jaffna, Sri Lanka was recorded from November 1981 to February 1982, from December 1982 to April 1983 and from October 1983 to March 1984, during the three year-study. The pattern of spore release and infection in the rainy season during the three years of study followed similar trends. However, the first phase where there was gradual building up of inoculum and the decline phase where the fungus started to disappear were slightly shifted depending on the weather conditions (Table 3).

Table 3 : Seasonal occurrence of downy mildew disease of grape vine in Jaffna, Sri Lanka.

Year	Period of occurrence of phases of the disease cycle: Logarithmic	Stationary	Decline
1981–1982	7 Nov to 2 Dec	3 Dec to 30 Jan	31 Jan to 18 Feb
1982–1983	1 Dec to 28 Dec	29 Dec to 2 Mar	3 Mar to 15 Apr
1983–1984	19 Oct to 24 Nov	25 Nov to 6 Feb	7 Feb to 12 Mar

Discussion

It has been observed for several years that the downy mildew disease of grape vine is a destructive fungal disease which is usually severe under rainy weather in the presence of dew.

The seasonal occurrence of downy mildew disease in the vineyards of Jaffna region showed that infections started when the rainy season starts and last till April with the severity of the disease observed in February. The introduction of the fungus to the vine leaves at the beginning of the season greatly depends on the occurrence of periods of rain. The longer the rainy season, the longer was the period of infection (Table 3). During the first year of study the period of infection was very short because of the brief period of rains, but during the next two years the infection remained in the vineyards for longer periods as there were prolonged rains. The initial appearance of the fungus, maximum disease occurrence and spore release and the disappearance of the fungus on vine leaves varied depending on the weather conditions such as rains and periods of dew.

Although all green parts of the vine plant were affected by the fungus (Ramanathan, 1985) the most apparent symptoms were on the leaves. The infection process was initiated by germination of air borne sporangia and required a cool and moist environment. However, the maturation of sporangia and their release took place in a relatively dry, high temperature environment and this fact is supported by the observation that high amounts of spore release were recorded during the daytime between 12 noon and 3 pm.

The amount of vertical deposition of sporangia was greater than that of the horizontal one. This may be mainly due to wind action by which the sporangia, detached from mature lesions, are deposited on the surface of slides. The mechanism of spore deposition on new host leaves can be similar to this.

The spore captures were maximum just below the canopy and this may be because the sporulating structures of the downy mildew fungus are formed only on the lower leaf surface and the air is still just below the canopy.

Although the present investigation provides information regarding development and occurrence of the downy mildew disease, further investigations are necessary on the development of disease in the field. A knowledge of the effects of weather parameters on the development of the disease will be useful in forecasting the disease incidence and in taking control measures against the downy mildew fungus.

Acknowledgement

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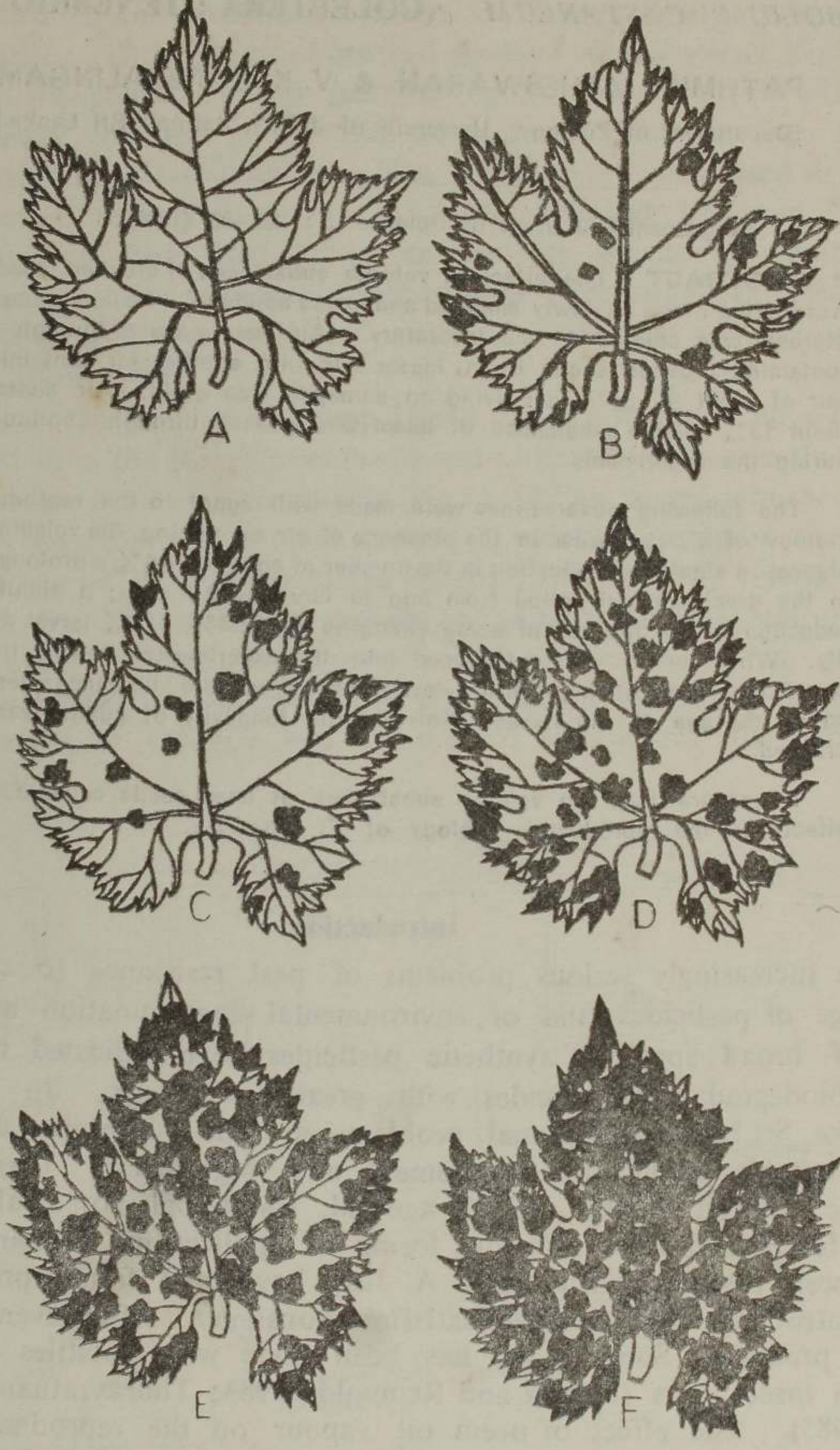
Appendix : I Standard score diagrams (Ramanathan, 1985).



Standard score diagrams for percentage area of infection of *plasmopara viticola* on leaves of grape vine : No infection (a), 5% infection (b), 10% infection (c), 25% infection (d), 50% infection (e), & 75% infection (f).

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EFFECT OF VOLATILE SUBSTANCES FROM *AZADIRACHTA INDICA* (NEEM) SEEDS ON THE REPRODUCTIVE BIOLOGY OF *TRIBOLIUM CASTANEUM* (COLEPTERA : TENEBRIONIDAE)

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Vingnanam — Journal of Science 3 : 20–26 (1988)

ABSTRACT : The effect of volatile substances of crushed seeds of *Azadirachta indica* on newly emerged and mated adults of *Tribolium castaneum* (Herbst) was studied in the laboratory. Air was passed through a jar containing crushed seeds of *A. indica* and into another jar containing a pair of adult *T. castaneum* living on damaged rice grain. Air containing about 13% volatile substances of neem was passed through continuously during the experiments.

The following observations were made with regard to the reproductive biology of *T. castaneum* in the presence of air containing the volatile substances: a significant reduction in the number of eggs by 27.5%; a prolongation in the developmental period from egg to larva by 2 5 days; a significant reduction in the number of larvae emerging by 22.8%; 100% larval mortality. When larvae were introduced into the experimental set-up it was found that prohibition of further development by volatile substances depended on the age of the larvae. However the longevity of adults was not affected.

It appears that the volatile substances of neem seeds cause adverse effects on the reproductive biology of *T. castaneum*.

Introduction

The increasingly serious problems of pest resistance to continuous or heavy usage of pesticides and of environmental contamination associated with the use of broad spectrum synthetic pesticides have indicated the need for effective, biodegradable pesticides with greater selectivity. In a developing country like Sri Lanka, additional problems are their improper use, nonavailability of suitable application equipment and high price. These induced a world wide interest in the use of age-old, traditional botanical agents such as neem for pest control. Various forms of applications of bark, leaves and seeds of neem tree (*Azadiracta indica* A. Juss) have been found promising agents of pest control. In addition, neem satisfies consumer safety even when applied to stored products. Some work has been done with volatiles of neem seed kernels on insect pests (Saxena and Rembold, 1983; Thurayratnam and Ganesalingam, 1985). The effect of neem oil vapour on the reproductive efficiency of *Earias fabia* (Stoll) was studied by Pathak and Krishna (1986). The reproductive biology of *Tribolium castaneum* (Herbst), an important pest of stored cereal was studied by Dawson (1977).

In the present study the effect of volatiles of neem seeds on the reproductive biology of *T. castaneum* was investigated.

Materials and Methods

Decorticated and shade-dried neem seeds were finely crushed by using mortar and pestle. Three grams of crushed seeds of *A. indica* were kept in a bottle (375 ml) which was connected by a glass tubing to another jar (840 ml) containing a pair of newly emerged and mated adult *T. castaneum* in 5 g. of broken rice grains in a 10 ml glass container. The broken rice grains used in the experiments were passed through a 3 mm mesh but retained by 2 mm mesh sieve. Damaged rice grains were used in the experiments because the rust red flour beetle *T. castaneum* is an important secondary pest requiring prior infestation by an internal feeder or some form of mechanical damage of the whole grain (Shazali and Smith, 1986).

Air was pumped by an air pump (Rena 101 – flow rate of air = 7·5 ml of air displacement/s) into the jar with crushed neem seeds and subsequently this air was carried into the jar containing the insects (Fig. 1). The air passed into the jar containing the insects was found to contain about 13% volatile substances. The percentage of volatiles in the set-up was calculated by adsorption of the volatile substances into activated charcoal powder in comparison with the normal atmosphere. Preliminary tests using different weights of crushed neem seeds to provide 13% volatiles in the set-up demonstrated three grams as the suitable minimum amount. The concentration of volatiles was maintained throughout the experiment by regular checks.

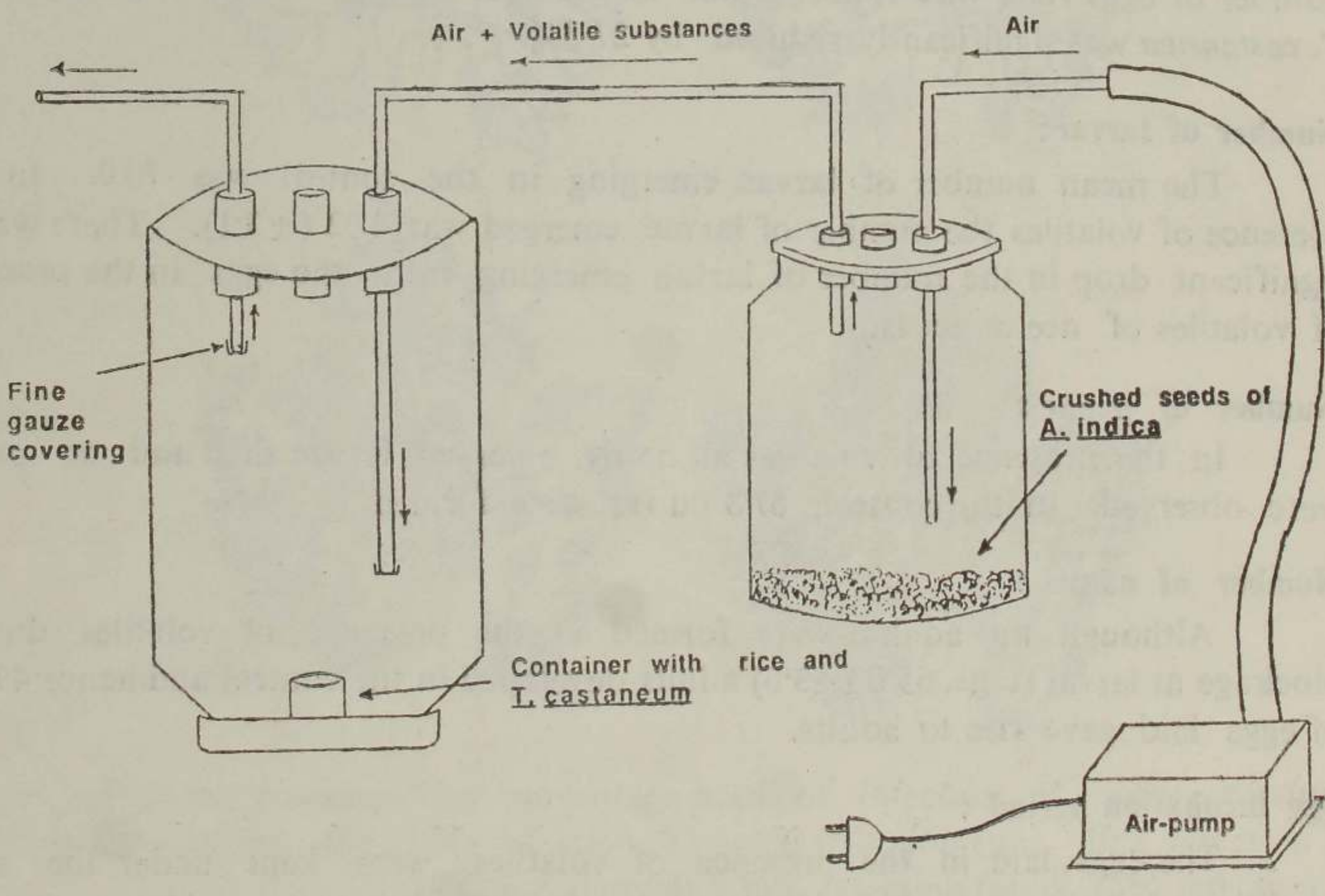

Fig. 1 Set up used to obtain volatiles of *A. indica*

The mated pair in the set-up was removed after 21 days and the reproductive biology of *T. castaneum* in the presence of the volatile substances of neem seeds was studied.

To study the effect of volatiles on larval development, larvae of varying ages were introduced separately into the set-up and observed daily. From newly hatched larvae (0-24 h old) to 24 day old larvae were tested. In each set-up, ten larvae of particular age were kept in a 10 ml glass container with five g of broken rice grains. These larvae were kept in the presence of volatiles until the adults emerged. The range of age of larvae susceptible to the volatiles of neem seed kernels was recorded.

The experiment was repeated six times and a control experiment was conducted concurrently by passing air only through the experimental set-up.

The studies were carried out in the laboratory at 28·5 ± 1·5°C temperature and 50–62% RH. Students t-test was used to analyse the data.

Results

Number of eggs :

In the presence of volatiles of neem seeds the mean number of eggs laid within 21 days was 95·2 (±4·4); whereas in the control experiment, the mean number of eggs laid was 131·3. Thus the number of eggs laid by a single female *T. castaneum* was significantly reduced by 27·5%.

Number of larvae:

The mean number of larvae emerging in the control was 70·0. In the presence of volatiles the number of larvae emerged was 47·2 (± 3·1). There was a significant drop in the number of larvae emerging from the eggs in the presence of volatiles of neem seeds.

Number of pupae :

In the presence of volatiles all newly emerged larvae died and no pupae were observed. In the control, 67·3 pupae were formed.

Number of adults :

Although no adults were formed in the presence of volatiles due to blockage at larval stage, 65·0 (±3·6) adults developed in the control and hence 49·5% of eggs laid gave rise to adults.

Egg incubation period :

The eggs laid in the presence of volatiles were kept under the same conditions continuously and the time taken for the emergence of larvae, i.e. egg incubation period, was recorded. Mean incubation period was 8.2(± 1·3) days in the presence of volatiles, whereas in the control it was found to be 5·7 days. A significant prolongation by 2·5 days was observed in the presence of volatiles of neem seeds.

Mortality at embryo and larval stages :

In the presence of volatiles 50·8% death occurred at the embryo stage within the egg whereas 47% death occurred in the control. The difference in mortality at the embryo stage was not significant ($P=0{\cdot}05$).

Newly emerged larvae were highly susceptible to the volatiles of neem seeds and showed 100% mortality. But only 3·3% mortality was observed during the larval stage under normal conditions. Hence larval mortality increased by 96·7% in the presence of volatiles.

Effect of volatiles on larvae of varying age:

Newly hatched to 12-day old larvae showed 100% mortality, whereas 13–24 day old larvae pupated even in the presence of volatiles.

Development of 13–day old larvae :

The youngest larvae that survived to become adults in the presence of volatiles were found to be 13-day old. Further studies on the development were made from these larvae.

1. Number of F_1 progeny :

Number of F_1 progeny that developed from ten 13-day old larvae was 7·2 ($\pm$ 1·2) and 9·3 in the presence of volatiles and in the control respectively. Here a significant reduction was recorded in the presence of volatiles.

2. Sex ratio of F_1 progeny:

The sex ratio of the F_1 progeny that emerged was unaffected by the volatiles and was 1 : 1 (male : female) in the presence of volatiles and in the control.

3. Mortality in larval and pupal stages :

In the experimental larvae, 1·5% and 0·3% died in the presence of volatiles and control respectively. In the pupal stage, 0·3% died in the control and 1·0% died in the presence of volatiles. Both larval and pupal mortalities showed significant differences from controls ($P=0\ .05$).

4. Duration of pupal development :

The duration of pupal development in the control was 6 3 days, whereas in the presence of volatiles of neem seed kernels it was prolonged significantly by 2·2 days.

Longevity of adult *T. castaneum* :

The mated pair of adults kept in the presence of volatiles and under normal conditions was removed from the experimental condition after 21 days and maintained in ambient conditions. All these survived for more than five months.

Discussion

Evaluation of neem seed kernel or extract against a number of insect pest species have demonstrated neem's diverse biological effects including the effects on reproductive biology (Akou-Edi, 1983; Saxena *et al.* 1981; Steffens and Schmutterer, 1982).

The total number of eggs laid by *T. castaneum* was reduced significantly in the presence of volatiles of neem seeds. Similar observation was made with *Sitotroga cerealella* in the presence of volatiles of crushed neem seeds (Thurayratnam and Ganesalingam, 1985). It appears that the effect on egg laying was either due to a lack of suitable environment for egg laying or due to inhibitory effects of the volatiles of neem seeds on *T. castaneum*.

Though there was no significant reduction in the number of larvae emerging the number of days taken for laval emergence increased significantly. It appears that the volatiles may contain a growth inhibitor as stated by Rembold *et al.* (1981).

The most prominent effect observed in the presence of volatiles is the 100% mortality of the larvae. This may be either due to the toxic effect of volatiles on the young stages or due to deterrent effect of feeding and / or careful effect on development caused by volatiles entering through respiratory pathways or during feeding or through larval cuticle. When retarding the development it may act either as metamorphosis disruptor (Ruscoe, 1972) or moult inhibitor (Redfern *et al.* 1979). The effect of volatiles on young larvae appears more likely due to toxic effects than to effect on feeding or development because the late instars developed under the same conditions. This may be a dosage/mortality effect where the late instars only had a sublethal dosage.

In the larval stage, inhibition of further development by the volatiles depended on the age of the larvae. Newly hatched larvae to 12-day old larval stages showed no further development. But larvae of 13–day old and older than 13-day underwent further development and gave rise to adults. This may either be due to the variation in susceptibility of larvae with age or due to variation in the cuticle of larva with age.

Even the larvae that survived under the experimental conditions showed significant prolongation of development to adult stage. Here prolongation occurred in the duration of both larval development and pupal development. This may be due to growth inhibitory activity or metamorphosis disruption effect or moult inhibition effect of neem seed volatiles.

Although a difference was observed in the number of F_1 progeny that developed in the presence of volatiles there was no difference in the sex-ratio. This may indicate equal susceptibility of male and female insect to volatiles.

The effects of volatiles were investigated at a concentration of only 13%. However, if the concentration of the volatile is increased, a better control of the pest could be expected.

An important advantage of the application of volatiles of neem seed kernel is that if neem kernels were applied directly to the edible materials for protection, neem substance may persist longer and hence be more undesirable than that which operates without direct contact.

The diverse effectiveness reported here against the reproductive biology of *T. castaneum*: i.e. safety, low cost, ease of application and availability to farmers in many developing countries including Sri Lanka, emphasises that application of volatiles of neem seed kernel could be considered for the control of *T. castaneum* in stored products.

But this may be used only on a small scale by farmers for preventing pest damage to a considerable extent. However, the use of volatiles, by their very nature may pose practical problems. Further research on ways of releasing these substances under the storage conditions is needed.

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ISOLATION OF INTRA-CELLULAR SYMBIOTES FROM THE BROWN PLANTHOPPER *NILAPARVATA LUGENS* (HOMOPTERA: DELPHACIDAE) OCCURRING IN SRI LANKA

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ABSTRACT: The existence of yeast-like symbiotes or mycetocytes in the mycetosome of eggs, fat bodies and ovaries of the brown planthopper, *Nilaparavata lugens* (Stål) has been repoıted from Japan. The present study describes the isolation of intracellular yeast-like symbiotes or mycetocytes from the mycetosome of eggs and fat bodies of *N. lugens* occurring in Sri Lanka. *N. lugens* used in this study was obtained from rice fields in Amparai district and cultured in the laboratory in Jaffna. Two kinds of yeast-like mycetocytes were observed in the eggs and fat bodies of *N. lugens*: elongated sheath-like mycetocytes and oval shaped mycetocytes, the former being more numerous. The mycetocytes from *N. lugens* in Sri Lanka are smaller than those reported from Japan.

Introduction

The occurrence of yeast-like organisms (YLO) in the cytoplasm of the mycetosome of the planthoppers has been known for some time (Buchner, 1963). Nasu (1963) demonstrated the existence of yeast-like organisms in the mycetocytes of eggs, fat bodies and ovaries of the smaller brown planthopper, *Laodelphax striatellus* Fallen. Kusumi *et al.* (1979) isolated two yeast-like cells from eggs and fat bodies of *L. striatellus*. Nasu *et al.* (1981) also isolated two yeast-like cells from the eggs and fat bodies of *Nilaparvata lugens* (Stål) occurring in Japan. The present study attempts to determine if symbiotes are present in the eggs and fat bodies of *N. lugens* occurring in Sri Lanka and to describe their morphological characteristics.

Materials and Methods

N. lugens used in this study was obtained from rice fields in Amparai district and cultured in the laboratory at the University of Jaffna on rice variety, TN 1. The mycetocytes were obtained from the eggs of *N. lugens* as follows. The ovaries of gravid female *N. lugens* were dissected out and the eggs removed. The eggs were surface sterilized by submersion in 70% ethyl alcohol for 1 min The mycetosome was then dissected out in sterile distilled water and the mycetocytes teased out. The mycetocytes were obtained from the fat bodies in a similar manner, by dissecting out the fat bodies from female *N. lugens* and suface sterilizing them in 70% ethyl alcohol for 1 min and teasing out the mycetocytes in sterile distilled water.

A thin smear of the mycetocytes was made, left to dry in the air, and then fixed by passing the slide through the flame. It was stained with carbol fuschin for 30—60 sec and then rinsed with distilled water. Alternately, a protozoan stain was used: the smear was immersed in Schaudinn's fixative for 10—20 min, then covered with mordant solution overnight, and with stained Heidenhain's Long Iron Hematoxylin overnight.

Results and Discussion

The mycetosome in the egg of *N. lugens* is a round body measuring 36 μm in diameter located in the posterior region of the egg. Two morphologically different yeast-like symbiotes could be distinguished by microscopic examination of the mycetocytes of both eggs and fatbodies of adult *N lugens*: (a) elongated sheath-like cells and (b) oval-shaped cells. The former kind of mycetocytes were more numerous.

The oval shaped mycetocytes from the eggs had an average length of 5.8 ± 0.85μm (range 3.6—6μm). The elongated cells averaged 14.35±2.02μm (range 12 to 18.0 μm).

The oval shaped mycetocytes from the fatbodies averaged 5.11±0.68μm (range 3.6—6.0μm) while the elongated cells averaged 13.87±2.05μm (range 10.8—18.0μm) Fig. 1).

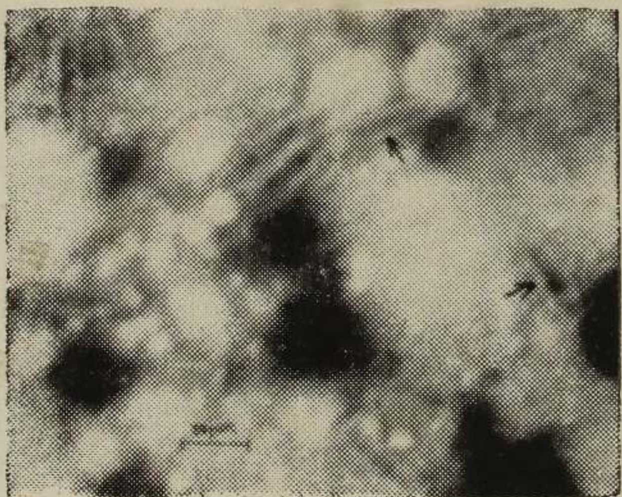

Fig. 1 Oval and elongated myoetocytes isolated frcm egg of *N. lugens*

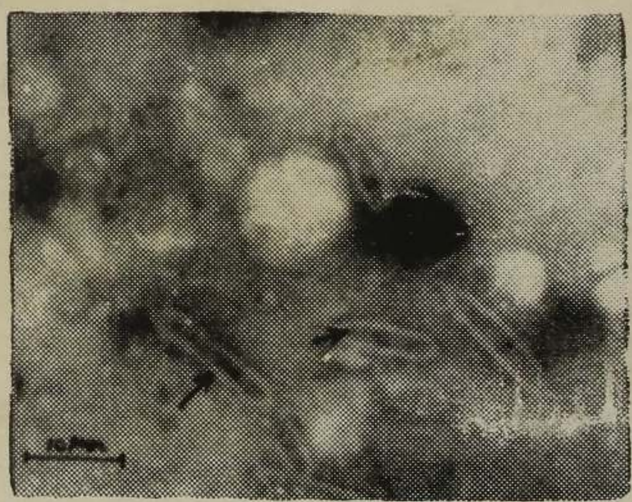

Fig. 2 Oval and elongated mycetocytes isolated from fatbody of abdomen of *N. lugens*

The elongated mycetocytes were significantly longer than oval shaped ones in both the eggs and the fatbodies (Table 1). However there were no significant differences in the size of elongated mycetocytes from eggs and fat-bodies and the oval shaped mycetocytes from eggs and fat bodies.

Table I Elongated and Oval-shaped Mycetocytes isolated from Eggs and Fatbodies of *N. lugens*

Organ of origin	Shape of mycetocyte	Total number of insects (n)	Average length (Mean±SD)	t-value
Egg	Oval	20	5.28±0.85	
	Elongated	20	14.35±2.05	17.10*
Fat body	Oval	20	5.11±0.02	
	Elongated	20	13.87±2.02	18.69*

*Significant at 0.005% level.

The two morphologically distinct mycetocytes found in the eggs and fat-bodies of abdomen of *N. lugens* in Sri Lanka resemble the two kinds of mycetocytes reported from *N. lugens* from Japan (Nasu *et al.* 1981) and *L. striatellus* also from Japan (Kusumi *et al.* 1979). However the YLO described in this study, with a size range of 3.6–6.0μm for the oval shaped cells and 10.0–18.0μm for the elongated cells, are smaller than the corresponding values of 8–10μm for the oval shaped cells and 15-20μm for the elongated cells of the mycetocytes reported from *N. lugens* in Japan (Nasu *et al.* 1981).

Although it is generally recognized that in the body of the adult female these organisms are transferred from fat bodies to ovaries and penetrate into the egg through the ovarial pedicel as a ball of symbiotes, the role of these symbiotes has still not been defined and await further study.

Acknowledgement

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OBSERVATIONS ON THE EMBRYONIC DEVELOPMENT OF *NEPHOTETTIX VIRESCENS* (HOMOPTERA : CICADELLIDAE)

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ABSTRACT The paper describes the embryonic development of the green leafhopper, *Nephotettix virescens* (Distant). Whole mounts of 1 - 6 day old eggs were stained with the aceto - orcein. In the embryo, protocephalon and protocorm regions were visible on day 1 and day 2, slight segmentation on day 3, eye spots on day 4, gnathal segments on day 5, and antenna and legs on day 6.

Introduction

The green leafhoppers of the genus *Nephotettix* are common pests of the rice crop in Southeast Asian countries (Kalode, 1983). In the Indian subcontinent, leafhoppers had the status of a minor pest till 1955, but suddenly became a major pest and caused severe damage, the first such incident being reported in 1956, in Bangladesh (Ramakrishnan, 1983). In Sri Lanka, *Nephotettix virescens* (Distant) and *Nephotettix nigropictus* (Stål are the most prevalent leafhopper species. Santa *et al*. (unpublished data) reported that *N virescens* and *N. nigropictus* were found in rice fields in Kandy district, comprising as much as 37.2% of the insect population (Rajendram, 1984). These were observed to increase very gradually till the heading stage of the crop and sharply after the heading stage, and were also noted before maximum tillering.

Both nymphs and adults cause damage by sucking the sap from leaves and stem of rice plants. Severe attack results in what is termed "hopper burn". Besides the direct damage, they also cause serious damage indirectly, by transmitting the causal agents of various diseases (Ling, 1972).

Eggs are laid in groups on the inner surface of the leaf sheath, especially in the basal portion. Valle & Kuno (1984) reported that the incubation period of *N. virescens* was 9.42±0.11 days in Japan, under conditions of 25±1°C room temperature and 16 h photoperiod, using a susceptible japonica variety. The present study describes the embryonic development of *N. virescens* of Sri Lanka.

Materials and Methods

N. virescens culture used in this experiment was obtained from a rice field at Arukalmadam in Jaffna peninsula and reared in the laboratory at the University of Jaffna, on rice variety BG 94-1. The temperature in the laboratory registered 28–32°C and relative humidity 30–100%.

Since *N. virescens* tends to occur together with *N. nigropictus* and other *Nephotettix* species in the rice field, *N virescens* was identified using the key prepared by Ghauri (1971). Eggs of varying stages of development, 0-6 day old, were obtained according to the method described by Rajendram & Selvadurai (1987). Morphological observations of the different stages of embryonic development were made under a microscope and measurements made with the help of an ocular micrometer, and averaged from 10 individuals. The eggs were stained in aceto-orcein or mounted in paraffin and 12μm sections stained with haematoxylin and eosin, as described by Rajendram & Selvadurai (1987).

Results

The incubation period of *N. virescens* was 6.95$\pm$0.65 days. Eggs are laid in single rows on leaf sheath tissues near the base of the plant or in ventral midrib of leaf blades. The anterior ends of the eggs are attached to the leaf sheath by a cementing material (Fig. 1).

0 day old egg

The newly laid egg is 760$\pm$40μm long and 240$\pm$20μm wide (Fig. 2). The egg is white in colour and contains a large yolky mass, granular in appearance. The chorion covers the egg.

1 day old egg

The 1 day old embryo is approximately 766$\pm$40μm long and 260$\pm$30μm wide. Protocephalon and protocorm regions are now visible. It appears pale yellow in colour (Fig. 3).

2 day old egg

The 2 day old embryo is 702$\pm$37μm long and 160$\pm$20μm wide. It is pale yellow in colour. Protocephalon and protocorm regions are visible. The head develops subsequently in the anterior region of the egg (Fig. 4).

3 day old egg

The 3 day old embryo measures 780$\pm$30μm long and 212$\pm$23μm wide. Slight segmentation of the head, thorax and abdomen can be observed. Head bears gnathal segments and antennal segments (Fig. 5).

4 day old egg

The 4 day old embryo measures approximately 1070$\pm$77μm long and 319$\pm$40μm wide. The embryo is now yellow in colour. Red eye spots become more prominent and can be discerned with the naked eye. The genital segments become clear and the thoracic appendages are developed. The abdominal segmentation is evident (Fig. 6).

5 day old egg

The 5 day old embryo is 1080 ± 45 μm long and 330 ± 20 μm wide. The gnathal segments can be divided into mandibles, maxillae and labrum. The segmentation of the legs can be seen. The length of the hind leg is 510 ± 40 μm long (Fig. 7).

6 day old egg

The 6 day old embryo is 1090 ± 40 μm long and 276 ± 22 μm wide. The antenna is approximately 300 ± 20 μm long and hind leg 950 ± 70 μm long. The abdominal markings are more evident. The chorion assumes the shape of the embryo (Fig 8).

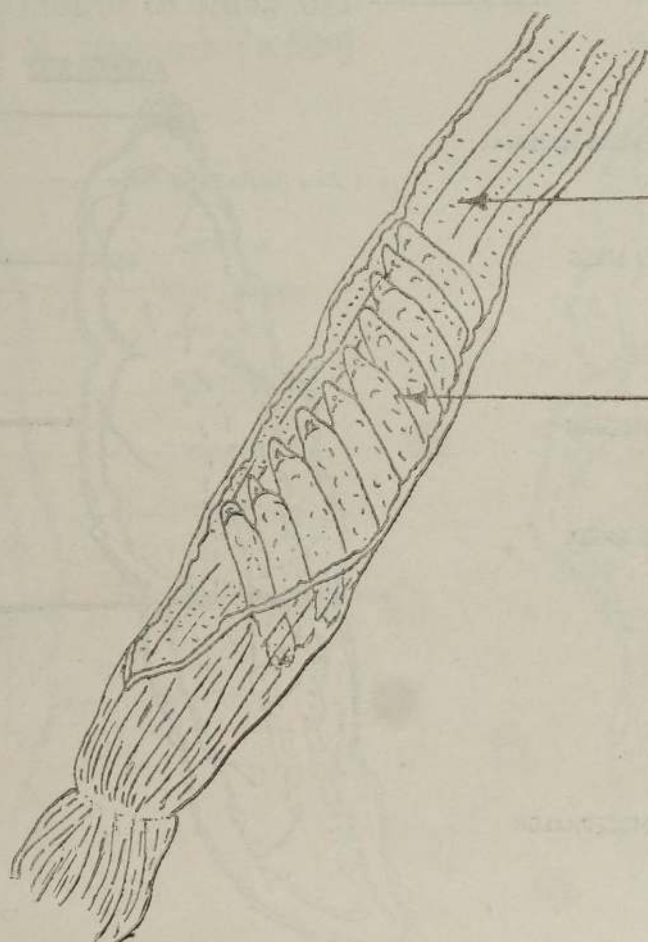

Fig. 1 Dissected rice stem showing eggs of *N. virescens*. (× 40)

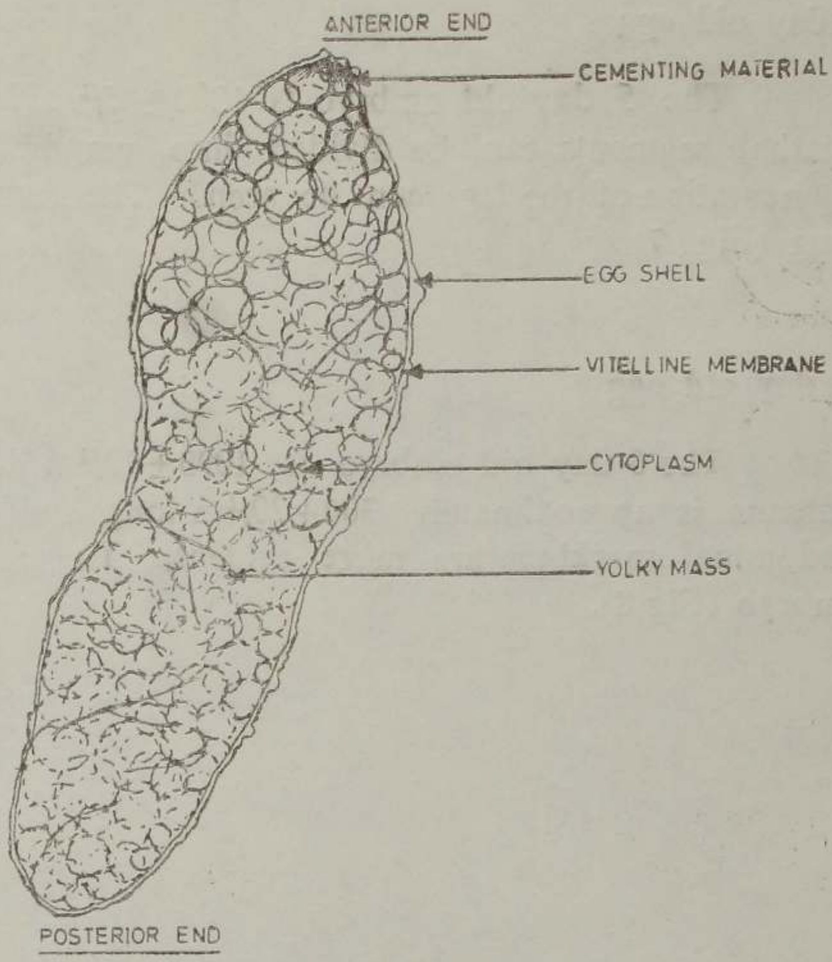

Fig. 2 Whole mount of 0 day old egg of *N.virescens*.(×500)

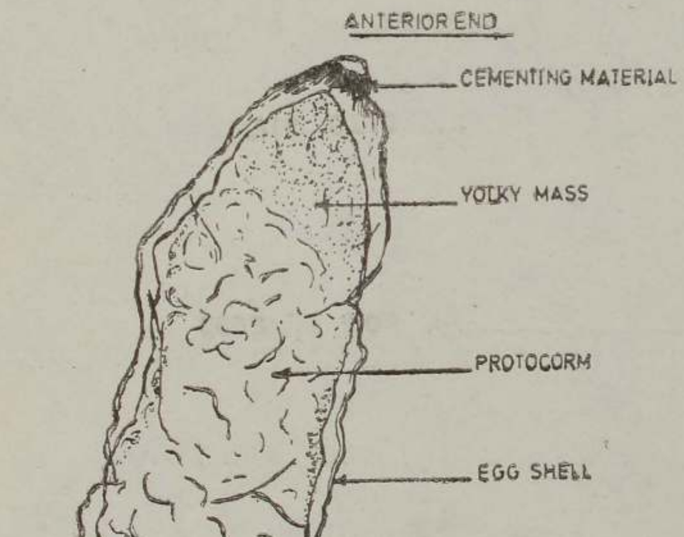

Fig. 3 Whole mount of 1 day old egg of *N. virescens*. (×500)

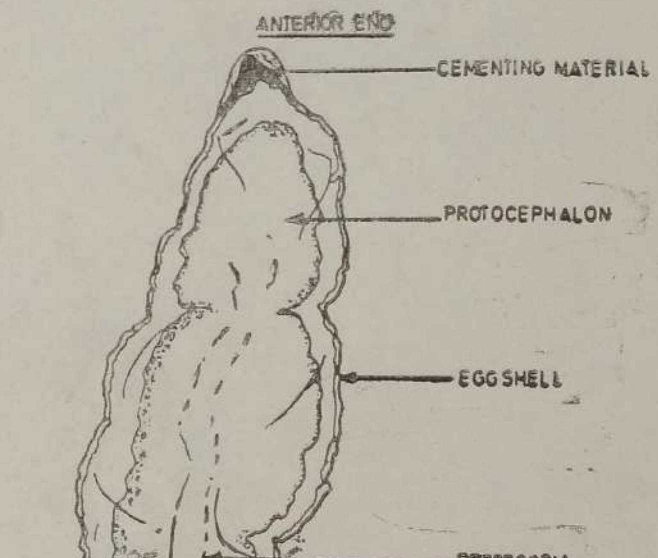

Fig. 4 Whole mount of 2 day old egg of *N. virescens*. (×500)

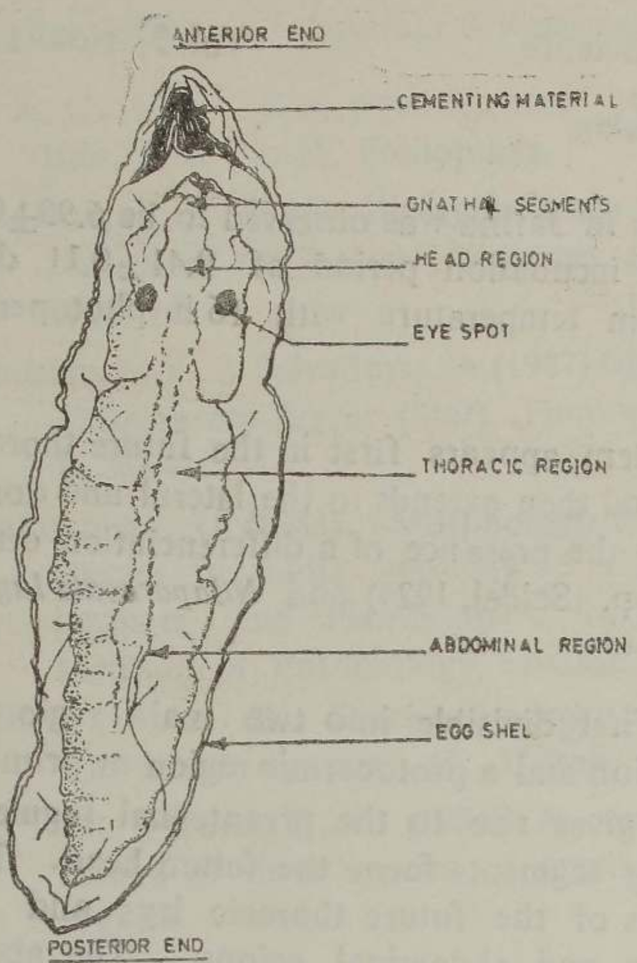

Fig. 5 Whole mount of 3 day old egg of *N. virescens*. (×500)

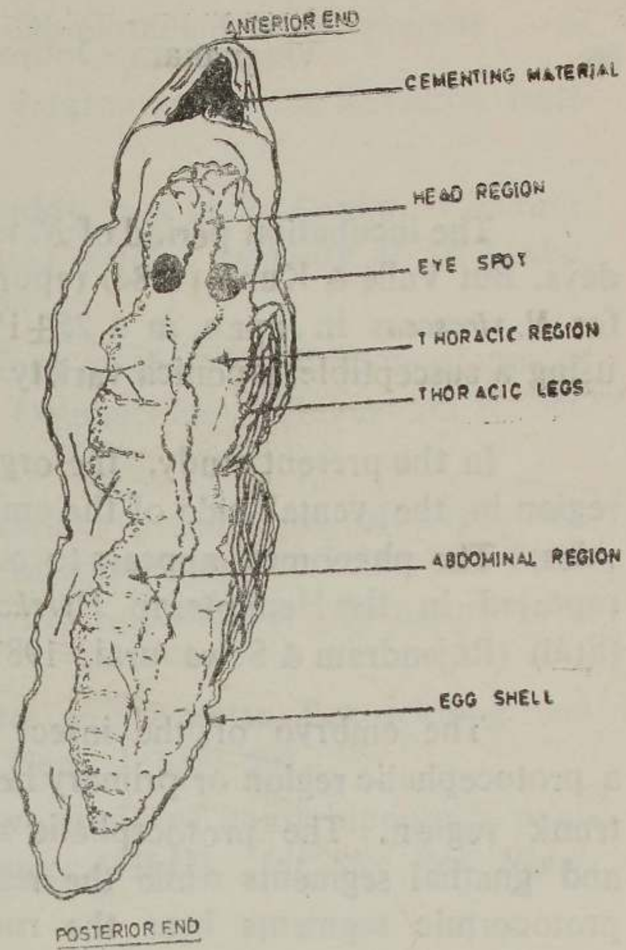

Fig. 6 Whole mount of 4 day old egg of *N. virescens*. (×400)

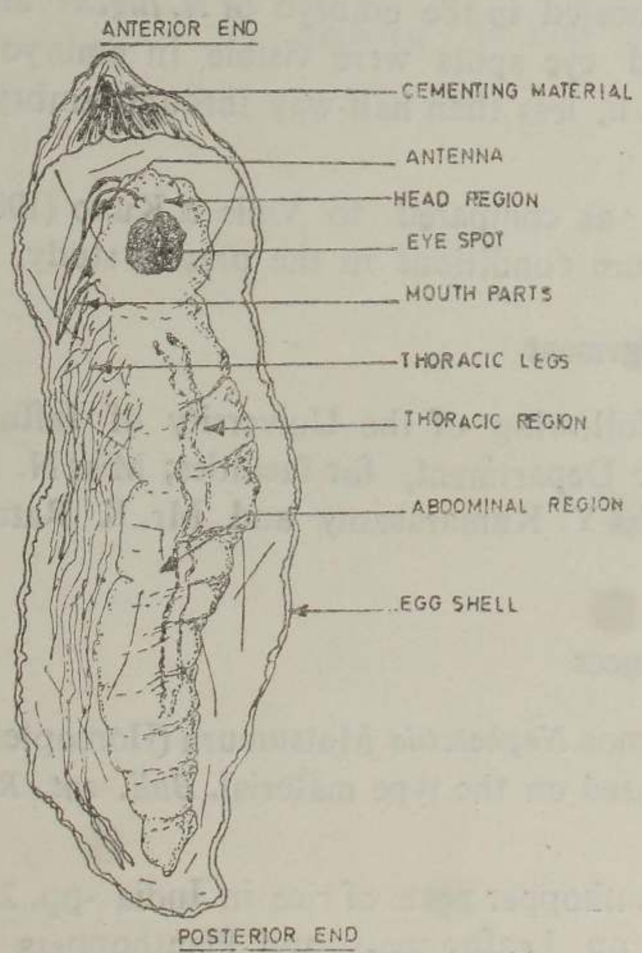

Fig. 7 Whole mount of 5 day old egg of *N. virescens*. (×400)

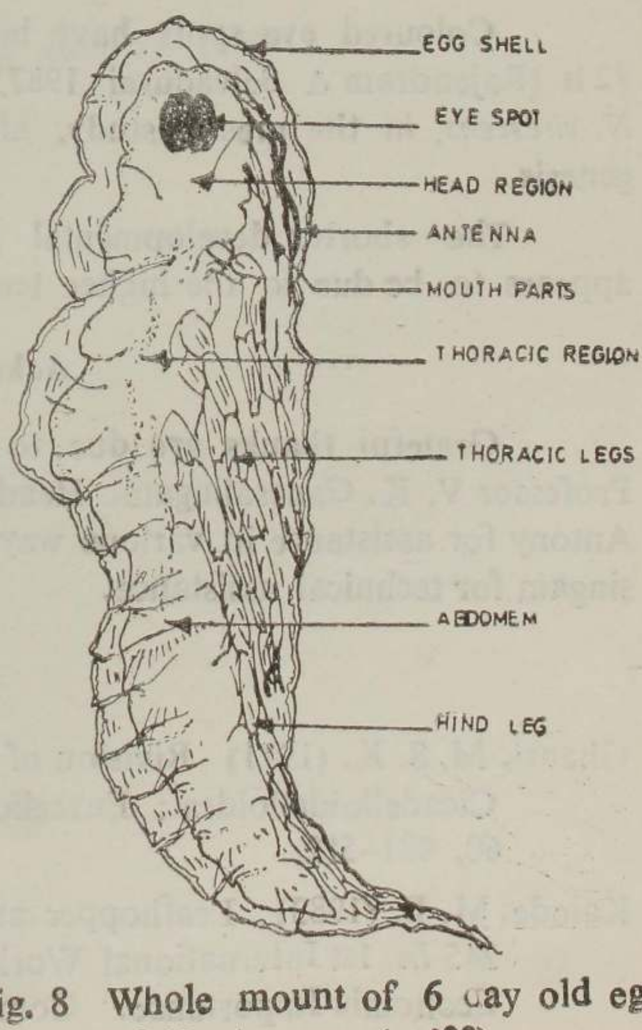

Fig. 8 Whole mount of 6 day old egg of *N. virescens*. (×400)

Discussion

The incubation period of *N. virescens* in Jaffna was observed to be 6.95 ± 0.65 days. But Valle & Kuno (1984) reported an incubation period of 9.41 ± 0.11 days for *N. virescens* in Japan, in a $25 \pm 1°C$ room temperature with 16 h photoperiod using a susceptible japonica variety.

In the present study, the organ system appears first in the future thoracic region in the vental side of the embryo and then extends to the lateral and dorsal sides. The phenomen appears to confirm the presence of a differenciation centre reported in the Hemipteran *Pyrrhocoris* sp. (Seidel, 1924) and *Nilaparvata lugens* (Stål) (Rajendram & Selvadurai, 1987).

The embryo of the insect is at first divisible into two main regions – a protocephalic region or primary head region and a protocormic region or primary trunk region. The protocephalic region gives rise to the preantennal segments and gnathal segments while the remaining segments form the future head. The protocormic segments bear the rudiments of the future thoracic legs and the remaining segments constitute the thorax and abdominal egions. The above segmentation is clearly seen in *N. virescens* embryo in the present study.

Coloured eye spots have been reported in the embryo of *N. lugens* after 72 h (Rajendram & Selvadurai 1987). Red eye spots were visible in embryo of *N. virescens*, in the present study, after 72 h, less than half-way through embryogenesis.

The shorter developmental period as compared to Valle & Kuno (1984) appears to be due to the higher temperature conditions in the present study.

Acknowledgement

Grateful thanks are due to the following of the University of Jaffna : Professor V. K. Ganesalingam, Head of the Department, for facilities; Miss N. R. Antony for assistance in various ways; Miss Y. Kumarasamy and Mr. K Ratnasingam for technical assistance.

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EFFECT OF HORIZONTAL CENTRFUGATION ON REPRODUCTIVE BIOLOGY *CALLOSOBRUCHUS MACULATUS* (FABRICIUS)

(Coleoptera : Bruchidae)

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ABSTRACT During centrifugation for 3 hours at speeds of 185 rpm and 370 rpm, adult *Callosobruchus maculatus* laid eggs at regular intervals on host seeds. The centrifugation caused no significant change in the number of eggs l id, number of viable eggs, developmental period from egg to adult and longevity of adult.

Centrifugation at speeds of 660 rpm, 1000 rpm and 3000 rpm brought about a significant drop in the total number of eggs laid and the number of viable eggs also was reduced.

When centrifuged at 4000 rpm and 5000 rpm, the weevil ejected the eggs in a heap on the glass surface of the container and subsequently the female died. There was a highly significant drop in the number of eggs laid and viable eggs.

It appears that centrifugation of *Callosobruchus maculatus* at lower speeds does not cause any harm, but centrifugation at higher speeds affects both the egg laying capacity and the viability of eggs.

Introduction

The cowpea weevil, *Callosobruchus maculatus* is an important pest of various pulse crops in Africa, India, the middle and Far East (Hill, 1975). It inflicts considerable damage to cowpea seed. Infestation which commences on mature pods and seeds in the field, persists and increases during storage (Osuji, 1982). Female lays her eggs on the surface of the cowpea and the newly hatched larvae tunnel directly into the kernal, ultimately the interior of the cowpea seed is virtually destoryed by the feeding activity of the developing larvae (Storey, 1978).

The principal method of controlling this pest is fumigation with methyl bromide in the stores (Metcalf and Flint, 1979). An alternative method of effective control other than fumigation would be desirable.

An attempt has been made in this study to determine the effect of horizontal centrifugation at different speeds on number of eggs laid, viability of eggs, developmental period from egg to adult and longevity of adult of *Callosobruchus maculatus*.

Materials and Methods

A mass culture of *Callosobruchus maculatus* was maintained under laboratory conditions on cowpea seeds which were previously heated to 140°F for four hours and cooled thereafter. *C. maculatus* was introduced into the jar. The adults that just emerged from these culture were used for experimental purposes.

In the experimental set-up, newly emerged adult *C. maculatus* (one female and two males) were allowed to mate and were introduced into a test tube (60 ml) containing 5g of cowpea seeds covered with fine gauze for ventilation. These test tubes were kept in each of the centrifuge tubes which was left open in order to fascilitate ventilation. The weevils were centrifuged for three hours. After centrifugation the test tubes were removed and observations were made until the weevils die.

Control experiments were conducted concurrently with the same number of weevils which were kept in comparable test tubes and observations recorded until death of the weevils under similar conditions (87.8°F and 78%RH) but without centrifugation.

Results

1) Number of eggs laid

Egg laying started during the period of three hours of centrifugation, and continued after removal from the container. The mean number of eggs laid per single adult on host seeds was 100.8 and 96.6 at speeds of 185 rpm and 370 rpm respectively. In comparison with the weevils of the control experiments, the centrifugation at this speeds caused no significant change in the number of eggs laid.

When centrifuged at 660 rpm, 1000 rpm and 3000 rpm, the eggs were not laid during centrifugation but laid after centrifugation. However the centrifugation at these speeds brought about a significant drop in the total number of eggs laid.

When centrifuged at 4000 rpm and 5000 rpm, most of the weevils (60%) ejected the eggs in a heap on the glass surface of the container and subsequently the weevils died. There was a highly significant drop in the number of eggs laid by the surviving weevils in comparison with that of the normal weevils. Most of the males were alive even after centrifugation at these speeds (Table I (a)).

2) Number of viable eggs

There was no significant change in the number of eggs hatched after centrifugation at 185 rpm and 370 rpm, when compared with the normal weevils.

Among the eggs that were laid by the weevils centrifuged at 660, 1000, 3000, 4000, & 5000 rpm, a significantly smaller number hatched out than those from the control experiment (Table I (b)).

3) **Developmental period from egg to adult and longevity of the adult.**

There was no significant difference in the developmental period (around 23 days) from egg to adult by centrifugation. But the longevity of adults at 4000 rpm and 5000 rpm, was reduced to 3.6 days and 3.4 days from 6.8 and 6.6 respectively (Table I (c)).

Discussion

The control of insect pests by horizontal centrifugation has not been attempted before. It appears that centrifugation affects most of the systems of insects, causing death. The effect of centrifugation on *C. maculatus* was experimented in this study.

It was found in this study that centrifugation of the weevils at lower speeds (185—370 rpm) has not affected the number of eggs laid, the number of viable eggs, developmental period and longevity. It appears that the weevil could withstand such centrifugation. However, the centrifugation at higher speeds

Table I : Effect of centrifugation on (a) Number of eggs (b) Number of viable eggs (c) Longevity (days), of *C. maculatus*. (rpm = Speed of centrifuge) *Significant (P = 0.05)

rpm	Control			Centrifuged weevils			Difference		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
185	105.5	62.8	6.9	100.8	60.2	6.7	4.7	2.6	0.2
370	101.8	56.5	6.5	96.6	51.5	6.5	5.2	4.0	0.0
660	98.3	59.2	6.8	70.0	47.0	6.3	*28.3	*12.2	0.5
1000	93.5	58.0	6.1	59.0	33.0	6.0	*34.5	*25.0	0.1
3000	100.1	61.4	6.5	59.3	32.0	5.4	*40.8	*29.4	*1.1
4000	91.0	57.0	6.8	32.0	15.0	3.6	*59.0	*42.0	*3.2
5000	95.0	58.5	6.6	15.0	10.0	3.4	*80.0	*48.5	*3.2

(660—3000 rpm) caused significant drop in the total number of eggs laid and the number of viable eggs. Obviously, the centrifugation at these speeds has affected the fecundity. This was probabaly due to physiological disturbances caused in the developmental stages of the oocytes. Such centrifugation did not cause considerable change either in developmental period of the larva or longevity of adult.

When centrifuged at still higher speeds (4000—5000 rpm), most of the female weevils ejected the eggs which did not develop at all. Centrifugation at these speeds too caused a drop in the number of eggs laid, the number of viable eggs, and reduced the longevity and the adult weevils. It appears that these speed caused mortality in this insect. Females were more affected than males by centrifugation at (4000 — 5000 rpm). Most of the males were alive after centrifugation at high speed. Therefore it is concluded that females are more susceptible to centrifugation than males.

Although fumigation has been the method of control of the pest, the centrifugation method gives an effective control of females and reduces the possibility of development of eggs of the weevils. This method of control is promising if chemical treatment had to be avoided for very specific reasons. Besides it gives some indication on the effect of gravitational force on egg development which may have morphogenetic significance related to polarity and development of physiological gradients during egg development.

Acknowledgement

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HEAT STRESS IN SRI LANKA — A HUMAN CLIMATIC APPROACH

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ABSTRACT Human Thermal climate of Sri Lanka was studied on the basis of heat stress. Theoretical and semi-empirical expressions were used for each individual heat exchange term in the steady state energy balance of a naked, average person standing at rest and facing the sun. Heat Stress on such a reference individual has been calculated from air temperature, vapour pressure, global solar radiation and wind speed for 22 meteorological stations in Sri Lanka on the basis of four weather seasons.

Introduction

In the past few years there has been a growing interest in using the Energy Balance approach to quantify the environmental impact on man. Of the interactions between man and his atmospheric environment, thermal or heat stress is more easily quantifiable than others. In the recent past a number of models have been developed to relate the man-environmental relations on the basis of the energy balance approach.

The energy Balance approach devised by Terjung (1966, 1976) for the United States, employing some estimates of all the four basic climatic parameters such as mean monthly maximum and minimum temperatures, mean monthly humidities, hours of sunshine and wind chill, delineate areas of effective temperature comfort zones. The scheme of effective temperature was first proposed by Houghten and Yogloglou (1923 a&b) as a tool of measuring heat stress for indoor sedentary man. However, despite its comprehensive nature, the scheme was not based on meaningful relationships between simultaneous data. Landsberg (1972), Auliciems (1973), and Auliciems and de Freitas (1976) used calorific insulatation requirements for a variety of metabolic rates in Canada, using empirical heat exchange constants applied to simultaneous observations of cloud cover, temperature and wind velocity at specified hours. The scheme was successfully applied to the Australian environment and the results proved that it had grater applicablity. As Auliciems and Kalma (1979) indicated, "the proposed procedures can be used with minor adjustments as well, either for the climatic classification or for the estimation of thermal stress at any given environment. This scheme is presently used to measure heat stress in Sri Lanka.

Before proceeding to explain the method in detail, it is important to see the Island's weather conditions in order to assess the heat stress situation of this tropical Island. Sri Lanka is an island situated at the South-eastern tip of

India. The island is located close to the equator and lies between the latitudes 5° 55′ and 9° 55′ North and between the longitudes of 79° and 81° East. Although, Sri Lanka is small in size, remarkable variations can be seen in its weather and climate. The latitudinal position, topography, neighbouring land mass, namely the Indian sub-continent, and upper air changes are factors which control the whether pattern of Sri Lanka. There are two monsoons which remarkably vary in terms of their origin, direction, relationship with the upper atmospheric circulation and the amount of rainfall they yield in two different regions of the Island - namely the dry zone and the wet zone. In between the two monsoons, there are also two other seasons, which are referred to as inter-monsoon seasons, with reference to their occurrence, and as convectional seasons with reference to their characteristics. The seasons and their months are given in Table 1.

Table 1 : General Weather Seasons of Sri Lanka

Months		Season
March	April	Convectional Season
May	September	South West Monsoon Season
October	November	Convectional Season
December	February	North East Monsoon

These seasons have been classified mainly on the basis of wind and rainfall variations. However, variations in the temperature over the Island are not significant. The annual range of temperature is not more than 70 °F in any part of the Island, and there is little difference in the length of day, unlike the conditions near the poles during summer. In Colombo, the longest day which falls on the 22nd of June is only 48 minutes longer than the shortest on the 22nd December. In Jaffna, it is 68 minutes longer while in Galle it is only 42 minutes.

The heat is also considerably ameliorated by the thick clouds which form during the hottest part of the day; these interfere with the transission of radiant energy in the air and protect land very considerably.

Powerful insolation throughout the year is a remarkable feature all over the island. However, the rainfall variation among the weather seasons, cloud and wind play a significant role in ameliorating the heat stress conditions. For example, when the seasonal dry weather prevails during the months of May to September in all parts of the dry zone, high wind speed subdue the heat stress conditions. When the wind speed falls, then excess sweating and discomfort result. Similarly, stress is higher on cloudless days than a cloudy days. But the heat stress does not vary as much as in temperate regions where extreme negative and positive stress conditions are found in winter and summer respectively. Reasonable heat stress variation arises from altitude. For example Nuwara Eliya (1830 m.) shows a negative stress condition due to its lower temperature caused by the environmental lapse rate. However, these negative heat stress values are insignificant when compared with the cold stress values are insignificant when compared with the cold stress or negative heat stress figures of winter season in temperate regions. For example, in Australia the negative heat stress value ranges from 100 watts to 900 watts in the winter season (Auliciems and Kalma, 1979).

Although several studies in bio-climatology have been carried out in other countries no such studies had been done in Sri Lanka in this field unit 1981.

The present work is a quantitative human heat stress study which is based on standard climatic data.

Materials and Methods

The Energy Balance approach is a modern technique which aids in the evaluation of the environmental impact such as heat and cold, upon the human body. The components of this energy balance equation satisfy both environmental and body heat regulation processes,

In this study the heat stress of a tropical Island was calculated from an equation which was derived from various methods developed in bio-meteorology particulary in human climatology. In this scheme the heat stress of the steady state energy balance of a naked, average person, standing at rest and facing the sun is calculated by using air temperature, vapour pressure, global solar radiation and wind speed.

The complete equation for calculating the heat stress is as follows:

$$HS = [132 + (Q+q)_m - (12.3 + 26.2\, V^{0.5})\,(35 - T_a)]\;\exp\,[0.6\,(E/E_{max} - 0.12)] \qquad -(W)$$

where, HS = Heat Stress. $(Q+q)_m$ = net (direct $-Q$, and diffuse $-q$) solar radiation on man, V = wind velocity in m s^{-1}, T_a = air temperature, E = evaporative heat loss and E_{max} = evaporative capacity of the nude body. The details of derivation of this equation are fully discussed in Appendix I.

Data :

Heat stress was calculated with the aid of the Thermal Stress equation for 22 meteorological stations which are fairly representative of the Island. Considering the weather seasons of the Island and the movement of the sun in Sri Lanka. We have selected five months and six time periods of the above seasons for heat stress calculations. This is given in the following Table.

Table 2 : Seasons and Time Periods Selected for the Study

Months	Time	Reason for Selection
March	21st	Month of Inter Monsoon (I) Equinox Vernal – vertical position of the sun at the equator.
April	8th	Overhead position of the sun at Colombo. Inter Monsoon (I) month.
June	22nd	Month of South West Monsoon–summer solstice.
September	5th	Overhead position of the sun at Colombo and last month of South West Monsoon season.
September	23rd	Autumnal Equinox – and last month of South West Monsoon season.
December	21st	Month of North East Monsoon and winter solstice.

On the basis of this classification, maps were drawn to illustrate the areal distribution of the heat stress. Data for the stress calculation were taken from the published and unpublished manuscripts from the Colombo meteorological department. Maximum temperature, average humidity, wind velocity, cloud coverage and air pressure were used with the average for the standard period of 1931 60. Vapour pressure (P_a) was calculated from the formula given bellow :

$$P_a = \frac{P'V - (P_B - P'_w)(t - t')}{2800 - t'}$$

where, $P'V$ is actual vapour pressure, in psia, (Appendix V), $P'w$ is vapour pressure corresponding to the wet bulb temperature in psia. P_B is total air pressure. (Appendix VI) in psia, t – is dry bulb temperature in degree F, and t' – is wet bulb temperature, in degree F (Appendix VII).

Sun angle and solar elevation for a particular location were calculated from latitude, date and time with the aid of the standard astronomical tables. Standard ground albedo figures were taken from the meteorological glossary with the consideration of the land use pattern of the island. The above data were utilized to calculate thermal stress for every selected location of the Island. Heat Stress was calculated for 1500 LST for the months shown in the Table 2 for Sri Lanka and the values were obtained for a representative day.

Results and Discussion

Heat Stress was quantified using climatic and physiological parameters with the aid of the scheme developed by Auliciems and Kalama (1979). The scheme is applied to an average man standing out doors, excluding any clothing insulation and standardizing his metabolic rate and in upright posture facing the sun. By solving the heat stress formula, the values of heat stress were obtained and they were ploted against the locations which are very well distributed and which are well represented over the Island. Heat stress was calculated for selected months according to the movement of the sun and the weather seasons of the Island.

March 21st and September 23rd are the months and days referred to as vernal equinox and autumn equinox in which the midday sun is located very close to the equator, it was realized that it will be useful to study the pattern of the thermal stress on these days. Similarly 8th April and 5th September are also taken for heat stress calculations due to the fact that these are the months and days receiving the sun rays directly overhead (90°) at Colombo and for a considerable period before and after these two dates the rays are nearly vertical. The months of March and Apirl fall on the first convectional season in the weather of Sri Lanka.

June 22nd is the summer solstice and it is also within a representative day for the south west monsoon season.

Similarly, December 22 which is in a representative month for the north east monsoon referred as the winter solstice in which the sun's rays come into contact with any segments of the surface at its lowest angle in Sri Lanka. However this angle is never lower than 57° above the horizon at midday. Taking the solar angle into account, the above months and dates have been selected for heat stress calculations.

The 21st of March is the day of the vernal equinox. On this day the solar angle for every part of the Island is more than 80°. The sun's rays striking at a high angle indicate that any part of the Island receives intense radiation heat, In March, a smaller region around Nuwara Eliya is close to neutrality and it shows the negative thermal stress (–71W) which is mainly due to the effect of the altitude. However, below this elevation a gradual increase in heat stress towards the low land is typical. The 200W heat stress line goes across the Island dividing two areas approximately south-east and north-west where the south-east section shows the heat stress values below +200W., and its counter part shows the increasing heat stress trend. Anuradhapura receives the highest heat stress in these months. High intensity of insolation due to mainly clear skies along with a reduced influence of the sea breeze mainly because of its interior location would have caused this pattern. Clouds forming over the sea, certainly have an effect on the solar radiation at the coastal stations. (Fig. 1.)

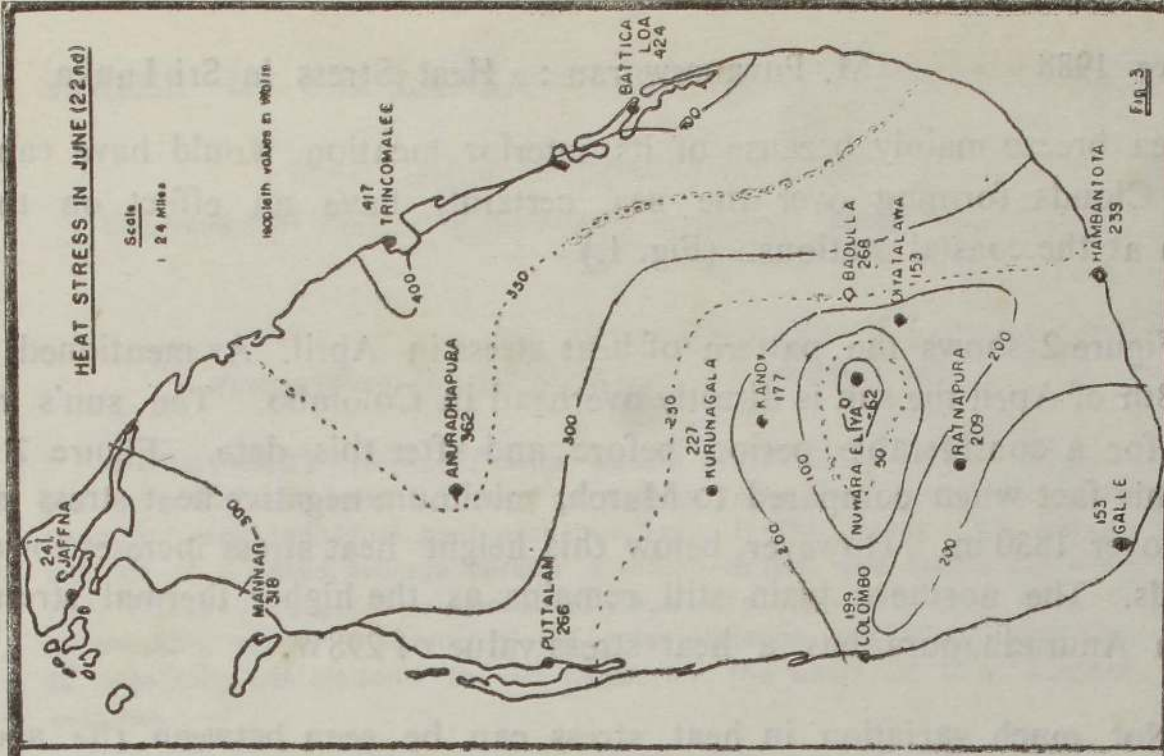
Figure 2 shows the pattern of heat stress in April. As mentioned earlier, on the 8th of April the sun is directly overhead in Colombo. The sun's rays are vertical for a considerable period before and after this date. Figure 2 clearly shows this fact when compared to March, minimum negative heat stress is typical in April over 1830 m. However, below this height heat stress increses towards the low lands. The northern plain still remains as the higher thermal stress region in which Anuradhapura has a heat stress value of 298W.

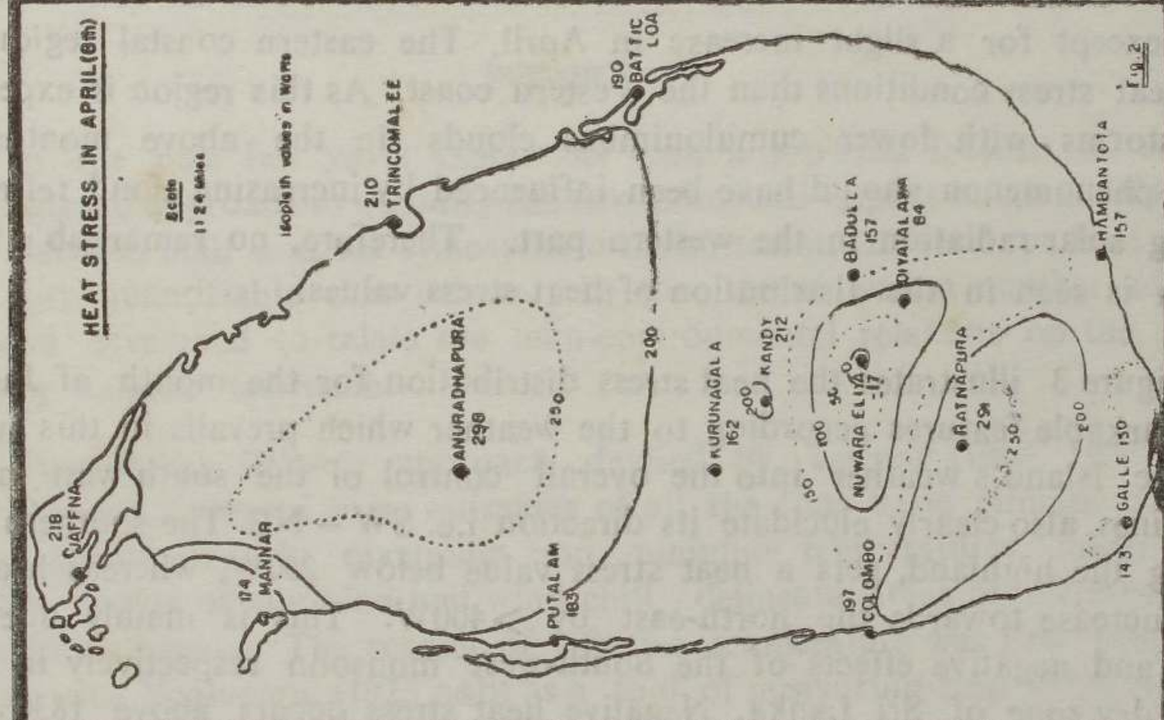
Not much variation in heat stress can be seen between the above two months except for a slight increase in April. The eastern coastal region shows higher heat stress conditions than the western coast. As this region is experiencing thunderstorms with lower cumulonimbus clouds in the above months, these weather phenomenon should have been influenced by increasing cloud reflection of incoming solar radiation in the western part. Therefore, no remarkab'e trend in direction is seen in the distribution of heat stress values.

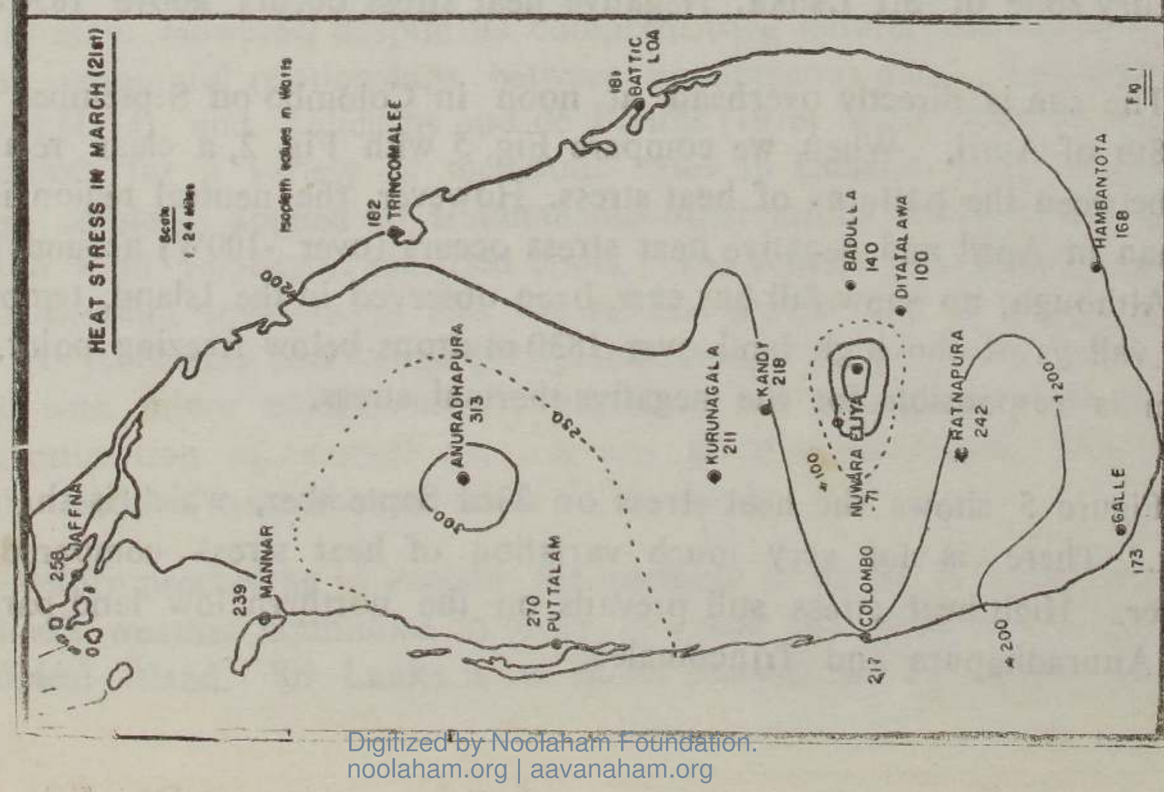
Figure 3 illustrates the heat stress distribution for the month of June. This has remarkable features according to the weather which prevails in this month as takes the Island's weather into the overall control of the south west monsoon. The isolines also clearly elucidate its direction i.e. SW – NE. The southern portion including the highland, gets a heat stress value below 250W, whereas heat stress values increase towards the north-east by >400W. This is mainly due to the positive and negative effects of the South-west monsoon respectively in the wet and the dry zone of Sri Lanka. Negative heat stress occurs above 1830 m.

The sun is directly overhead at noon in Colombo on September 5th and on the 8th of April. When we compare Fig. 5 with Fig 2, a clear relationship is seen between the patterns of heat stress. However, the neutral region is much wider than in April and negative heat stress occurs (over -100W) around Nuwara Eliya. Although, no snow fall has ever been observed in the Island, temperatures in deep valleys of the high land over 1830 m drops below freezing point. Such condition is responsible for the negative thermal stress.

Figure 5 shows the heat stress on 23rd September, which is the Autumn Equinox. There is not very much variation of heat stress compared to 5th September. High heat stress still prevails on the northern low land particularly around Anuradhapura and Trincomalee.


HEAT STRESS IN JUNE (22nd)
Scale
1 24 Miles
Isopleth values in Watts
JAFFNA 241
MANNAR 318
PUTTALAM 266
ANURADHAPURA 362
TRINCOMALEE 417
BATTICALOA 424
KURUNAGALA 227
KANDY 177
NUWARA ELIYA -62
BADULLA 268
DIYATALAWA 153
RATNAPURA 209
COLOMBO 199
GALLE 153
HAMBANTOTA 239
Fig 3


HEAT STRESS IN APRIL (8th)
Scale
1 24 Miles
Isopleth values in Watts
JAFFNA 218
MANNAR 174
PUTTALAM 183
ANURADHAPURA 298
TRINCOMALEE 210
BATTICALOA 190
KURUNAGALA 162
KANDY 212
NUWARA ELIYA -17
BADULLA 157
DIYATALAWA 84
RATNAPURA 291
COLOMBO 197
GALLE 150
HAMBANTOTA 157
Fig 2


HEAT STRESS IN MARCH (21st)
Scale
1 24 Miles
Isopleth values in Watts
JAFFNA 258
MANNAR 239
PUTTALAM 270
ANURADHAPURA 313
TRINCOMALEE 182
BATTICALOA 181
KURUNAGALA 211
KANDY 218
NUWARA ELIYA 71
BADULLA 140
DIYATALAWA 100
RATNAPURA 242
COLOMBO 217
GALLE 173
HAMBANTOTA 168
Fig 1

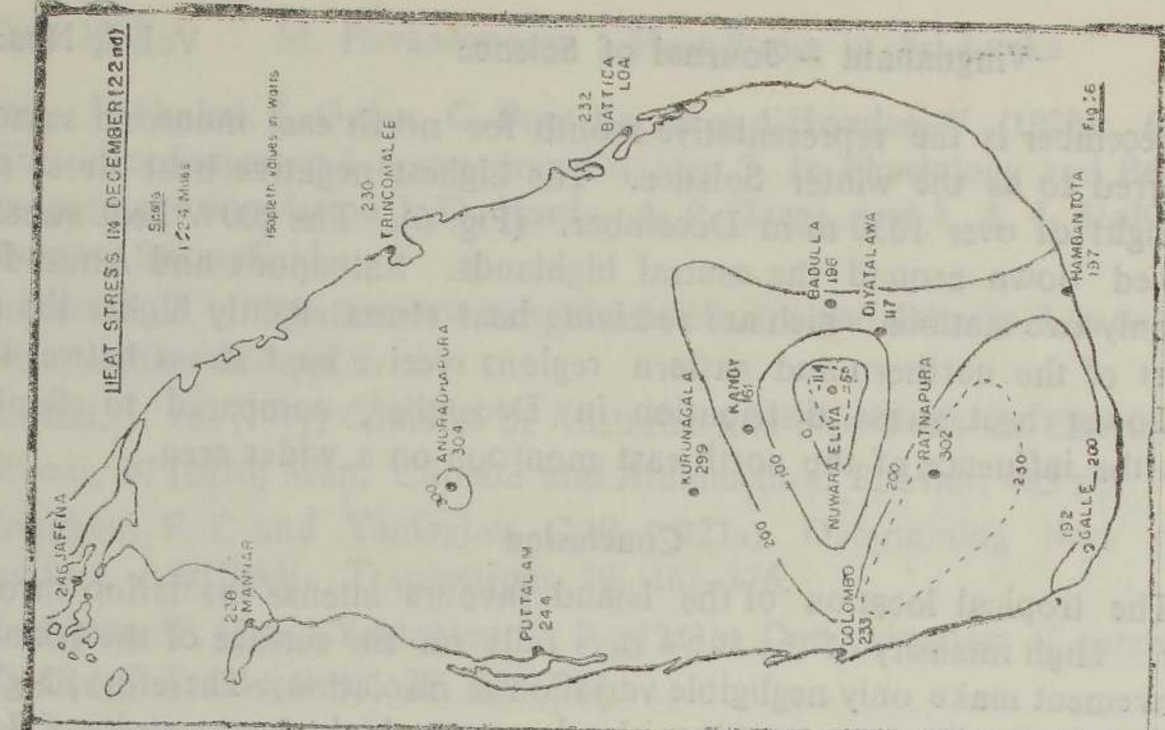


Fig. 6

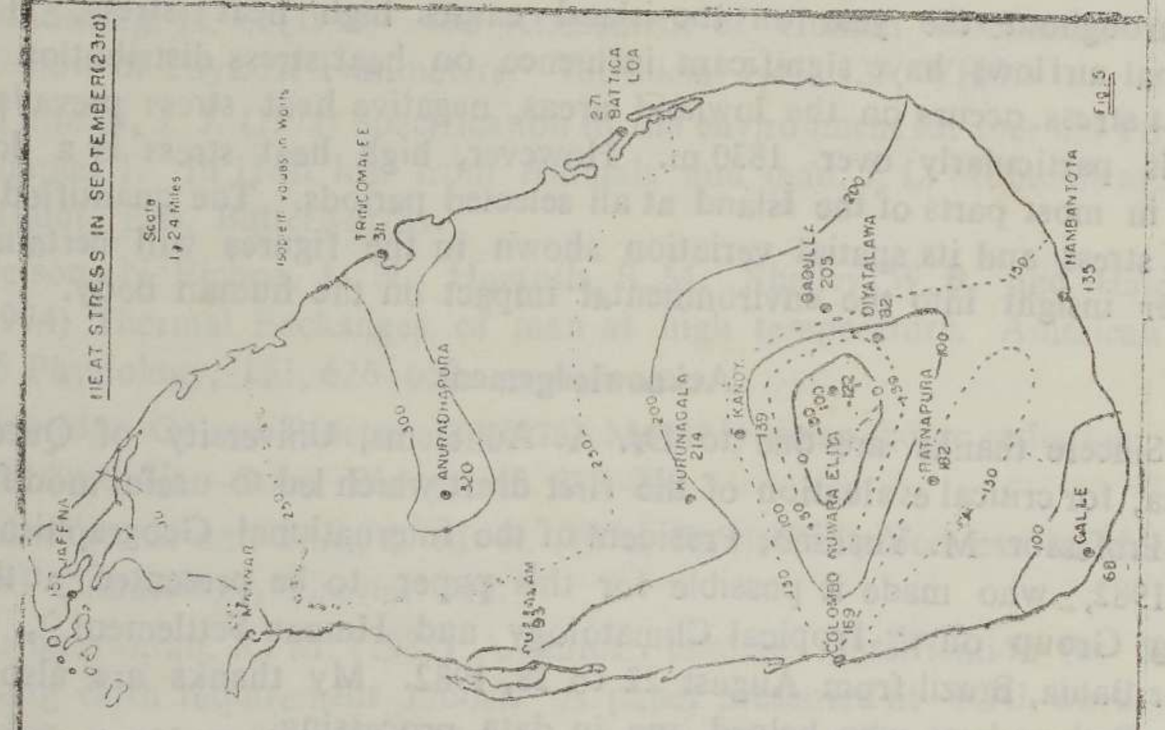


Fig. 5

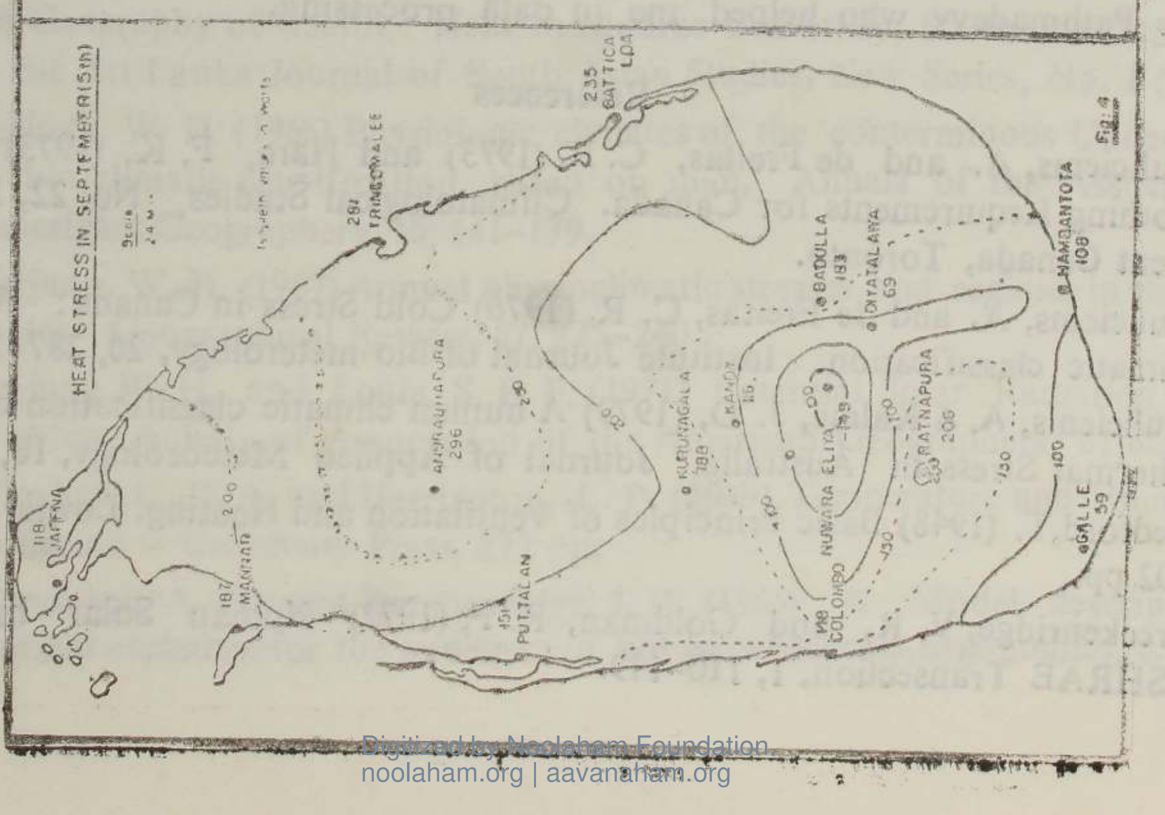


Fig. 4

December is the representative month for north east monsoon season and it is referred to as the winter Solstice. The highest negative heat stress prevails at the height of over 1830 m in December. (Fig. 6). The 200W heat stress curve is narrowed down around the central highlands. Ratnapura and Anuradhapura are the only two stations which are receiving heat stress slightly higher than 300W. Most part of the northern and eastern regions receive heat stress between 200 – 300W. Lower heat stress distribution in December, compared to September, indicates the influence of the north east monsoon on a wider area.

Conclusion

The tropical location of the Island favours intense insolation throughout the year. High intensity of the sun's rays falls on the surface of the Island. The sun's movement make only negligible variation in insolation. Therefore, high insolation throughout the year on the island causes high heat stress. However, monsoonal airflows have significant influence on heat stress distribution While high heat stress occurs on the lowland areas, negative heat stress prevails in the highlands particularly over 1830 m. However, high heat stress is a dominant feature in most parts of the Island at all selected periods. The quantified version of heat stress and its spatial veriation shown in the figures will certainly give a greater insight into the environmental impact on the human body.

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Appendix I

Derivation of Heat Stress Equation

Energy Balance approach is a modern technique which aids in the evaluation of the environmental impact such as heat and cold, upon human body, the components of this energy balance equation processes. This can be written as follows:

$$M_T \pm R \pm C - E = \pm S \qquad [W\,m^{-2}] \qquad -(1)$$

where, M_T is net metabolic heat production. R is long wave or infrared radiant heat exchange (+ for net loss), C is convection heat exchange (+ for net loss), E is evaporative heat loss, S is storage within body tissues, $W\,m^2$, is energy flux density in watts per square metre of surface-area of body. When considering the thermo-regulatory process with the environmental factors, the heat dissipation occurs in two ways :

(1) Those controlled by thermo-regulatory mechanisms wich respond to environmental factors and (2) processes which are either constant or largely uncontrollable and are going on at all times irrespective of ambient warmth (Auliciems and Kalma, 1979).

Of the second category the heat loss through the respiratory tract (M_R) insensible perspiration (M_P) and transformations into mechanical work (M_W) are the typical examples. Quantitative data of respiration and perspiration loss show that these are remarkably constant and they amount to some 25% of the metabolic rate (Dubois, 1927). However, 20—30% of the metabolic increase above the basal rate of 50 $W\,m^{-2}$ is transformed into mechanical work (Winslow and Herrington, 1949).

Long wave radiation and convection may be considered together as heat exchange (D) resulting in cooling in accordance with Newtonian principles, which directly apply to the human body over a wide range of environmental conditions (Bedford, 1948).

Thus :

$$D = R + C \qquad [W\,m^{-2}] \qquad -(2)$$

Thus equation (1) may be written:

$$M_T \pm D - E = \pm S \qquad [W\,m^{-2}] \qquad -(2a)$$

where,

$$M_T = M - (M_R + M_P) - M_W \qquad -(2b)$$

The Metabolic rate was taken for the upright standing posture with the M of 116 $W\,m^{-2}$ without any clothing insulation.

The equation in formula (2a) has the required physiological parameters for the heat balance calculations. Given appropriate data on air temperature, solar radiation and cooling constants, heat stress (HS) may be estimated under a variety of physiological circumstances. Perhaps, it is most useful to assume that man is attempting to achieve maximum thermal comfort or neutrality only by sweating at a skin temperature of 35°C. Setting M at 116 $W m^{-2}$, ($M_R + M_P$) is 29 $W m^{-2}$ and $M_W = 0.25 (M - 50)$ is 16.5 $W m^{-2}$. M_T therefore becomes 71 $W m^{-2}$. Total metabolic heat loss is obtained by multiplying by $A = 1.86 m^2$, the average surface area of man. (Terjung and Louie, 1971); Thus AM_T is 132W.

D is dry heat exchange or portion of heat loss by a sweating man at 35°C and D can be calculated as follows:

$$D = h (35 - T_a) \quad [W m^{-2}] \quad - (3)$$

where T_a is temperature of air, h is the combined coefficent of heat transfer to the air consisting of radiation (h_r) and convection (h_c) components. A large number of both theoretically and empirically based calculations have demonstrated that the long wave radiation component h_r may be regarded as a constant in homogeneous environment (Auliciems and Kalma, 1979). Since Sri Lanka is an island and its areal extent is very small, this factor is taken as constant. Loss through convection, on the other hand, (h_c) varies according to the rate of air motion. These combined heat transfer coefficients have been estimated by various researches by experiments (Nelson et al, 1947, Woodcock and Brechenridze, 1965, Colin et al, 1970). The equation by Nelson et al (1947) closely corresponds to the general formula proposed for day heat lossess from both men and animals (Monteith, 1974) and it is a very well known equation.

$$h = 6.6 + 8.7 V^{0.5} \quad [W m^{-2} °C^{-1}] \quad - (4)$$

where, V is wind velocity in $m S^{-1}$ (Appendix II)

E, the evaporative heat loss is equvalent to the actual sweating rate of human body.

$$E = AM_T + (Q+q)_m - AD \quad - (5)$$

where, $(Q+q)_m$ is net solar radiation load on man. A is average surface area of man, M_T is net metabolic heat production, D is dry heat exchange.

Evaporative heat loss is equivalent to the amount of heat which has not been eliminated by long wave radiation and convection.

Solar radiation data is an essential component to solve the heat balance formula. However, no instrumentally measured radiation data is available in Sri Lanka. Due to lack of insolation data in Sri Lanka, radiation in this case was calculated with empirical methods described by Paltridge and Proctor (1976) and Paltridge and Platt (1976) based on cloud cover observations. First Q_h the direct clear-sky radiation on a unit horizontal surface per unit time is calculated from the following formula (Appendix III).

$$Q_h = 1000\,[1 - \exp(-0.06x)]\,(1-\phi)\,\text{Sin}\,\alpha \quad [W\,m^{-2}] \quad -(6)$$

Where. α is solar angle (degree) and ϕ the observed fractional cloud cover (0–1). Solar angle α is calculated from the coordinates of the station concerned, its time zone, date and station time.

The total (Global) radiation on a horizontal surface per unit time $(Q_h + q_h)$ is then calculated from:

$$(Q_h + q_h) = I_o\,(1 - a\,\phi)\,[1 - k_i - k_{ii}\,(1-\phi)]\,\sin\alpha \quad [W\,m^{-2}] \quad -(7)$$

where, Q_h = Direct clear-sky radiation on a unit horizontal surface per unit time.

q_h = Diffuse radiation on horintal surface. $(W\,m^{-2})$

I_o = Solar constant. $(1353\ W\,m^{-2})$

a_1 = Mean could albedo taken at 0.5 (Paltridge, 1973).

K_1 = Absorption due to H_2O Vapour set at 0.18.

K_{11} = Albedow of clear sky in fraction $(1-\phi)$ calculated from Paltridge (1973)

It then follows that:

$$q_h = (Q_h + q_h) - Q_h \quad [W\,m^{-2}] \quad -(8)$$

The net direct radiation falling in the vertical human body surface Q_v is obtained from:

$$Q_v = A A_i\,(Q_h / \text{Sin}\,\alpha)\,(1 - a_b) \quad [W] \quad -(9)$$

where, A_i is the fraction of body area, A_i is receiving radiation on a plane normal to the beam (measured from intersept area for specific angle by Breckenridge and Goldman (1972) and a_b the albedo of the human body. Net diffuse radiation q_v falling on the vertical body surface is calculated from:

$$q_v = A(A_z + A_v / 2)\,q_h\,(1 - a_b) \quad [W] \quad -(10)$$

where, A_z is the fraction of A facing zenith and A_v the fraction facing horizon. (Breckenridge and Goldman, 1972).

If Q_q and q_q are the direct and diffuse radiation reflected by the ground and falling on the vertical body surface, then:

$$Q_q + q_q = (A A_v / 2)\,(Q_h + q_h)\,(\cos\alpha)\,a_q\,(1 - a_b) \quad [W] \quad -(11)$$

Here, a_q is the fractional albedo of ground obtained from Gentilli (1971) and α the solar angle (degree).

The net solar radiation load on man become.

$$\begin{aligned}(Q+q) &= Q_v + q_v\,Q_q + q_q \\ &= A\,(1 - a_b)\,(A_i\,Q_h / \text{Sin}\,\alpha) + [(A_z + A_v / 2)\,q_h] + \\ &\quad [(A_v / 2)\,(Q_h + q_h)\,(\cos\alpha)\,a_q]. \quad [W] \quad -(12)\end{aligned}$$

Given that $A = 1.86\ m^2$, a_b is the albedo of dark skin and set at 0.3 and $A_z = 0.1$, $A_v = 0.6$ for a standing person facing the sun, it follows that,

$$(Q + q)_m = 1.12\ A_i\ Q_h / \text{Sin}\ \alpha + 0.45\ q_h + 0.34\ (Q_h + q_h)\ (\text{Cos}\ \alpha)\ a_q \qquad [W] \qquad -(13)$$

The calculation of net direct and diffuse solar radiation absorbed by the human body $(Q + q)_m$ thus depends on the solar elevation and surface albedo.

When radiation R and convection C fail to eliminate the heat load of the human body, active sweating may be expected to occur once the temperature of skin reaches 35°C. The evaporation term E in equation (1) then represents the amount of latent heat of vaporization required to be removed inorder to maintain homeothermy but as such it does not indicate the levels of inefficiency involved in sweating processes. This depends on the rate and place of evaporation and the amount of energy drown from the adjoining air. Lower efficiencies are clearly associated with higher sweating, i.e. excess sweating. Givoni (1976) has expressed such excess sweating in terms of a cooling efficiency factor in his Index of Thermal Stress formula. This may be regarded as equivalent to :

$$HS = [M_T + (1/A)\ (Q+q)_m - D_{ii}\ ]\ (A / f) \qquad [W] \qquad -(14)$$

Where, HS is the heat stress, which is equivalent to the total amount o sweating per unit time, and according to Givoni (1976), (f) is the cooling efficiency of sweating:

$$1/f = \exp\ [(0.6\ (E/E_{max}\ - 0.12)] \qquad -(15)$$

with $1 \geq f \geq 0.29$.

The actual sweating rate $E = M_T + (1/A)\ (Q+q)_m - D_{ii}$ is equivalent to the amount of heat which has not been eliminated by long-wave radiation and convection.

E_{max} in formula (15) is the evaporative capacity of the nude body. This can be calculated from :

$$E_{max} = 37.2\ V^{0.3}\ (42 - P_a) \qquad [W] \qquad -(16)$$

Where, P_a is the vapour pressure of air in mmHg; and 42 mmHg represents the vapour pressure on the surface of the skin at 35°C and V is wind speed (ms^{-1}).

Considering all the factors mentioned above, the heat stress or Thermal Stress of a human body, expressed as a positive thermal stress can be written as follows :

$$HS = [132 + (Q + q)_m - (12.3 + 26.2\ V^{0.5})\ (35 - T_a)\ \exp\ [0.6\ (E / E_{max} - 0.12)] \qquad [W] \qquad -(17)$$

Appendix II

Wind velocity $m\ s^{-1}$

$$ms^{-1} = \frac{(Vmph \times 0.44715)}{30}$$

Station	Representative Months March	April	June	September	December
Colombo	1.55	1.63	2.38	2.23	1.89
Puttalam	1.80	1.98	4.08	3.65	2.41
Mannar	2.83	2.47	2.34	3.57	2.59
Jaffna	1.60	2.83	5.90	5.10	1.64
Trincomalee	2.32	2.28	4.84	3.65	4.10
Batticaloa	2.42	2.11	2.20	2.16	2.86
Hambantota	3.63	3.37	5.14	5.22	3.95
Galle	2.02	2.49	4.37	4.02	2.10
Ratnapura	0.95	0.98	1.36	1.22	0.83
Anuradhapura	0.95	0.98	1.36	1.22	0.83
Kurunegala	1.09	1.06	2.37	2.23	1.04
Kandy	1.36	0.88	1.37	1.41	1.13
Badulla	1.27	1.12	2.01	1.49	1.22
Diyatalawa	0.88	0.92	1.91	1.36	0.97
Nuwara Eliya	2.19	1.40	3.77	2.37	2.20

Appendix III

Direct Clear Sky Radiation on a Unit

Horizontal Surface Qh (Calculated data) $W\ m^{-2}$

Stations	March	April	June	Sept 5th	Sept. 23rd	Dec. 22nd
Colombo	463	398	142	219	217	335
Puttalam	590	537	207	348	344	318
Mannar	588	590	204	308	304	286
Jaffna	636	496	308	407	401	308
Trincomalee	551	478	230	298	325	249
Batticaloa	491	447	274	378	393	246
Hambantota	523	428	254	378	375	330
Galle	474	388	237	328	356	339
Ratnapura	395	308	168	249	247	235
Anuradhapura	540	400	222	278	324	272
Kurunegala	502	378	175	289	276	275
Kandy	522	398	150	279	276	270
Badulla	503	328	318	348	404	235
Diyatalawa	444	348	260	279	336	185
Nuwara Eliya	424	308	84	189	187	243

Appendix IV

Diffuse Radiation on Horizontal Surface

Qh=(Qh+gn) – Qh [W $\bar{m}^2$]

Station	March	April	June	Sept. 5th	Sept 23rd	December
Colombo	299	239	379	419	419	285
Puttalam	235	218	348	355	352	291
Mannar	235	152	338	419	415	292
Jaffna	212	284	277	327	324	288
Trincomalee	225	290	326	391	359	323
Batticaloa	302	307	304	351	329	320
Hambantota	266	314	327	338	337	290
Galle	290	328	333	381	350	288
Ratnapura	330	419	365	402	300	332
Anuradhapura	259	329	330	412	359	306
Kurunegala	279	338	360	375	383	331
Kandy	256	331	368	385	383	326
Badulla	279	362	291	387	326	330
Diyatalawa	306	355	322	315	357	359
Nuwara Eliya	313	419	403	429	427	328

Appendix V

Vapour pressure [Psia] (Calculated)

Stations	March	April	June	September	December
Colombo	24.0	25.8	26.3	24.7	22.4
Puttalam	23.4	25.9	25.1	23.3	22.5
Mannar	23.5	25.2	25.5	24.4	21.6
Jaffna	23.0	25.9	24.0	22.4	21.4
Trincomalee	23.4	25.2	22.2	22.3	21.1
Batticaloa	24.5	25.3	21.8	24.3	22 5
Hambantota	24.3	25.9	24.4	23.9	22.9
Galle	25.0	26.7	25.2	24.5	22.9
Ratnapura	23.1	25.1	24.9	24.1	23.6
Anuradhapura	22.7	24.7	22.6	20.8	20.7
Kurunegala	22.7	23.6	24.5	23.2	15.0
Kandy	21.7	20.7	21.4	20.8	20.0
Badulla	20.6	21.5	21.7	18.5	20.1
Diyatalawa	17.0	17.5	15.8	15.5	17.2
Nuwara Eliya	13.8	13.3	13.9	13.6	13.4

Appendix VI

Air Pressure (mb)

Stations	March	April	June	September	December
Colombo	1010.25	1008.75	1009.6	1008.85	1014.9
Puttalam	1010.55	1008.75	1008.85	1008.3	1010.65
Mannar	1010.65	1008.45	1007.45	1007.45	1010.8
Jaffna	1010.95	1008.3	1007.05	1007.1	1011.05
Trincomalee	1010.55	1008.2	1007.0	1006.95	1010.01
Batticaloa	1010.6	1008.5	1007.3	1007.3	1010.05
Hambantota	1010.15	1008.45	1008.55	1008.15	1009.45
Galle	1010.45	1008.8	1009.8	1009.2	1009.75
Ratnapura	1010.45	1009.8	1009.8	1009.2	1009.85
Anuradhapura	1001.1	998.2	997.8	997.25	1000.2
Kurunegala	996.65	995.2	995.75	995.1	996.6
Kandy	957.3	956.1	956.3	955.6	956.85
Badulla	936.4	934.8	934.0	933.7	935 65
Diyatalawa	876.4	875.15	874.5	874.1	875.3
Nuwara Eliya	814	813.2	812.4	812.05	812.45

Appendix VII

Mean Wet Bulb Temperature (°F)

Stations	March	April	June	September	December
Colombo	79.2	80.6	80.0	79.0	77.4
Puttalam	79.2	81.1	79.5	78.4	76.9
Mannar	79.0	81.5	80.4	79.4	76.6
Jaffna	78.5	81.3	78.9	79.7	75.9
Trincomalee	78.3	80.5	78.6	78.7	76.4
Batticaloa	78.6	80.7	79.9	79.9	76.9
Hambantota	79.2	80.8	79.2	78.8	77.8
Galle	78.9	80.1	79.2	78.3	77.3
Ratnapura	79.4	80.9	79.7	79.0	78.6
Anuradhapura	77.9	80.5	78.2	77.3	76.4
Kurunegala	78.0	80.4	79.1	78.2	76 7
Kandy	75.6	78.0	75.1	74.7	74.3
Badulla	73.4	75.6	76.1	73.3	71.3
Diyatalawa	68.0	70.0	67.7	67.5	66.8
Nuwara Eliya	62.5	64.5	62.0	62.3	62.0

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விஞ்ஞானம்

JOURNAL OF SCIENCE

விஞ்ஞானம் இதழ் 3 னது வெளியீடு எமக்கு கட்டுப்படுத்த இயலாத சூழ்நிலைகளினால் தாமதப்பட்டதுடன் மீண்டும் இரு வெளியீடுகளை சேர்த்து ஒன்றாக பிரசுரிக்கும் நிலை ஏற்பட்டுள்ளது.

ஏனைய இதழ்களைப் போல இதழ் 3இலும் ஆய்வுரைகள் எமது பிரதேசத்திற்குரிய பிரச்சனைகளுடன் தொடர்புடையதாகும்.

எமது விவசாய விளைபொருட்களின் உற்பத்தியின் குறிப்பிடத் தக்களவு செலவு பீடைகள் நோய்களின் கட்டுப்பாடாகும். வெளியிடப்பட்ட கட்டுரைகளில் ஏழில் ஆறு இவ்வகையான ஆராய்ச்சிகளுடன் சம்பந்தப்பட்டது.

நிரஞ்ஜனி இராமநாதன், சிவபாலன் ஆகியோரது ஆய்வுக்கட்டுரை யாழ்ப்பாணத்தில் காணப்படும் ஒரு பொதுவான, வெங்காய இலைக்குரிய நோயினைக் கட்டுப்படுத்துவதில் பங்கசு கொல்லிகளின் சரியான பாவனையோடு சம்பந்தப்பட்டது. இன்னோர் கட்டுரையில் யாழ் திராட்சை பயிர்ச்செய்கையாளருக்கு ஒரு பாரிய பிரச்சனையாக உள்ள திராட்சை வெண் பூஞ்சண நோயினது விருத்தியில் சூழலிற்குரிய காரணிகளின் தாக்கம் பற்றிய கண்டுபிடிப்புகள் வெளியிடப்பட்டுள்ளன.

பத்மினி மகேஷ்வரன், கணேசலிங்கம் ஆகியோர் வேப்பம் விதைகளிலிருந்து பெறப்படும் வேப்பம் புண்ணாக்கினது பூச்சி கொல்லி பண்புகள் பற்றிய ஆர்வமிக்க தகவலை தந்துள்ளனர். இது சேதன விவசாயத்தில் ஆர்வமுள்ளோர்க்கு பிரயோசனமானது.

இரு ஆய்வுக்கட்டுரைகளில் பீடைகளின் முட்டைவிருத்தி பற்றி விளக்கப்பட்டுள்ளது. இராஜேந்திரம், ரஜனி இராஜேஸ்வரன் ஆகியோர் ஒரு உள்நாட்டிற்குரிய நெல்பீடையின் முட்டையின் விருத்தியை விபரிக்கின்றனர். இன்னோர் கட்டுரையில் சகுந்தலாதேவி அம்பிகைபாகன், கணேசலிங்கம் ஆகியோர் ஒரு பூச்சிப்பீடையின் முட்டை விருத்தியில் மையநீக்கத்தின் விளைவை அறிவித்துள்ளனர்.

இராஜேந்திரம், அனெற் குணசிங்கத்துடன் தமது இரண்டாவது கட்டுரையில் ஒரு இலங்கையிலுள்ள நெல் பீடையின் ஒன்றியவாழி பற்றி குறிப்பிட்டுள்ளார்.

சூழல் காலநிலை தற்போது பல்வேறுவகை பிரிவுகளைச் சார்ந்த பல விஞ்ஞானிகளும் ஆர்வம் காட்டும் ஒரு படிப்பாகும். புவனேஸ்வரனினது கட்டுரையானது இது சம்பந்தப்பட்டதாகும். பல வருடங்களுக்குரிய வானிலை அளவேடுகள் நன்கு ஆராயப்பட்டு இலங்கையில் வெப்ப அழுத்தத்தின் விளைவு பற்றி ஒரு தெளிவான அறிவு பெறப்பட்டுள்ளதுடன் இது எமது நாட்டின் பருவ காலங்களை விவேகமுள்ள முறையில் பகுத்தறியவும் உதவும்.

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பேராசிரியர் சோ. கந்தையா
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இதழ் 3 1ம் 2ம் வெளியீடு

விஞ்ஞானம்

JOURNAL OF SCIENCE

விஞ்ஞானம் இதழ் 3 னது வெளியீடு எமக்கு கட்டுப்படுத்த இயலாத சூழ்நிலைகளினால் தாமதப்பட்டதுடன் மீண்டும் இரு வெளியீடுகளை சேர்த்து ஒன்றாக பிரசுரிக்கும் நிலை ஏற்பட்டுள்ளது.

ஏனைய இதழ்களைப் போல இதழ் 3இலும் ஆய்வுரைகள் எமது பிரதேசத்திற்குரிய பிரச்சனைகளுடன் தொடர்புடையதாகும்.

எமது விவசாய விளைபொருட்களின் உற்பத்தியின் குறிப்பிடத் தக்களவு செலவு பீடைகள் நோய்களின் கட்டுப்பாடாகும். வெளியிடப்பட்ட கட்டுரைகளில் ஏழில் ஆறு இவ்வகையான ஆராய்ச்சிகளுடன் சம்பந்தப்பட்டது.

நிரஞ்ஜனி இராமநாதன், சிவபாலன் ஆகியோரது ஆய்வுக்கட்டுரை யாழ்ப்பாணத்தில் காணப்படும் ஒரு பொதுவான, வெங்காய இலைக்குரிய நோயினைக் கட்டுப்படுத்துவதில் பங்கசு கொல்லிகளின் சரியான பாவனையோடு சம்பந்தப்பட்டது. இன்னோர் கட்டுரையில் யாழ் திராட்சை பயிர்ச்செய்கையாளருக்கு ஒரு பாரிய பிரச்சனையாக உள்ள திராட்சை வெண் பூஞ்சண நோயினது விருத்தியில் சூழலிற்குரிய காரணிகளின் தாக்கம் பற்றிய கண்டுபிடிப்புகள் வெளியிடப்பட்டுள்ளன.

பத்மினி மகேஷ்வரன், கணேசலிங்கம் ஆகியோர் வேப்பம் விதைகளிலிருந்து பெறப்படும் வேப்பம் புண்ணாக்கினது பூச்சி கொல்லி பண்புகள் பற்றிய ஆர்வமிக்க தகவலை தந்துள்ளனர். இது சேதன விவசாயத்தில் ஆர்வமுள்ளோர்க்கு பிரயோசனமானது.

இரு ஆய்வுக்கட்டுரைகளில் பீடைகளின் முட்டைவிருத்தி பற்றி விளக்கப்பட்டுள்ளது. இராஜேந்திரம், ரஜனி இராஜேஸ்வரன் ஆகியோர் ஒரு உள்நாட்டிற்குரிய நெல்பீடையின் முட்டையின் விருத்தியை விபரிக்கின்றனர். இன்னோர் கட்டுரையில் சகுந்தலாதேவி அம்பிகைபாகன், கணேசலிங்கம் ஆகியோர் ஒரு பூச்சிப்பீடையின் முட்டை விருத்தியில் மைய நீக்கத்தின் விளைவை அறிவித்துள்ளனர்.

இராஜேந்திரம், அனெற் குணசிங்கத்துடன் தமது இரண்டாவது கட்டுரையில் ஒரு இலங்கையிலுள்ள நெல் பீடையின் ஒன்றியவாழி பற்றி குறிப்பிட்டுள்ளார்.

சூழல் காலநிலை தற்போது பல்வேறுவகை பிரிவுகளைச் சார்ந்த பல விஞ்ஞானிகளும் ஆர்வம் காட்டும் ஒரு படிப்பாகும். புவனேஸ்வரனினது கட்டுரையானது இது சம்பந்தப்பட்டதாகும். பல வருடங்களுக்குரிய வானிலை அளவேடுகள் நன்கு ஆராயப்பட்டு இலங்கையில் வெப்ப அழுத்தத்தின் விளைவு பற்றி ஒரு தெளிவான அறிவு பெறப்பட்டுள்ளதுடன் இது எமது நாட்டின் பருவ காலங்களை விவேகமுள்ள முறையில் பகுத்தறியவும் உதவும்.

மே 1989

பேராசிரியர் சோ. கந்தையா
இதழ் ஆசிரியர்

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இவ்விதழ் கட்டுரைகளின் சுருக்கங்கள்

ALTERNARIA ALTERNATA (Fr.) Keissler இனது உயிரியலும் அதன் விருத்தியில் பங்கசு கொல்லிகளின் தாக்கத்திற்கான ஆய்வுகூட மதிப்பீடும்.

ஆசிரியர்கள் :
நிரஞ்ஜனி இராமநாதன்
(தாவரவியல் துறை, யாழ். பல்கலைக் கழகம்.)

அ. சிவபாலன்
(உயிரியல் துறை, பிரித்தானிய கயானா பல்கலைக்கழகம், கயானா).

Vingnanam J. Sci. 3 : 1 – 9 (1988)

சுருக்கம் :

Alternaria alternata எனப்படும் பங்கசானது தொடர்ச்சியாக வெங்காயத் தாவரங்களின் இலை விழுதலுடன் சம்பந்தப்பட்டிருப்பது தோட்டங்களின் அவதானங்களிலிருந்து காட்டப்பட்டதுடன் இது இலை விழுதலைத் தூண்டுவதில் பங்கெடுக்கலாமென சந்தேகிக்கப்பட்டது. இப்பங்கசானது பிரித்தெடுக்கப்பட்டு அதன் தூளியவித்தி முளைத்தலிற்கான சிறப்பு வெப்பநிலை, 100% ஈரப்பதனிலையில், 25°ச எனக் கண்டறியப்பட்டது. ஆயினும் பூஞ்சண வலை வளர்சியானது 25°ச ஐ விட 30°ச விலேயே சிறப்பானதெனக் காணப்பட்டது.

பங்கசு வித்தி முளைத்தல், பூஞ்சணவலை வளர்ச்சி வீதம் ஆகியவற்றில் இரு தொகுதிக்குரிய பங்கசு கொல்லிகளினதும் (benomyl, baycor) ஒன்பது தொகுதிக்குரியதற்ற பங்கசு கொல்லிகளினதும் (cupravit, morestan, pomarsol, sulphur, brassicol, morut, antracol, difolatan, daconil) 0 தொடக்கம் 1000ppm வரையிலான செறிவுகளின் தாக்கங்கள், ஆய்வு கூடத்தில் ஆராயப்பட்டன. Cupravit தவிர்ந்த மிகுதி எல்லா பங்கசு கொல்லிகளும் வித்தி முளைத்தலை 10 ppm செறிவில் பாதித்தன.

பங்கசு பூஞ்சண வலை வளர்ச்சி வீதம் வெவ்வேறு பங்கசு கொல்லிகளிற்கு வேறுபட்டது. Difolatan, daconil, benomyl, pomarsol ஆகியன 0 தொடக்கம் 500 ppm வரையான செறிவுகளில் பூஞ்சண வலை வளர்ச்சியைப் பாதித்ததுடன் 1000 ppm செறிவில் முற்றாகத் தடை செய்தன. Morestan, brassicol, morut, baycor, antracol ஆகியவை 10 தொடக்கம் 1000 ppm வரையிலான செறிவுகளில் வளர்ச்சியைக் குறிப்பிடத்தக்களவு குறைத்தன. Cupravit, Sulphur ஆகியன குறிப்பிடத்தக்களவு வளர்ச்சியை சகல செறிவுகளிலும் காட்டின.

பங்கசானது பொதுவாக daconil, benomyl அல்லது pomarsal கொண்ட ஊடகத்தில் மூன்று நாட்களில் இறக்கச் செய்யப்பட்டது.

மேற்கூறிய ஆய்வானது benomyl, daconil, pomarsol போன்றவை *Alternaria alternata* ஐக் கட்டுப்படுத்தப் பாவிக்கலா மென்பதனைக் காட்டுகிறது

திராட்சை வெண்பூஞ்சண நோய் தோற்றப்படுதல், பரம்புதல் ஆகிய வற்றிற்குரிய வெளிக்கள அவதானங்கள்.

ஆசிரியர் :

நிரஞ்ஜனி இராமநாதன்

(தாவரவியல் துறை, யாழ். பல்கலைக்கழகம்.)

Vingnanam J. Sci. 3 : 10 – 19 (1988)

சுருக்கம் :

யாழ்ப்பாணத்தில் திராட்சைக்குரிய வெண் பூஞ்சண நோய்த் தாக்கமானது அதிக ளவு ஈரப்பதன், தாழ் வெப்பநிலை மற்றும் பனி தோற்றப்படும் மழை காலத்தில் அவ தானிக்கப்பட்டது. தொற்றலானது பங்கசின் வித்திக்கலன் முளைத்தலுடன் தொடக்கி வைக்கப்பட்டு பின் வித்தி முளைத்தல் தொடக்கம் வித்திப் பரம்பல் வரையிலான நோய் வட்டம் எட்டு நாட்களில் முடிவடைந்தது. திராட்சையின் ஓரளவு முதிர்ந்த இலைகளே முதலில் பாதிக்கப்பட்டுப் பின் பங்கசானது இவற்றிலிருந்து ஏனைய தொற்றல்களை ஏற் படுத்தியது.

ஒரு திராட்சைத் தோட்டத்தில் பரம்பப்படும் வித்திக்கலன்களின் எண்ணிக்கை பகல் 12 மணி தொடக்கம் 2 மணி வரையும், தோட்டத்தின் செங்குத்தான திசையிலும், உயர் பெறுமானங்களைக் கொண்டிருக்கக் காணப்பட்டது. அதியுயர் எண்ணிக்கை வித்தி கள் திராட்சை இலைக்கூடலின் நேர் கீழாகக் கண்டறியப்பட்டன. தொற்றலின் அள வும், தினமும் வெளிவிடப்படும் வித்தியினளவும், மழைகாலங்களில் ஒரு, நான்கு அவத் தைகளைக் கொண்ட வளர்ச்சி வளையியை ஒத்துக் காணப்பட்டன. தோட்டத்தில் கிருமியினளவு அதிகரித்தல், பங்கசு நிலைநிறுத்தல், மழைகாலம் முடிவடைகையில் பங்கசு அழிவடைதல் போன்றவை காலநிலையில் தங்கியிருக்கக் காணப்பட்டன.

TRIBOLIUM CASTANEUM இன் இனப்பெருக்க உயிரியலில் வேப்பம் விதையிலுள்ள (*AZADIRACHTA INDICA*) ஆவியாகும் பதார்த்தங்க ளின் விளைவு. (*COLEOPTERA : TENEBRIONIDAE*)

ஆசிரியர்கள் :

பத்மினி மகேஸ்வரன், V. K. கணேசலிங்கம்

(விலங்கியல் துறை, யாழ். பல்கலைக்கழகம்)

Vingnanam J. Sci. 3 : 20 26

சுருக்கம் :

நொருக்கப்பட்ட *Azadirachta indica* (வேம்பு) விதைகளின் ஆவியாகும் பதார்த்தங் களின் விளைவு, புதிதாக வெளியேறியதும், புணர்ந்ததுமான நிறையுடலி *Tribolium castaneum* இல் படிக்கப்பட்டது. வளியானது நொருக்கப்பட்ட *A. indica* விதைகள் கொண்ட சாடியினூடாக செலுத்தப்பட்டு பின்னர் அங்கிருந்து சேதமாக்கப்பட்ட அரிசி மணிகளில் வாழுகின்ற 1 சோடி *T. castaneum* உள்ள சாடியினூடாக செலுத்தப்பட் டது இவ் வளி கொண்ட கிட்டத்தட்ட 13% *neem* இனது ஆவியாகும் பதார்த்தம் பரிசோதனை முழுவதிற்கும் தொடர்ச்சியாக செலுத்தப்பட்டது.

ஆவியாகும் பதார்த்தங்களைக் கொண்ட வளியின் முன்னிலையில், *T. castaneum* இன் இனப்பெருக்க உயிரியல் சம்பந்தமான பின்வரும் அவதானிப்புகள் தயாரிக்கப்பட்டன 27 5% ஆல் முட்டைகளின் எண்ணிக்கையில் கருதத்தக்களவு குறைப்பு; 2.5 நாட்களால் முட்டையில் இருந்து குடம்பியின் விருத்திகாலம் நீடிப்பு; குடம்பிகளின் எண்ணிக்கையில் 22 8ஆல் கருதத்தக்களவு குறைப்பு; 100%மான குடம்பி இறப்பு. மேற்கூறப்பட்ட பரிசோதனை அமைப்பில் குடம்பி நிலையில் அறிமுகப்படுத்தப்படின் ஆவியாகும் பதார்த்தங்களால் தடைப்படும் குடம்பிகளின் தொடர்ந்த விருத்தி அதன் வயதில் தங்கியிருந்தன.

ஆயினும் நிறைவுடலிகளின் வாழ்வு காலம் பாதிக்கப்படவில்லை.

இது *T. castaneum*இன் இனப்பெருக்க உயிரியலானது வேப்பம் விதைகளின் ஆவியாகும் பதார்த்தங்கள் பாதகமான விளைவுகளை உருவாக்குகின்றன என்பதைக் காட்டுகின்றது.

NEPHOTETTIX VIRESCENS (Homoptera : Cicadellidae) ன் முளைய விருத்தியின் அவதானிப்புக்கள்

ஆசிரியர்கள் :
G. F. இராஜேந்திரம், ராஜினி ராஜேஸ்வரன்
(விலங்கியல் துறை, யாழ் பல்கலைக்கழகம்)
Vingnanam J. Sci. 3 : 27 – 30 (1988)

சுருக்கம் :

இக்கட்டுரை *Nephotettix virescens* (distant) என்னும் பச்சை இலைத் தத்தியின் முளைய விருத்தியை விபரிக்கின்றது. 1—6 நாள் வயதுள்ள முட்டைகளின் முழுப்பதிப்புகளும் அசற்றோ - ஒசினால் சாயமேற்றப்பட்டன. இரண்டாம் நாளில் முதல் தலைக்குரிய, முதல் உடலுக்குரிய பிரதேசங்கள் தெளிவாகின. மூன்றாம் நாளில் எளிய துண்டாக்கல், கட்புள்ளி என்பனவும், நான்காம் நாளில் நெஞ்சறைக் கால்களும், ஐந்தாம் நாளில் வாயுறுப்புக்கள், உணர் கொம்புகள் என்பனவும் தெளிவாகின. கோரியோன் ஆனது முளைய உருவை ஆறாம் நாளில் பிரதிபலித்தது.

இலங்கையில் காணப்படும் கபில தத்தி *NILAPARAVATA LUGENS* இலிருந்து கலத்திடை ஒன்றிய வாழிகளின் பிரித்தெடுப்பு

ஆசிரியர்கள் :
G. F. இராஜேந்திரம். அனற் குணசிங்கம்
(விலங்கியல் துறை, யாழ். பல்கலைக்கழகம்)
Vingnanam J. Sci. 3 : 31 – 47 (1988)

சுருக்கம் :

ஜப்பானில் கபில தத்தியான *Nilaparavata lugens* (Stal) (Homoptera : Delphacidae) இன் கொழுப்புடல்களிலும், சூலகங்களிலும், மதுவம் போன்ற ஒன்றிய வாழிகளின் வழித்தோன்றல்கள் அல்லது முட்டை இழையங்களில் காணப்படும் நுண்ணங்கிகளை

ஒன்றியவாழிகளாகக் கொண்ட இழைய கலங்கள் அறிவிக்கப்பட்டன. இவ் ஆய்வு இலங்கையில் காணப்படும் *N. lugens*ன் (கபிலதத்தியில்) கொழுப்புடல்கள், முட்டைகளின் இழையங்களில் காணப்படும் ஒன்றியவாழியான நுண்ணங்கிகளைக் கொண்ட கலங்கள் ஆகியவற்றின் பிரித்தெடுப்பு பற்றி விபரிக்கின்றது. இவ்வாய்வின்போது *N. lugens* ஆனது அம்பாறை மாவட்டத்திலுள்ள நெல்வயல்களிலிருந்து பெறப்பட்டு, யாழ்ப்பாண ஆய்வுசாலையில் வளர்க்கப்பட்டது. *N. lugens*ன் கொழுப்புடல் மற்றும் முட்டைகளிலிருந்து இருவகை மதுவத்தை ஒத்த, நுண்ணங்கிகளை ஒன்றிய வழியாகக் கொண்ட கலங்கள் அவதானிக்கப்பட்டது நீண்ட உறைபோன்ற நுண்ணங்கிகளை ஒன்றியவாழியாகக் கொண்ட கலங்கள், நீள்வடிவ நுண்ணங்கிகளை ஒன்றிய வாழியாகக் கொண்ட கலங் ள்; இவற்றில் முந்தியது அதிகளவில் காணப்படுகிறது. இலங்கையில் காணப்படும் *N. lugens* இலிருந்து பெறப்பட்ட நுண்ணங்கிகளை ஒன்றிய வாழியாகக் கொண்ட கலங்கள், ஜப்பானிலிருந்து பெறப்பட்டதிலும் சிறியது என அறிவிக்கப்படுகிறது.

CALLOSOBRUCHUS MACULATUS (Fabricus) இன் இனப்பெருக்க உயிரியல் கிடையான மையநீக்கத்தின் விளைவு. (Coleoptera : Bruchidae)

ஆசிரியர்கள் :

சகுந்தலாதேவி அம்பிகை பாகன், V. K. கணேசலிங்கம்
(விலங்கியல் துறை, யாழ் பல்கலைக்கழகம்)

Vingnanam J. Sci. 3 : 38 – 41 (1988)

சுருக்கம் :

மூன்று மணித்தியாலத்திற்கு 185 rpm, 370 rpm வேகத்தில் மையநீக்கம் செய்யும் போது நிறையுடலி *Callosobruchus Maculatus* ஆனது ஒழுங்கான இடைவெளிகளில் முட்டைகளை விருந்து வழங்கி விதைகளில் இட்டது. இந்த மையநீக்கம் இட்ட முட்டைகளின் எண்ணிக்கை, வாழ்தகவுள்ள முட்டைகளின் எண்ணிக்கை, முட்டையில் இருந்து நிறையுடலி வரையான விருத்தியடையும் காலம், நிறையுடலியின் வாழ்வுகாலம் என்பவற்றில் கருதத்தக்களவு மாற்றம் எதனையும் விளைவிக்கவில்லை.

மையநீக்கம் வேகம் 660 rpm, 1000 rpm, 3000 rpm ஆகும்பொழுது இடப்பட்ட முட்டைகளின் மொத்த எண்ணிக்கையில் கருதத்தக்களவு வீழ்ச்சியை ஏற்படுத்தியதுடன், வாழ்தகவுள்ள முட்டைகளின் எண்ணிக்கையும் குறைக்கப்பட்டது.

மையநீக்கம் 4000 rpm இலும் 5000 rpm இலும் செய்யப்பட்டபோது நீள்மூஞ்சி வண்டானது முட்டைகளை குவியலாக கொள்கலனின் கண்ணாடி மேற்பரப்பில் வெளித்தள்ளியது. அதைத் தொடர்ந்து பெண்வண்டு இறந்தது. அது இட்ட முட்டைகளின் எண்ணிக்கையிலும் வாழ்தகவுள்ள முட்டைகளின் எண்ணிக்கையிலும் அதிகளவு கருதத்தக்களவு வீழ்ச்சி காணப்பட்டது.

குறைந்தளவு வேகத்தில் *callosobruchus maculatus* இன் மையநீக்கம் எதுவித தீங்கையும் விளைவிக்கவில்லை. ஆனால் உயர் வேகத்தில் மையநீக்கமானது அவற்றின் முட்டையிடும் திறனையும் முட்டைகளின் வாழ்தகவையும் பாதிக்கிறது.

இலங்கையில் நிலவும் வெப்ப அழுத்தம் - ஒரு மனித காலநிலை நோக்கு

ஆசிரியர் :
மாணிக்கம் புவனேஸ்வரன்
(புவியியற் துறை, யாழ் பல்கலைக்கழகம்)

Vingnanam J. Sci. 3 : 42—58 (1988)

சுருக்கம்:

வெப்ப அழுத்த அடிப்படையில் இலங்கையின் மனித வெப்பக் காலநிலை ஆராயப்பட்டுள்ளது. கொள்கை ரீதியாகவும், ஓரளவு செயலறிவால் உணரப்பட்ட வெளிப்பாடுகள் பாவிக்கப்பட்டுள்ளன. இவை சராசரி ஒரு மனிதன் வெயிலை எதிர்கொள்ளும் சமயத்திலும், ஓய்வு நேரத்திலும் வெறுமையாக நிற்கின்றபோது நிகழுகின்ற நிலையான சக்திச் சமநிலை பரிமாற்றத்தை விளக்கப் பயன்படுத்தப்பட்டுள்ளன. மேற்குறிப்பிட்ட ஆதார அடிப்படையில், தனிப்பட்ட ரீதியில் வெப்ப அழுத்தம், காற்றின் வெப்ப நிலை, நீராவி அமுக்கம், கோளத்திற்குரிய கதிர்வீச்சு, காற்றின் வேகம் ஆகியவற்றின் அவதானங்கள் நான்கு பருவகால அடிப்படையில் இலங்கையின் 22 வளிமண்டல அவதான நிலையங்களில் கணக்கிடப்பட்டுள்ளது.

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