

**STUDIES ON SUGARCANE SCALE INSECT**  
*Melanaspis glomerata* (Green)

THESIS SUBMITTED TO THE  
ANDHRA PRADESH AGRICULTURAL UNIVERSITY  
IN PART FULFILMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE OF  
**Doctor of Philosophy**

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CERTIFICATE

Shri T.A.V.S. RAGHUNATH, has satisfactorily prosecuted the course of research and that the thesis entitled 'STUDIES ON SUGARCANE SCALE INSECT, MELANASPIS GLOMERATA (GREEN)' submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

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This is to certify that the thesis entitled "STUDIES ON SUGARCANE SCALE INSECT, MELANASPIS GLOMERATA GREEN" submitted in partial fulfilment of the requirements for the degree of "DOCTOR OF PHILOSOPHY" of the Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carried out by Shri T.A.V.S. RAGHUNATH, under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

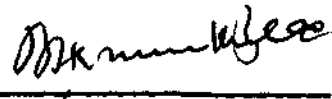
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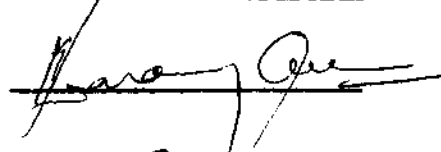
  
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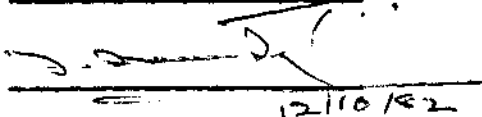
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## A B S T R A C T

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Sugarcane is an important commercial crop of Andhra Pradesh. It is subjected to severe damage by various insect and non-insect pests, resulting in heavy loss in yield and sugar content. Among them the sugarcane scale, Melanaspis glomerata (Green) has turned out to be the most destructive pest affecting the crop almost all over the important sugarcane belts of the country, now.

Studies on the losses from the infestation of scales on Coà 7602 indicated that losses to be perceptible only when the extent of incrustation was more than 0.5 gram per cane.

Trials were established, to survey the susceptibility of ten commercial varieties of sugar cane to the scale insect, the varieties screened in this experiment showed CoC 671, Coà 7701 and Co 6907 to be

free from scales to some extent and the most susceptible variety was CoA 7602. Varieties in which the leaf-sheaths adhered closely to the stem were more heavily infested.

Among the factors that influence scale incidence, to an appreciable extent, moisture in leaf (3-6) sheath in the maturity phase (300-330 days) was found to be important one.

Studies on the effect of some granular insecticides on scale insect have shown that among the granular insecticides tried, Aldicarb and Disulfoton at 2.5 kg a.i./ha. were effective in the control of sugarcane scale insect when applied in the early vegetative phase of the crop. Better crop growth, plant vigour, higher sucrose content and purity of juices, and higher yields were also associated with the treatment of aldicarb and disulfoton at 2.5 Kg a.i./ha. Good monetary returns and cost benefit ratios were obtained in aldicarb and disulfoton treatments at the above cited dosages. Sett treatment with malathion 0.1 per cent is recommended in IIM for scale insect as it was found to be effective and economical.

Studies on the effects of insecticides on the adults of C. nigrinus proved that dimethoate and methyl demeton brought the maximum mortality and endosulfan the lowest, while malathion was intermediary in toxicity to the predator. Endosulfan closely followed by malathion recorded maximum number of eggs, while dimethoate and methyl demeton had adverse effect on the fecundity of the predator. Hence C. nigrinus

could be released without the risk of high mortality. Releases would have to be delayed 7-10 days after the spraying.

The degree of parasitism in sprayed and unsprayed fields did not reveal any evidence of reduction in the rate of parasitism, indicating that application of 0.1 per cent malathion had no effect after one week on the emergence of the parasite, A. mayurai.

Search for natural enemies of M. glomerata in Krishna zone reveal two Coccinellid predators, C. nigrinus, P. horni, a mite S. sudus, five Hymenopterous parasites, A. mayurai, A. bifasciata, Microterys sp., A. delhiensis and Phycus sp. found attacking scale in this area. Their usefulness in the biological control of scale insect in A.I. was discussed.

Application of Potash at 168 Kg/ha at planting was suggested in drought prone areas where scale insect is a problem.

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INTRODUCTION

## CHAPTER I

### INTRODUCTION

Sugarcane is one of the most important commercial crops of India supporting many sugar industries. It provides raw-material for vacuum pan sugar factories and a number of Khandasari Units for sugar production and innumerable cane crushers for jaggery production. It is cultivated over an area of 2.7 million hectares and the production is 128.0 million tonnes of raw sugar annually. (Anon 1980). The current annual loss of sugarcane production due to pests and diseases has been estimated at Rs.50 crores.

The pests of sugarcane take a heavy toll through reduction in hectare yields and sugar recovery and the most important among them is the scale insect, Malanaspis glomerata (Green). It was considered, till recently as a minor pest on sugarcane but has assumed the status of a major and serious pest, in recent years. It is causing considerable losses to cane, sugar and jaggery industries. Scale insects are some of the most fascinating and unusual organisms in the Insecta. Their unconventional approach to the plant-parasitic regime has produced a myraid of bizzarre adaptations. Sugarcane scale insect occurs throughout the year. Infestation commences with the formation of the internodes and continues to increase as the cane plant grows. Plant sap is sucked and the plant is devitalised. Severe attack on sugarcane was noted to substantially reduce the yield of cane and sucrose content

of juice. It is estimated that the loss due to this pest goes upto 54 per cent in yield and 47 per cent in sucrose content. Urgent action is therefore called for, to mitigate the loss caused by this pest, explore possibilities of arresting its further spread and evolve suitable measures for its effective control.

Even though certain recommendations have been made for the control of scales reliable and economic control measures could not be evolved till now in view of peculiar habits of the insect, complications in the assessment of intensity of incidence of the scale and the interference of weather factors for judging the comparative efficacies of different control measures.

An ideal method of preventing scale insect infestation of sugarcane crop would be to cultivate varieties that are resistant to scale attack. Use of resistant or least susceptible cultivars coupled with adoption of cultural, mechanical, biological and chemical methods of control in an integrated manner offers scope for an efficient population management of this pest. Among the factors that influence cane yield to an appreciable extent, moisture in leaf sheaths is the most important one. In view of the scanty information available on resistance and also considering its importance for an effective management of this pest at the farmers' level, studies were made to identify the degree of resistance among the commercial varieties of sugarcane, most extensively planted in Krishna zone, varieties which can answer the need.

Much work on the chemical control of scale insect has been done by using various insecticides. However, work on the control of sugarcane scale by using granular soil insecticides is limited. Soil application is preferable to treat the plant as a prophylactic measure where there is no immediate insect damage. Hence, studies were undertaken to assay the potentialities of soil application of some promising systemic granular insecticides for management of sugarcane scale insect, when they are applied in early vegetative phase of the crop growth, at different economic levels.

Biological control of agricultural pests has developed with modern agriculture and has been concomitant with the accelerated acquisition and application of knowledge in biology in the last century and offers the best scope for minimising environmental pollution. This has led to a search for natural enemies of scale insect in Krishna District. Even though a number of predators and parasites have been recorded on M. glomerata the possibilities of their utilisation in biological control has not been fully exploited. Basic information on the status of these parasites and predators is a pre-requisite for planning a biological control programme of the pest. This aspect along with some factors affecting their abundance, has been taken up in the present studies.

In recent years, in chemical control programmes, increasing attention has been paid to the possibility of upsetting the natural control of other pests or potential pests. For control of scale insect, an understanding of the effects of insecticides on the emergence and

survival of parasites is essential. Such a knowledge would be useful in an integrated approach to scale control problems in sugarcane. With this in view the effect of malathion, an extensively used insecticide for scale control, on the emergence of A. mayurai, a natural enemy of primary importance on scale insect, was assessed. Control of scale insect, has so far been mostly by the use of insecticides and to some extent by cultural methods. The integration of broad spectrum insecticides with biological agents for pest control often creates problems of pesticidal toxicity to the latter. In a rational combination of insecticidal treatment with biological control only selective pesticides which are non-toxic to non-target biological agents have to be preferred. Hence, in the present investigations, studies on the toxicity of commonly used insecticides, for the control of scale, on Chilocorus nigritus Fabr., most common predator of scale insect in nature are taken up.

Potassium has been recognised to play a prominent role in providing resistance to crop plants against pests and diseases. Information of the effect of K, on scale is not much in evidence. Hence, studies were conducted to find out the effects of K-level on the incidence of scale insect of sugarcane.

It is presumed that the results obtained in these studies would not only offer scope for managing the scale insect infestations more effectively but also provide a more clear understanding of the lacunae in our knowledge of the pest and its management.

## REVIEW of LITERATURE

## CHAPTER II

## REVIEW OF LITERATURE

The armoured scales (Family Diaspididae) constitute one of the most successful groups of plant-parasitic arthropods and include some of the most damaging and refractory pests of perennial crops and ornamental plants. (Beardsley and Gonzalez, 1975).

On sugarcane, two species of armoured scales have come into prominence as important and persistent pests. They are:

1. Aspidiotus (Targionia) glomerata Green which is presently termed as Melanaspis glomerata Green, and
2. Aulacaspis tegalensis Zehntner.

M. glomerata is recorded only from India while A. tegalensis is reported from Uganda, Java, Formosa and East Africa (Rao, 1977).

### 2.1 INCIDENCE OF SUGARCANE SCALE

The sugarcane scale M. glomerata was first collected by Watt (1903) beneath the sheathing bases of sugarcane leaves.

Pruthi and Rao (1942) reported the incidence of this pest in Northern India and in Coimbatore. From Coimbatore this pest has been reported to have spread to Gujarat and Madhya Pradesh through seed cane setts sent for research purposes (Kalra, 1965).

In Andhra Pradesh it has been reported as early as 1952 and appeared to have been introduced into sugarcane research station, Rudrur and the Deccan plantations from Maharashtra (Prasad Rao, 1972).

From Nizamabad District, it appeared to have spread to the East Godavari District through sugarcane setts and by 1972-73 it was noticed in Godavari Districts (Seshagiri Rao, 1975).

According to a recent survey, it has been shown that sugarcane cultivation in many areas in Madhya Pradesh has been seriously hampered due to the rapid spread of scale insect, resulting in low sugar recoveries in sugar factories around Jaora area (Dubey et al., 1976).

The sugar cane scale has been reported to be assuming the status of a serious pest, of late, in Gujarat State (Shah et al., 1976).

The scale was also reported from Eastern Uttar Pradesh (Shukla and Tripathi, 1979). Very recently Singh and Varma (1981) have recorded scale insect infestation in Dimapur (Nagaland), West Bengal and Bihar. From these reports it is very evident that M. glomerata is present in almost all the important sugarcane growing states of the country.

## 2.2 LOSSES DUE TO SCALE INSECT

Khanna (1957) reported a loss of 43 per cent in cane weight and 8.03 per cent in sucrose content in the case of infested cane of variety B.O.11. He found that in this variety the scale attacked not only the stalk but also the leaf sheath and the lamina including the midrib.

It has been found that in the case of Co 745, a highly susceptible variety, the infestation reduced germination by about 20 per cent while the weight of canes, sucrose content of the juice, brix and purity were reduced by about 13 per cent, 47 per cent, 28 per cent and 26 per cent respectively (Agarwal, 1960).

Tembhekar (1965) reported the loss of as much as 63.4 per cent of cane (65 tons/ha) in the case of variety Co 775 grown at Bardoli (Gujarat).

Moholkar and Ranadhive (1973) have reported a reduction in the length of infested cane by about 29 per cent and relative reduction in the length of millable portion of cane stalk by about 18 per cent in Co 775. In case of ratoon crop, the cane yield was reduced by 29 per cent in Co 62059 and 44 per cent in Co 775.

Studies made with infested cane of variety Co 997 indicated that the weight of cane reduced upto 32.6 per cent while sucrose content in juice, purity and brix by 44.38, 16.68 and 32.98 per cent respectively as compared to healthy canes (Seshagiri Rao, 1975).

In susceptible varieties germination of buds was reduced to about 20 per cent. The decrease in sugar was noted to be as high as seven units (Avasthy, 1974).

There was loss in germination of the buds to an extent of 11.30 per cent in Co 740 and 21.40 per cent in Co 419 when scale infested cane was used as seed material (Thontadarya and Govindan, 1976).

In Adsali crop Murthy and Rao (1976) reported an yield loss of 25 to 30 tons/ha.

On an average there was 54.63 per cent reduction in cane weight while the reduction in brix, Pol and purity were by 5.05, 5.66 and 6.64 units respectively in Co 527, a highly susceptible variety as reported by Bhaskar Rao et al. (1976).

Rao and Murthy (1977) reported that in variety Co 62175 loss in weight of canes, sucrose content of juice and purity by 19.13, 15.86 and 5.13 per cent respectively when the infestation was heavy. They found that in this variety the losses were perceptible only when the extent of incrustation was more than one gram per cane.

Shukla and Tripathi (1980) observed 1-9 units loss in sugar recovery as a result of scale insect infestation in variety BO 70 grown in Eastern Uttar Pradesh.

Moholkar and Ranadhive (1973) report that gur prepared from infested cane has 10% more reducing sugar and the colour intensity is increased by 10 units. Such an increase in colour intensity is not a desirable character as it adversely affects the market value of the Jaggery.

### 2.3 RESISTANT VARIETIES

Observations made by Agarwal and Sharma (1960) have shown that there was a definite correlation between the number of stomata in the stem epidermis and the intensity of scale attack.

The pest occurs more freely on sugarcane varieties that have enveloping persistent leaf-sheaths showing that a safe protective cover is conducive to its prolific multiplication and spread on stem. Old ratoon crops are found to be more susceptible and the damage is extensive as reported by (Rao, 1970; Dubey, et al., 1976 and Rao, 1977).

Based on the intensity of attack, Rao, et al., 1975 suggest that Co 419 (with stray occurrence of individual scales here and there on the cane) as resistant parent and Co 740 (with mat-like incrustation of scales on the canes) as susceptible variety. Other varieties like Co 775, Co 954, Co 997, Co 1295, Co 1205, Co 1334 are susceptible to scale insect.

Nageswara Rao (1976) reports that Co 69 A 20, Co 70 A 30, Co 70 A 58 and Co 70 A 161 are less infested in Nizamabad area of Andhra Pradesh.

In Madhya Pradesh Co 421, Co 617, Co 997 and Co 1169 are reported to be less infested (Dubey et al., 1976).

Varieties like Co 70 A 11 and Co 69 A 49 which have a loose leaf-sheath and almost self-stripped are preferable for planting in areas endemic to this pest as mentioned by Nageswara Rao 1976.

Thontadarya and Govindan (1976) reported the incidence of the scale insect was more on varieties which had enveloping, persistent leaf-sheaths (Co 775, Co 740) while it was less on the variety Co 6415 which detaches the leaves systematically. They found that the loss of crop was more on light soils compared to heavy soils.

Moholkar et al. (1976) report varieties Co 62059, Co 740, Co 775 and Co 419 to be more infested in Maharashtra state.

Studies carried out regarding varietal susceptibility revealed that Co 775 and Co 740 were most susceptible varieties as stated by Murthy and Rao, (1976).

Shukla and Tripathi, (1979) reported that ratoon canes suffered more seriously than plant canes in some districts of Eastern Uttar Pradesh, and the main varieties found heavily infested were BO 70, BO 71, BO 54, Co 1148 and Co 1158.

#### 2.4 CHEMICAL CONTROL OF SUGARCANE SCALE INSECT

Agarwala, (1956) found that scales are not easily dissolved by most organic and inorganic solvents, acids and alkalines. He suggested that insecticidal treatment has also been timed in such a way that the most vulnerable stage of the insect namely the crawlers are also destroyed.

Application of parathion (Folidol) at 0.04 per cent has been reported to reduce the adult scale population by 90 per cent and the crawlers by 100 per cent in 48 hours after spraying (Agarwal, 1960).

Kalra and Malhotra (1967) suggested spraying Folidol 0.05 per cent or Malathion 0.1 per cent twice or thrice at 2 to 3 weeks interval after detrashing the crop for effective control of the pest.

Williams (1969 and 1970) reported application of systemic insecticides in granular form to the soil being of no avail for control of another allied sugarcane scale Aulacaspis tegalensis (Zhnt) in Mauritius and East Africa and suggested hot water treatment of infested Setts at planting, burning of cane before harvest, removal of dead leaves and leaf sheaths several times during the "grand period of growth" as preventive measures for its control. But he also mentioned that some of these methods of control are uneconomical.

Results of the preliminary studies made at sugarcane Research Station, Anakapalle (Anon, 1973) indicated that soil application of disulfoton granules at 3 kg a.i./ha to be helpful for the control of the pest, when used five times at monthly interval.

The sugarcane scale is controlled effectively by insecticides used either as sprays or granules. The time of application and the types of chemicals used in this regard differ. Insecticidal use for controlling this pest is resorted to at 3 different times viz.,

- (a) at planting of setts or while preparing the stubble for taking up the ratoon;
- (b) in standing young crop of 5 to 6 months age when 3 to 4 clear nodes are formed in the shoots, and
- (c) in grown up crop which has been wrapped and propped, (Rao, 1977).

For sett treatment at planting, it is necessary that the setts are kept immersed in the insecticidal solution, whether the insecticides is of contact or systemic nature. Information available in this regard shows that malathion 0.1 per cent is the most prominently used and recommended chemical as sett treatment for control of the scale, (Rao, 1977). Other insecticides found useful are dimethoate 0.1 per cent (Venkateswar Rao et al., 1976 and Moholkar, et al., 1976). The most easily adopted and cheap insecticide in vogue now is malathion 0.1 per cent solution for sett treatment and it is advisable to immerse the setts for about 15 minutes (Rao, 1977).

As regards spraying in the infested standing crop for control of the pest, phosphomidon 0.05 per cent (Thontadarya and Govindan, 1976 and

Moholkar et al., 1976); dimethoate 0.1 per cent (Rao and Murthy, 1977); malathion 0.1 per cent (Venkateswara Rao et al., 1976); Chloropyriphos (dursban) 0.05 per cent (Rao and Murthy, 1976); Quinalphos (Ekalux) 0.05 per cent (Rao and Murthy, 1976) and Anthio 0.05 per cent (Murthy and Rao, 1976) are the most effective chemicals and among these malathion 0.1 per cent and dimethoate 0.1 per cent are the widely adopted and recommended insecticides (Rao, 1977).

In a number of trials conducted in Madhya Pradesh disulfoton (Disyston 5 G) at 3 Kg a.i./ha gave effective control of scale insect and was superior to Carbofuran 3 G (3 kg a.i./ha) and found economical to use (Anon, 1976).

The performance of disulfoton 5 G at 3 Kg a.i./ha in respect of scale control and yield has been found to be superior than other systemic granular insecticides namely dimethoate 5 G and Carbofuran 3 G at equivalent dosages. Five applications at monthly interval starting first at internode formation has been recommended (Moholkar et al., 1976).

Application of disulfoton 5 G at 3 kg a.i./ha has been proved to be effective and economical for the control of sugarcane scale insects and sugarcane mealy bugs in Gujarat (Shah et al., 1976).

Venkateswara Rao et al., (1976) reported that soil application of disulfoton 5 G granules at 50 Kg (2.5 kg a.i.) per hectare in single application during July-August months when the crop was about six to seven months old proved to be very effective in reducing the sugarcane scale insect to an extent of 88.0 per cent on node basis with resultant increase in yield by 7.80 t/ha over the plots which received only 25 kg (1.2 kg a.i./ha) of granules. The increase in yield worked out to be 43.4t/ha.

In a review article, Rao (1977) has concluded on the basis of available information that soil application of disulfoton at 2.5 - 3.0 Kg a.i./ha is very effective for controlling sugarcane scale insect. It has therefore, been recommended in all major sugarcane growing areas.

In a number of trials organized by the Project on sugarcane scales at various locations, soil application of aldicarb (Temik 10 G) by pocketing closely followed by disulfoton 5 G at 2.5 Kg a.i./ha were given superior control of the sugarcane scale insect when compared with standard products like lindane, citrolane, endrin, sevidol etc., at equivalent dosages.

In most of these trials, better crop growth, plant vigour, higher sucrose content and purity of juice and higher yields were also associated with the treatment of aldicarb and disulfoton (Anon, 1979-80).

Studies conducted at Nidadavole (Seshagiri Rao and Subba Rao, 1979) revealed higher cost benefit ratio for Sott treatment with malathion 0.1 per cent as compared to control.

## 2.5 NATURAL ENEMIES OF MELANASPIS GLOMERATA GREEN

### Parasites and Predators:

Agarwala (1956) found the scale at Pusa (Bihar) parasitized by Adelencyrtus sp. and also obtained Azotus sp. which he however, thought to be a secondary parasite.

Narayanan, et al., (1957) reported parasitisation of over 50 per cent by hymenopterous in a sugarcane field at New Delhi, the species concerned being Anabrolepis mayurai N & S (Encyrtidae) and Azotus delhiensis Lal (Aphelinidae), the former accounting for about 90 per cent

of the parasite population. Two hyperparasites, Marietta cheriani (Mani) (Aphelinidae) and Ceraphron sp. (Ceraphronidae) were found by them to be of negligible importance.

At Coimbatore, Agarwal (1960) found the scale to be parasitized by three Encyrtids, Xanthoencyrtus fullawayi Timberlake, Microterys sp. and Anabrolepis bifasciata Ishii and an aphelinid, Azotus chionaspidis Howard. He noticed that A. bifasciata was the most prominent amongst the parasites but the total parasitisation was only 10-15 per cent during May and June and again in September - October. He also found two species of predatory mites belonging to the family - Caligonellidae.

Rao and Sankaran (1969) have reported two Eulophid parasites, Physcus sp. and Tetrastichus lecanii (Gir), a Coccinellid, Pharoscymnus horni Weise and a mite, Saniosulus nudus Summers (Eupalopselliidae), attacking the scale at Bardoli in Gujarat.

Three species of predators and ten species of parasites are associated with M. glomerata, in South India (Sankaran and Mahadeva, 1974). The predators are Chilocorus nigritus (F.), Pharoscymnus horni Weise (Coccinellidae), and Saniosulus nudus (Acarina, Eupalopselliidae).

The parasites recorded on scale insect are

Adelencyrtus femoralis Compere and Annecke (Hym., Encyrtidae).

Adelencyrtus close to odonaspidis Fullaway (Hym., Encyrtidae)

Anabrolepis mayurai Subba Rao (Hym, Encyrtidae)

Azotus chionaspidis Howard (Hym., Aphelinidae)

Azotus sp. - secondary

Ceraphron sp. (Hym., Ceraphronidae) - Secondary

Marietta cheriani (Mani) (Hym., Aphelinidae) - Secondary

Microterys sp. (Encyrtidae)

Phycus sp. (Hym., Eulophidae).

Sathiamurthy and Muthukrishnan (1976) recorded three species of hymenopteron parasites - Anabrolepis mayurai, Microterys delhiensis and Cheiloneurus sp. on the scale insect. In addition two predatory, mites, Saniosulus nudus and Tyrophagus putrescentiae are also noticed feeding on the scale insect.

## 2.6 EFFECT OF INSECTICIDES ON COCCINELLID PREDATORS

Campbell et al., (1953) tested insecticides on Coccinellid predators, Adalia bipunctata, Ceratomagilla fuscilabris, Coccinella 9 notata, Cyclonida munda, Hippodamia convergens, Olla abdominalis, O. abdominalis plagiata and Scymnus species. They reported that, although B.H.C., Toxapheno, and Calcium arsenate caused mortalities in excess of 70%, only E.P.N. and Parathion completely eliminated C. fuscilabris. Hippodamia convergens was reported to be tolerant to many of the insecticides. On Scymnus species chlordane was least effective whereas Aldrin, Dieldrin and Heptachlor were intermediate. They further stated that, in general, all the insecticides used affected the predators.

Harris and Volcarce (1955) studied the effect of insecticides on the Coccinellid predators Hippodamia convergens and Coleomegilla maculata. According to these authors phosphorous compounds like Parathion, Malathion, Clorhion, and Diazinon were more significantly toxic than any other material.

Van Den Bosch et al., (1956) reported that Parathion was most toxic to beneficial Coccinellids of alfalfa fields. Similarly Malathion and Demeton were reported to show high toxicity to Hippodamia species; wherein adults were moderately affected and larvae were completely destroyed.

Bartlett, (1958) studied selective aphicides for spotted alfalfa aphids. He reported that comparison of toxicities of 13 aphicides to Therioaphis maculata and the adults and larvae of Hippodamia convergens showed that at the L.D. 95 for the alfalfa aphid, conservation of Coccinellids was highest with Nicotine sulphate and decreased in degree with Schradan, Demeton, Trithion, Phosdrin, Pyrethrum extracts, T.E.P.P., Lindane, B.H.C., Toxaphene, Parathion, Malathion and Rotenone.

Jotwani, et al., (1960) tested various insecticides against the predator, Stethorus pauperculus. They reported that Malathion was 913.2 and B.H.C. 16.5 times as toxic as was D.D.T.

Harding, (1961) tested Demeton, Phorate, Dimethoate, Phosphamidon, Ronnell, Diazinon, Trithion and Parathion, against the melon aphid Aphis gossypii. He reported that the predator, Hippodamia convergens was abundant at the beginning of the test and after the aphids built up again. No beetles were present in any plot until after 7 days of treatment.

Bartlett, (1963) tested many insecticides against six species of Coccinellid predators. He found that Carbaryl (Sevin), Guthion and Malathion were highly toxic to all the 6 species. His results with Lindane varied from non-toxic to highly toxic, depending on the species.

Hukusima and Kondo, (1964) reported the effect of certain pesticides on predators, wherein they found Malathion to be quite harmful whereas Lead arsenate and Glyodine were found to be only slightly toxic.

Prakash Sarup et al., (1965) have tested 14 insecticides against C. septempunctata. Out of these 14 insecticides tested against the adults of C. septempunctata they found that Mevinphos, Phorate, Phosphamidon and Dichlorvas were respectively about 7.0, 3.7, 1.4 and 1.1 times as toxic as Carbaryl (Sevin). Carbophenothion, Trichlorphon, Pyrethrins, Endosulphan and Rotenone were found to be less toxic than Carbaryl. Toxicity of Bromodan, Chlorobenzilate, Heptachlor and Thanite was so low that as high as 1 per cent concentration of these insecticides gave only 38.6, 27.8, 20.5 and 19.9 per cent mortality respectively. They further added that, as compared to Aphis gossypii, C. septempunctata proved to be more resistant to Heptachlor, Endosulphan, Mevinphos, Carbaryl and Phorate. Amongst these insecticides Rotenone and Endosulphan have been reported to have shown a very high safety margin for C. septempunctata.

Khasimuddin (1967) tested three insecticides against the Coccinellid predator, Menochilus sexmaculata Fabr. Insecticides most toxic to the predator are Malathion, Carbaryl and B.H.C. respectively in order of toxicity.

Rattanlal and Prakash Sarup (1970) reported that lindane, diazinon, rotenone and endosulfan were less toxic to the mite predator, Stethorus paupereulus Weise.

Abdelrahman (1973) reported that the Coccinellid predator, Lindorus lophanthae (Blaisd) was considerably more susceptible to malathion than females of Aonidiella aurantii (Mask).

Ghani and Muzaffar (1974) reported that almost all stages of the Coccinellid predator Pharoscymnus flexibilis (Muls) were completely destroyed in a field sprayed with endrin to control Diaphorina citri Kuwana.

Croft and Brown (1975) have reviewed exhaustively on the response of arthropod natural enemies to insecticides.

Kirknel (1975) reported that endosulfan was relatively non-toxic to adults of Coccinella septumpunctata L.

Walters (1976) found that endosulfan and malathion at field concentration were highly toxic to three species of Stethorus.

Lingappa et al., (1979) reported the effect of certain pesticides against the predator, Menochilus sexmaculata F. wherein they found malathion to be quite harmful. Phosalone was moderately toxic while endosulfan was found to be non-toxic.

Fish oil rosin soap was relatively non-toxic to adults of Coccinellids namely, Chilocorus nigritus F. and Pharoscymnus horni W. whereas malathion was found to be highly toxic, to these sugarcane scale predators, (Anon 1979-80).

## 2.7 EFFECT OF INSECTICIDES ON PARASITES

De Bach and Bartlett (1951), Bartlett (1958), have reported the detrimental effects of many insecticides on various natural enemies. De Bach and Bartlett's work demonstrates that many of the very small Hymenopterous parasites, such as Aphytis spp., are very susceptible to such materials.

Adverse effects of commercial pesticides on the natural enemies of pest organisms have been recorded in numerous instances, especially since the advent of modern broad-spectrum organic pesticides, (Bartlett, 1964).

Rosen (1967) tested a number of insecticides on Aphytis holoxanthus (Hymenoptera: Aphelinidae) an important parasite of the Florida red scale and reported that Antracol, Kelthane, Kepone, Morestan were proved harmless to parasitic Hymenoptera, whereas Ethopaz, dimethoate (Rogor) and endosulfan (Thiodan) were found to be highly toxic.

Tobbi (1970) observed the selective action of the insecticides, carbaryl and endosulfan on castor semi-looper, Achaea janata Linn. leaving its egg parasite, Telenomus sp. unaffected.

In investigations on the toxicity of malathion to natural enemies of Aonidiella aurantii, the parasites Aphytis melinus D. and Comperiella bifasciata H. were found to be considerably more susceptible to malathion than females of Aonidiella (Abdelrahman, 1973).

Campbell (1975) has concluded on the basis of available information that malathion and oil emulsion could be used in sprays to keep infestations of Aonidiella aurantii (Mask) in check on Citrus and later in

in the season Aphytis melinus could be released without the risk of high mortality. Releases would have to be delayed 30-35 days after the use of 0.15 per cent malathion or one week after oil.

Davies and McLaren (1977) tested the toxicity of 20 chemicals at field rates in the laboratory for all stages of Aphytis melinus De Bach in Australia. Among these preparations that appeared safe for use in citrus groves were the acaricide Propangite and the insecticides Bacillus thuringiensis, endosulfan and Primicarb. Other preparations were found to be highly toxic. However, it is considered that careful application of these preparations is safe.

Ishihara (1973) has referred to the elimination of parasites such as Temelucha biguttula (Mats.) in many parts of Japan after the second world war and warned against a similar situation developing in India, where large numbers of natural enemies of rice pests occur at present.

De Bach (1974) has noted that the adverse effects of insecticides on natural enemies affecting non-target insects may last upto four years after a given insecticide has been applied.

Croft and Brown (1975) have reviewed the literature on the responses of arthropod natural enemies to insecticides and also tabulated the data on the toxicity of the more common insecticides to 10 species of Coccinellid predators, 13 species of other arthropod predators, 17 species of hymenopterous parasites and one species of tachinid parasite.

Bogenschutz (1979) tested a number of insecticides on Coccygominus turionella L. (Hymenoptera: Ichneumonidae). Insecticides most deleterious to the parasite were endosulfan, Cyhexatin and Metasystox, which had caused reduction in oviposition of 100, 70, and 37 per cent respectively.

Mazzone et al., (1980) reported that Demeton-S-methyl and phosalone appeared to be highly toxic to the adults of Leptomastix dactylopii H. (Hymenoptera: Encyrtidae).

## 2.8 EFFECT OF POTASH NUTRITION ON THE INCIDENCE OF CERTAIN INSECT PESTS

Enhanced rate of application of potash was found to reduce the incidence of sugarbeet black-fly (Aphis fabae) (Stapel, 1958).

Van Emden (1966) reported that aphids are particularly sensitive to the levels of N in the plant, but respond negatively to the levels of K, even in the presence of high N. He suggested the possibility of using this N-K relationship to induce resistance to aphids.

Rodriguez (1960) and Singh (1970) wrote extensive reviews on the effect of Plant nutrition on insect pests.

At higher K levels reduction of gall midge of rice (Pachytiplosis oryzae) and red oak scale (Eulecanium refulum) were reported. (Israel and Prakash Rao, 1967; Bruning and Uebel, 1971).

Hatmosoewarno (1970) reported that application of Potash to sugarcane halved the damage caused by chilo sacchariphagues.

Sithanamtham and Srinivasan (1972) reported that foliar application of Potassium chloride with endrin resulted in survival of more number of mother shoots and reduced the number of borer infested tillers in sugarcane.

Plants deficient in potash nutrition become more susceptible to the onset of damage by pests and pathogens (Chaboussou, 1972).

Potassium plays a prominent role in providing resistance to crop plants against pests and diseases, (Subramanian and Balasubramanian, 1976 & Vaithilingam and Raghunathan, 1977).

MATERIALS and METHODS

## CHAPTER III

### MATERIALS AND METHODS

The present study was undertaken at Agricultural Research Station, Vuyyuru, Krishna District, Andhra Pradesh.

#### 3.1 LOSSES DUE TO SCALE INSECT IN THE POPULAR SUGARCANE VARIETY CoA7602

##### Field studies (1980-81):

The study was undertaken with the cooperation of M/s K.C.P. Ltd., Vuyyuru (Krishna District) in the farmers holdings. The fields chosen were away from fields receiving frequent insecticidal applications. The variety studied was CoA 7602, which covers 50 per cent of the acreage in Krishna District and suffers severe damage by this pest.

Shortly before harvesting at random, 2000 canes were selected. These canes were separated into 10 arbitrary categories depending upon the amount of visual damage from scale insect. (Percentage of attack on node basis from 0 to 100 % incidence). Weight of cane and scale encrustation weight were taken for each cane adopting the methods described by Rao and Murthy (1977).

In order to assess the relationship between Intensity of infestation (weight of scale incrustation) and weight of cane, simple correlations were worked out between the above factors. No correlations were indicated (Appendix 1). Hence this method was not adopted in these studies.

Field studies (1981-82):

The effects of the scale insect (Melanaspis glomerata (Green)) on CoA 7602 were studied with reference to weight of single cane, percent brix of juice, per cent juice sucrose, per cent reducing sugars and co-efficient of purity.

Another point worth considering is the sampling technique i.e., the size and number of samples to be recorded. The basic principles of sampling is, the bigger the sample lesser will be the error and hence better. But the size has to be a manageable one to minimize labour and time without sacrificing accuracy. Thus on this basis a few samples each containing 10 canes and replicated four times of first ratoon were cut from the infested fields of the popular variety CoA 7602. All scale was scraped off with a wire brush and weighed. Due care was taken to avoid the presence of bits of roots, leaf sheaths etc. This method was found to be the only practicable way of estimating numbers when infestations were severe and the canes were covered with an overlapping felt of living and dead scales. The canes were categorised according to the intensity of attack into:

- i. Very light infested canes (canes with less than 0.5 gram of scale incrustation per cane);
- ii. Light infested canes (canes with more than 0.5 gram of scale incrustation per cane);
- iii. Moderately infested canes (canes with more than 1 gram of scale incrustation per cane);
- iv. Heavily infested canes (yellow canes) (canes with more than 1.5 gram of scale incrustation per cane);
- v. Healthy canes (The canes practically free from scale insects).

In each of the above 5 categories, canes without reddening or hollow pith only were used for assessment. For each treatment, the analyses were done in the laboratories of Agricultural Research Station, Vuyyuru, during the last week of January, 1982. In the data obtained all the values expressed as percentage were transformed into angular values, statistically analysed and interpreted.

The analysis of juice was done by 'Horn's dry lead acetate method'. Samples of healthy and infested canes were analysed for Brix, Pol per cent, purity and Glucose per cent.

### 3.2 RELATIVE SUSCEPTIBILITY OF SUGARCANE VARIETIES TO INFESTATION BY SCALE INSECT

#### Field studies (1980-81)

All tests were conducted at the Agricultural Research Station, Vuyyuru, Krishna District, Andhra Pradesh during 1980 and 1981. Resistance testing was done in an isolated field, away from areas of frequent insecticide use.

Ten commercial varieties of sugarcane (CoA 7602, Co 975, Co 62175, 73 A 22, CoR 8001, 72 A 304, Co 7219, Co 6907, CoA 7701 and CoC 671) were evaluated in replicated field plantings for differences in infestation by N. glomerata. The commercial varieties have comprised 90 per cent of the acreage in Andhra Pradesh which commonly suffer damage by this species. Varieties were planted in a randomized complete block experimental design with individual plots of each variety replicated four times. Plot size was 8 x 5 m.

Except for occasional routine observations the plot was left undisturbed, shortly before harvesting, samples consisting of twenty canes randomly selected from each experimental unit was taken.

To calculate the intensity of infestation (I.I.) the following formula was applied.

$$I.I = \frac{\text{No. infested internodes}}{\text{Total No. of internodes}} \times 100$$

All data were subjected to analysis of variance at the 5% level. In order to assess the relationship between 'Intensity of infestation' and quality of cane juice and weight of scale incrustation, simple correlations were worked out between the above factors.

### 3.3 RELATIONSHIP BETWEEN SHEATH (3-6) MOISTURE AND SCALE INCIDENCE

#### Field studies (1981-82)

Preliminary screening led to the selection of moderately resistant Co 6907 and highly susceptible Coa 7602 for further testing during 1981-82. The effect of sheath (3-6) moisture on scale incidence was studied, from the age of 90 days till harvest (330 days) at monthly interval. Sheath moisture content (green weight basis) was determined by the method described by Babu (1979).

### 3.4 STUDIES ON THE EFFECT OF INSECTICIDES APPLIED TO SOIL ON SUGARCANE SCALE INSECT IN EARLY VEGETATIVE PHASE.

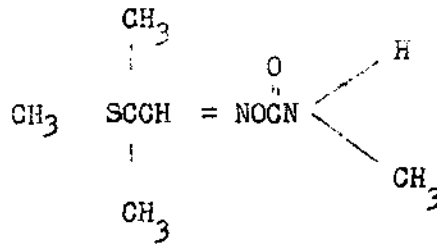
To study the effect of some systemic and new insecticides in granular form on sugarcane scale insect an experiment was laid out on 31-3-1981 at Agricultural Research Station, Farm, Vuyuru (Krishna Dist.).

Three granular insecticides used in the study are:

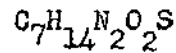
1. Aldicarb (TEMIK<sup>(R)</sup> 10G)

Structure and Identity:

Structural Formula.



Empirical Formula



Molecular weight 190.3

Chemical Identity

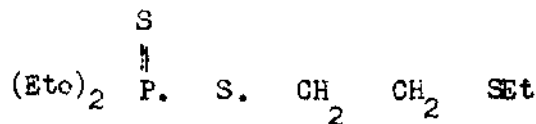
Common name : Aldicarb

Chemical name: (2-Methyl-2-(Methylthio) Propanal

O-(Methylamino) Carbonyl) oxime)

Trade mark : TEMIK (Registered trade mark of Union Carbide Corporation, U.S.A. for Aldicarb pesticide).

2. Disulfoton (SOLVIREX 5 G)



It was introduced in 1956 by Bayer AG under the code number 'Bayer 19639' and the trade marks 'DISYSTON' and by Sandoz AG under trade mark 'Solvirex'.

Chemical name : (O,O - Diethyl S-(2-Ethylthio)Ethyl)  
Phosphorodi Thioate)

Empirical formula:  $C_8 H_{19} O_2 PS_3$

Practically insoluble in water.

### 3. Carbofuran (Furadan 3 G)

Chemical name : (2,3 - Dihydro-2,2-Dimethyl-7-Benzofuranyl  
Methylcarbamate)

Empirical formula:  $C_{12} H_{15} NO_3$

Common name : Carbofuran

Registered  
Trade mark : Furadan<sup>R</sup>

Molecular weight: 221.3

### 4. Malathion (Cythion 50 EC)

Empirical formula:  $C_{10} H_{19} O_6 PS_2$

Chemical structure:  $(Meo)_2 \overset{S}{\underset{P}{\parallel}} S \begin{array}{l} CH_2 - Co_2 - Et \\ | \\ CH_2 - Co_2 - Et \end{array}$

Chemical name : (Diethyl ( Dimethoxy Phosphinothioyl)Thio)  
Butanedioate)

It was introduced in 1950, by American Cyanamid Co., under the  
trade mark 'Cythion' (Worthing, 1979).

Insecticidal treatments used in the studies are tabulated

below:

Sl. No.	Trade name	Common name	Conc. used/ha	Supplied by
1	Temik 10 G	Aldicarb	2.5 Kg. a.i. 1.25Kg. a.i.	M/s Union Carbide India Ltd., Bhopal.
2	Solvirex	Disulfoton 5G	2.5 Kg. a.i. 1.25Kg. a.i.	M/s Sandoz (India) Ltd., Bombay.
3	Furadan 3G	Carbofuran	2.5 Kg. a.i. 1.25Kg. a.i.	M/s Rallis India Ltd., Secunderabad.
4	Cythion 50 E.C.	Malathion	a) 0.1% Sett treatment  b) Detrashing+ Spraying 0.1% malathion.	M/s Cynamide (India) Ltd., Bombay.

The sugarcane variety used in the study was Coà 7602, a late maturing, popular and high yielding variety.

Preparatory cultivation:

Sugarcane setts were planted in deep trenches spaced 1 meter apart. Depth of the trench was 20 cm. The width of trench was 40 cm. Channels 45 cm deep, 60 cm wide and 10 meters apart were formed to serve as good drains.

### Seeds and Planting:

Sugarcane is universally propagated vegetatively for cultivation. Planting 3 buded setts is most common. Usually 30,000 three buded setts are sufficient to plant one hectare of land with 100 cm spacing in between rows. In the present study scale infested setts taken from a 1st ratoon crop of variety Coa 7602 was planted, with a view to ensure scale incidence in plant crop, as there was evidence that primary infestation in the field was due to planting of scale affected setts in field (Moholkar et al., 1976).

### Nutrition:

The experiment was laid out in loamy soil. The plots were fertilized with 168 Kg N/ha. The above quantity of Nitrogen was applied in two equal halves, on 45th and 90th day after planting, by placement in the soil near the base of the clump. Response to Phosphorus and Potash fertilization are not consistent and hence these were not considered in the study.

The experiment was fitted in a randomised block design with 9 treatments including control and replicated 3 times. The net area of each plot was 10 x 4.8 m (Fig. 7). Irrigations were given at weekly intervals, during the formative phase and at 21 day interval in the maturity phase (November - February).

When the crop was about 100 days old application of calculated quantity of the granular insecticides was weighed and mixed thoroughly.

with fine sand and applied by pocketing at a depth of 15.0 cm close to the cane clump. In one plot within the treatments, the seed material was treated, with malathion 0.1% before planting. In another plot within each of the treatments, in the months of July - August, sugarcane crop was detashed and sprayed with 0.1% malathion, when the shoots were having a few well defined nodes.

### Cultural Operations:

#### 1. Weeding:

Till the young sugarcane crop grows up and covers the land weed growth is heavy. Of late due to high cost of manual weeding chemical weed control is becoming popular in this zone. Chemical weed killers like Gramoxone (2.5 lts/ha) and Fernoxone (2.5 kg/ha) in combination were used in controlling the weeds.

#### 2. Earthing-up:

High earthing-up is one of the methods adopted for keeping the crop erect as it provides good anchorage to cane stalks. This operation was done after completion of tillering.

#### 3. Wrapping and Propping:

A method of propping using partially dried leaves of the growing sugarcane stalks is being advocated to keep the crops erect. This is called 'trash twist' propping, and is adopted in the crop growth in the experimental fields.

### Harvesting:

Harvesting of the crop was done at peak maturity (March-April, 1982). Incidence of scale insect (on node basis), cane yield and quality of juice (Brix, percent sucrose and per cent purity) were recorded at harvest. Incidence of scale insect (on node basis) was calculated by the method as described earlier. The values expressed in percentage were transformed into angular values and the data were statistically analysed.

### 3.5 EFFECT OF COMMERCIAL PESTICIDES ON THE FECUNDITY OF *CHILOCORUS NIGRITUS* (F.)

The Coccinellid predator, *Chilocorus nigritus* (F.) was selected for studying the effect of four insecticides viz., endosulfan, malathion, dimethoate and Demeton-S-methyl,

The doses of these insecticides adopted in the study are listed below. All formulations and doses were those currently recommended for control of sugarcane pests.

Two concentrations were tried for each of the four insecticides while a check (water spray) was maintained for every concentration. Generally recommended doses of each of the insecticides, were taken as 'Normal' doses. One and a half times the normal dose was taken as the 'High' doses. In all there were 12 treatments and the number of replications were four.

Predators were collected from field and maintained on scale affected setts in rearing jars of 18.5 x 10.0 cm size. The open end is tied with a thin muslin cloth. Scale infested cane bits sealed with wax (cut ends) were placed in the bottle as feed for the predators. The feed was changed once a week.

List of commercial pesticides used to study  
their effect on fecundity of C.nigritus(F)

Sl. No.	Name of the Pesticide	Manufacturer	Concentration (%)
1	Malathion 50 E.C.	Cynamid India Ltd., Bombay.	0.10
2	Malathion 50 E.C.		0.15
3	Endosulfan 35 E.C.	Hoechst Pharmaceuticals Ltd., Bombay.	0.10
4	Endosulfan 35 E.C.		0.15
5	Dimethoate 30 EC	Rallis India Ltd., Bombay.	0.10
6	Dimethoate 30 EC		0.15
7	Methyl demeton 25 EC	Bayer India Ltd., Bombay.	0.10
8	Methyl demeton 25 EC		0.15
9	Control (Water spray)	-	-

### 3.5.1 Effect of Insecticides on C. nigritus adults:

Laboratory studies comprised of tests conducted on the adults of C. nigritus. The active ingredient present in the insecticides were taken into consideration; while preparing spray solutions of different concentrations.

In this test, glass jars of 18.5 x 10.0 cm in size were used. Different concentrations of the insecticides were sprayed over scale infested setts, cut to the size of the glass jars. Spraying was done until a suitable droplet size was formed on the sett (the quantity of solution required for this being determined by preliminary trials). As such 20.0 ml of solution was used for spraying each affected sett. For

checks (control) the setts were sprayed with water. The sprayed sugarcane setts were then kept in respectively labelled glass jars and allowed to dry for a period of 24 hours. (Bartlett, 1963). After drying for 24 hours, the adult beetles were released into the glass jars, at five adults per glass jar (treatment).

In this test the effect of insecticides was proportional to the activity of the beetles on the treated sett surfaces.

Mortality counts of the beetles were taken after 24 hours spraying and the data were analysed.

#### 3.5.2 Effect of Pesticides on the egg production (for 24 hours) of *C. nigritus*:

The study was undertaken in the laboratory in which three buded light infested setts having scales of about 2/3rd the maximum size of the adult were used, to eliminate the possibility of the study being vitiated due to release of crawlers by gravid female scales. These setts were planted in earthen pots, keeping one bud in the soil. The other end of the sett was covered with melted paraffin wax to avoid drying of setts. The variety used was CoA 7602.

Different concentrations of insecticides were sprayed on the setts. Each potted sett represented a single treatment. Sprayings on the setts were done using a hand sprayer. After spraying the setts were caged with nylon net, to avoid external contamination.

One week after spraying, the cages were removed the time of 7 days required for this study was determined by preliminary trials and one pair of adult beetles were released from the culture onto each sett, and the potted setts were covered by nylon cages again. Preliminary studies conducted have revealed that mating takes place in C. nigritus on third or fourth day of its emergence. The female predator is ready to ovi-posit generally on fifth day. Hence five days old beetles were released on setts for 24 hours. Water sprayed setts served as control. On the infested setts, from which all but approximately 1000 live scales had been very carefully removed prior to the treatment. The pots were covered with polythene bags to avoid laying of eggs on the potted surface soil. After 24 hours these adults were transferred to separate jars.

As the eggs are fragile and tend to adhere to the scale it was not possible to count the number of eggs laid without damaging them; hatching larvae were therefore, counted to estimate egg production (for 24 hours). Similar difficulty is reported by Greathead (1975). This method was employed as a standard technique in the present study. All the data obtained were statistically analysed.

### 3.6. EFFECTS OF THE APPLICATION OF MALATHION ON SCALE INSECT, AND ITS PARASITE, ANAEROLEPIS MAYURAI (N & S).

The survey was undertaken with the cooperation of M/s K.C.F. Ltd., Vuyyuru (Krishna District) in the holdings of their cane suppliers.

The present investigation was divided into two phases:

### 3.6.1 Comparison of damage by *Melanaspis* in sprayed and unsprayed fields.

#### Method of assessing damage:

Damage by *Melanaspis* has so far been assessed by determining the percentage of nodes infested by the scale. This value reflects the accumulated damage, in the canes actually reaped, from the time the nodes were formed upto the time of survey, which in this case was carried out at fortnightly intervals from June to October, during which period the activity of scale and its parasites is more. Although no account is taken of canes which are killed or broken off, it does not give a comparable estimate of the damage from field to field and from year to year. Pairs of fields which closely resembled each other in their position and in the variety CoA 7602 and class of cane in the field (Plants, ratoons, etc.) were sampled. One field of each pair was sprayed with malathion (after detrashing) whereas the other was left unsprayed. (detrashing only done in it). Twenty canes (4 replications of 5 canes each) were taken at random from each field and the total internodes and scale affected nodes were counted. Data were expressed as percentage of incidence on node basis. All the data obtained were statistically analysed by Fisher's 't' test.

### 3.6.2 Comparison of Parasitism in sprayed and unsprayed fields

Parasitism was assessed in the same fields used for the scale infestation survey. Therefore, it proved necessary to inspect a number of fields and to continue collecting only in those fields where scale insect was abundant. The assessment of parasitisation in the scales seems to be highly complex. In order to assess the percentage of

parasitisation ten cane bits of one internode each, with scale infestation (both sprayed and ~~unsprayed~~) were kept in individual jars of 18.5 x 10.0 cm size. From each infested sett all but approximately 1000 live scales were carefully removed prior to the parasite studies. Number of parasites emerged were counted daily in each jar separately. The emergence of parasites was observed 7 days after spraying and it continued for a period of ten days. By this, approximate estimation of the parasitism was obtained. Among the parasites obtained in this study, A. mayurai was separated-out and counted, and per cent parasitism was estimated. The data were analysed by Fisher's 't' test.

### 3.7 SEARCH FOR NATURAL ENEMIES OF SCALE INSECT IN KRISHNA DISTRICT.

The occurrence of natural enemies of M. glomerata in Krishna district have been investigated. Periodic collection and examination of infested material aided in the recovery of the natural enemies. Some of the parasites noticed on scale insect of sugarcane in the field were got identified from Commonwealth Institute of Entomology, London.

Collections of scale affected setts were made from plant and ratoon sugarcane fields. All collections of the predators and parasites were brought to the laboratory, where they were isolated in glass tubes, and later identified.

The natural enemies were divided into three groups:

Predaceous Coleoptera (Coccinellidae), parasitic Hymenoptera (Encyrtidae and Aphelinidae) and a miscellany of predaceous organisms comprising mites, cockroaches, ear-wigs etc. Biology of the important predators like Chilocorus nigritus F. and Pharoscymnus horni W. was studied in the laboratory on scale insect by the method described by Raghunath (1979).

### 3.8 EFFECT OF POTASSIUM ON THE INCIDENCE OF SCALE INSECT OF SUGARCANE

The study was undertaken with the cooperation of the Sugarcane Specialist, Agricultural Research Station, Vuyyuru (Krishna District) in the holdings of his experimental plots under 'Potash nutrition'. The variety used in this investigation was CoA 7602 (ratoon crop of 1981-82 season). The level of Nitrogen was applied at 168 Kg/ha and the levels of Potash were as follows:

Treatment	K <sub>2</sub> O levels Kg/ha
T <sub>1</sub>	0
T <sub>2</sub>	168
T <sub>3</sub>	336

Potash was applied at ratooning. There were eight replications of each treatment. The net area of each plot was 8 x 5 m. i.e., 40 sq.m. The crop was harvested during February, 1982. Incidence of scale insect was recorded at harvest on node basis and were expressed as percentage of nodes showing evidence of infestation. The data were analysed statistically by the method of analysis of variance.

DISCUSSION and CONCLUSIONS

## CHAPTER V

## DISCUSSION AND CONCLUSION

## 5.1 LOSSES DUE TO SCALE INSECT

Investigations of earlier workers indicate that losses varied from variety to variety. So far losses in Co 997 (Seshagiri Rao, 1975), Co 527 (Bhaskara Rao, 1976) and certain other varieties (Rao 1977) are reported. Detailed studies are made in the present investigations to quantitatively assess the damage (based on the intensity of infestation of scales) due to this pest on CoA 7602.

At the first instance an attempt was made to evolve a method to assess the reduction of the intensity of infestation. As the scale insect is very small, counting the number of scales per cane is extremely tedious, difficult and time consuming. When the percentage of canes or internodes infested is used as criteria it only indicate the number of canes or internodes infested but cannot reflect the intensity of scale infestation on each cane or node. As such intensity of infestation is assessed by the weight of incrustation of scales per cane calculated from a representative random sample.

Results presented in Table 1 and 2 disclose a significant reduction in weight of cane and juice quality in scale affected canes as compared to that in healthy canes. The per cent depression in cane weight, sucrose content of juices and purity per cent amounted to 51.6, 39.0 and 13.39 respectively under heavy infestation. It is inferred

that the variability of loss is positively related to the degree of infestation. When the infestation is very light no significant reduction in cane weight and juice quality are noted. Thus the losses appear to be perceptible only when the extent of incrustation is more than 0.5 gram per cane.

These results are in conformity with the report of Rao and Murthy (1977), in respect of qualitative losses due to scale infestation, in sugarcane variety Co 62175.

Feeding of M.glomerata prevents increase of sucrose and brix in the cane. This is accompanied by low purity, which leads to additional loss in the factory, since lower the purity, lower is the per centage recovery of sucrose from the juice. Thus in the management of scale insect in the problem areas it is suggested to cane growers that they should harvest the infested fields particularly ratoon canes as earlier as they can to minimise loss in sugar recovery. Similar suggestion is reported by Shukla & Tripathi (1980).

## 5.2 RESISTANT VARIETIES

Estimates of scale damage on node basis appear to be good criteria to use in the initial screening of sugarcane varieties for resistance to scale insect. This method is also faster and less expensive than making scale counts.

Certain morphological characteristics appear to be associated with sugarcane scale insect resistance. Moderately resistant plants tend to be loose sheath clasping than the susceptibles. Among the varieties considered here, highly susceptible varieties like CoA 7602 and Co 975 have tight clasping leaf sheaths whereby they offer more favourable sites for settling crawlers.

Nageswara Rao (1976) reported that resistance based on leaf sheath clasping nature was heritable. Consistent with the conclusions of Nageswara Rao (1976) these data indicate that genetic control of the scale insect problem through breeding is feasible.

Since, both the varieties studied are subjected to attack, though relatively, by the scale insect as evidenced by the presence of a few scales even in moderately resistant variety Co 6907, it is inferred that resistance is only comparative.

During maturity phase, a relatively large amount of sheath moisture was observed in a highly susceptible variety CoA 7602 while the sheaths of Co 6907 had relatively poor moisture. Since leaf clasping nature is to an appreciable extent influenced by sheath moisture, differences in moisture content could have been a factor for consideration. The test also indicated that planting date had an effect on severity of scale insect damage and that variety CoA 7602 was more susceptible than Co 6907 within the same planting date. It is observed that late maturing cane variety CoA 7602 tend to suffer more damage than early maturing Co 6907 in the field.

The data indicated that Co4 7602 is highly susceptible to M. glomerata and should not be grown in areas infested by this pest.

Additional aspects of insect and plant relationships must be studied before definite conclusions can be made regarding resistance or susceptibility of sugarcane varieties to the sugarcane scale insect.

### 5.3 INSECTICIDAL CONTROL

Data presented in Table 8 show that all the chemical treatments are effective and superior to control. Aldicarb and disulfoton at 2.5 Kg a.i./ha are superior over other chemical treatments, in keeping down the scale incidence till harvest. The rest of the chemical treatments are superior to control but on par with one other. Aldicarb and disulfoton @ 2.5 Kg a.i./ha recorded the lowest incidence of 3.1 and 4.5 per cent respectively on node basis. Carbofuran is slightly inferior (10.4 per cent scale incidence). Lower doses of aldicarb and disulfoton also gave satisfactory control but control is significantly better in higher doses. Spraying 0.1 per cent malathion after detrashing has checked the scale incidence to a considerable extent (15.4 per cent incidence) while it was 18.5 per cent in malathion 0.1 per cent sett treatment.

It is also observed that aldicarb and disulfoton at 2.5 Kg a.i./ha are superior over other chemical treatments and control in respect of Brix per cent in cane juice and recorded a high juice brix per cent of 20.7 and 20.3 respectively. This is closely followed by Carbofuran (19.3 per cent) at the same dose. Lower doses of 1.25 kg a.i./ha

aldicarb, disulfoton and carbofuran also gave fairly high brix per cent ranging from 18.0 to 18.7, which were on par with that in the treatment detrashing + spraying 0.1 per cent malathion.

The data in Table 9 shows that the treatments aldicarb and disulfoton @ 2.5 Kg a.i./ha closely followed by Carbofuran recorded a sucrose content of 20.7, 20.3 and 19.2 per cent respectively in the juice and this is significantly better than that in the other treatments. Lower doses (@ 1.25 kg a.i./ha) of the above three chemicals also recorded a fairly high juice sucrose of 18.7, 18.3 and 17.5 per cent respectively. In the treatment detrashing + spraying 0.1 per cent malathion the juice sucrose recorded is 19.2 per cent which is significantly superior to that of malathion 0.1 per sett treatment (17.4 per cent). Juice purity also followed the same trend.

It is evident from the cane yield recorded at harvest (Table 10) that aldicarb followed by disulfoton at 2.5 kg a.i./ha have given highest yields of 100.5 and 97.5 tonnes/ha respectively. These are superior to the remaining treatments. Among the other treatments, carbofuran (2.5 kg a.i./ha), aldicarb and disulfoton (lower doses) and detrashing + 0.1 per cent malathion spray recorded high yields of 90.7, 89.9, 89.2 and 82.9 t/ha respectively. Malathion 0.1 per cent sett treatment and carbofuran (lower doses) recorded only 79.3 and 80.0 t/ha respectively while control plots recorded lowest yields (74.3 t/ha).

Soil application of systemic granular insecticides has been recommended for the control of sugarcane scale insect (M. glomerata) by earlier workers (Dubey et al., 1976; Shah et al., 1976 and Rao, 1977).

The superiority of aldicarb and disulfoton is once again observed as reported earlier (Dubey et al., 1976; Shah et al., 1976; Moholkar et al., 1976). Carbofuran at equivalent dose is slightly inferior as reported earlier by Dubey et al., 1976. Lower doses of aldicarb, disulfoton and carbofuran though gave satisfactory control yet percentage control is comparatively better in higher doses. These results compare favourably with those of Venkateswara Rao et al., 1976 and Dubey et al., 1976.

In the present study, detrashing and spraying 0.1 per cent malathion during July - August months also gave spectacular results in reducing scale incidence, in improving the sucrose content of juice and cane yield. Efficacy of detrashing and spraying 0.1 per cent malathion for scale control once again confirms the results of earlier workers (Venkateswara Rao et al., 1976 and Rao, 1977). Detrashing + spraying 0.1 per cent malathion checked the scale incidence and kept the crop free from scale insect throughout the season.

Detrashing helps to expose the scale insect, (M. glomerata) on cane to factors adverse to it like intense light, natural climatic conditions besides natural enemies. Detrashing also helps the chemical to come in direct contact with the scale insect and thus aids for more effective control of the pest. The results suggest that detrashing of

dried leaves and spraying 0.1 per cent malathion in July - August is beneficial to reduce the scale incidence to a considerable extent.

From the results (Table 11) it is seen that aldicarb (2.5 kg a.i./ha) is the best treatment in obtaining highest monetary returns about Rs.17,801. Aldicarb closely followed by disulfoton with equivalent dose recorded Rs.17,128. Carbofuran (high dose), lower doses of aldicarb and disulfoton were the next best treatments in obtaining high monetary returns. Insecticide treated plots recorded significantly higher yields when compared to the untreated check. This is due to the efficacy of insecticides in controlling the scale insect and keeping the canes free from scales resulting in higher yields. Similar conclusions were reported by Shah et al., 1976.

Highest cost benefit ratio (Table 12) is obtained in aldicarb and disulfoton treatments at different concentrations (2.5 Kg a.i./ha and 1.25 kg a.i./ha), when compared to the equivalent doses of carbofuran. The results compare favourably with Shah et al., (1976).

A cost benefit ratio of 1 : 5.1 was obtained in the sett treatment with 0.1 per cent malathion. Thus the sett treatment with malathion 0.1 per cent found to be economical in checking the pest. As the method is harmless to predators and parasites, unlike in foliar application, it suitably fits into 'Integrated Pest Management' of the sugarcane scale insect.

#### 5.4 INSECTICIDES ON C. NIGRITUS

The data recorded (Table 13 and 14) indicate that the toxicities of the four insecticides on the adults of C. nigrilis are in the descending order ranked as methyl demeton, dimethoate, malathion and endosulfan. Bartlett (1953) however, reports malathion to be highly toxic to the predator Lindorus loyanthae B.

The residual toxicity of these insecticides to predators differed considerably when released 7 days after spraying. Methyl demeton and dimethoate ranked first, causing cent per cent mortality. In contrast, endosulfan and malathion did not cause any mortality and thus are completely safe to the beetles.

The relatively non-toxic nature of endosulfan to predatory Coccinellids was once again observed as reported earlier (Prakash Sarup et al., (1965), Abdelrahman (1973), Makar and Jadhav (1981) and Sharma and Adlakha (1981). In the present experiment 'high' concentrations of the four insecticides are observed to cause greater mortalities. This is due to the fact that 'high' concentrations, which are the double the normal recommended doses for these insecticides against sugarcane pests. Campbell et al., (1953) have arrived at similar results with organo phosphorus compounds including malathion against Scymnus sp.

It is evident that species variation in their susceptibility is one of the reasons for differential toxicity of an insecticide. Mortality of beetles in methyl demeton and dimethoate treatments observed

seven days after treatment as compared to malathion and endosulfan is evidently to increased toxicity of methyl demeton and dimethoate and the sensitivity of adults beetles to trace quantity of the insecticides. Since, all the insecticides tried in this experiment are recommended for the sugarcane pest control, malathion and endosulfan have to be preferred over others in view of their low toxicity to the predatory beetles. These results need, to be under field conditions and conclusions drawn before their wider use.

Studies conducted on the effect of pesticides on egg production for 24 hours of C. nigritus reveal that endosulfan closely followed by malathion recorded maximum number of eggs 7 and 6 respectively under 'low' doses (0.10 per cent) (Table 15). Pesticides having a marked adverse effect on the fecundity of C. nigritus are dimethoate (0.1 per cent and 0.15 per cent) and methyl demeton (0.1 per cent and 0.15 percent). Similar results were also reported by Mazzonne et al., 1980.

From the results it is concluded that malathion (0.1 per cent) and endosulfan (0.1 per cent) could be used (after detashing) in sprays to keep infestations of M. glomerata in check, and later in the season Chilocorus nigritus (F.) could be released without the risk of high mortality. Releases would have to be delayed at least 7-10 days after the use of malathion or endosulfan in the integrated approach. Thus, pesticide formulations that proved in these tests to be relatively harmless to the predators need to be studied further for lowest effective dose, mode and time of application under field conditions before recommendations are made for sugarcane growers.

### 5.5 MALATHION ON A. MAYURAI

The results (Table 15) in the foregoing section on the possible effects of the application of malathion on sugarcane scale, M. glomerata and its parasite, A. mayurai indicate that adults of Anabrolepis in protected situations in the sprayed area are not greatly affected by low volume spraying with malathion. It would be expected, however, that in the course of normal movement, adults would come in contact with the insecticide and 100 per cent mortality would occur among adults present in the field at the time of the spray application. However, as there is little residual effect with malathion and since individual fields rather than large fields in a block are sprayed, adults of Anabrolepis could migrate safely from unsprayed areas on the day following application. Thus, although spraying could cause a substantial reduction in parasitism, there is little likelihood that parasites would be eliminated.

The results given in Table 16, show no evidence of a reduction in parasitism in the sprayed fields (as is evidenced from 't' test which was found to be not significant). For the same reason that the effects of malathion spraying can be regarded as having only a temporary effect on populations of Anabrolepis, the effect on populations of scale insect also can be expected to be only temporary. If the application of malathion also caused mortality of Melanaspis - presumably either when adult female or newly hatched (crawler) prior to entering the leaf sheath - a temporary drop in damage might be expected. Since the system of assessing damage is by counting the number of infested nodes, giving a record of accumulated damage over a period of several months, reduction

in damage for even a short interval within this time would, if large enough, be revealed in these counts. This would be a logical explanation for the results obtained in the survey of infestation of nodes where the number of infested nodes are significantly less in the sprayed fields. The results are in agreement with the findings of Manser and Bennett (1962); who had reported that the effects of malathion on parasitism would be more than temporary, to the parasite, Lixophaga diatraeae (Tns)

A comparison of the degree of parasitism in sprayed and unsprayed fields did not reveal any evidence of reduction in the rate of parasitism, indicating that application of 0.1 per cent malathion has no effect after one week on the emergence of the parasites. This is possibly due to the protection given by the scale covering of the host as suggested by Hoskins (1940).

Higher percentage of parasite emergence noted after 7 days is possibly due to the degradation of the malathion due to the climatic factors. The results broadly agree with the findings of Paul et al., 1976.

The results suggest that although there is evidence to show that the application of malathion for the control of sugarcane scale is detrimental to adults of A. mayurai there is no indication that spraying has upset the balance between this parasite and its host. On the contrary, the degree of damage by Melanaspis in malathion sprayed fields is significantly less than in unsprayed fields.

## 5.6 NATURAL ENEMIES

List of Hymenopterous and Coleopterous natural enemies of scale insect are furnished in Table 17.

The assessment of parasitisation and role of parasites in the control of scales seems to be highly complex. As a rule only adult females of M. glomerata are attacked by anabrolepis sp. The degree of parasitisation is extremely low during summer months (April-May) and did not exceed 3 per cent of the living females. The high temperatures and low humidities prevailing in this region during the summer months may be limiting factors for these species. The relatively small role played by parasitic Hymenoptera in the fauna of sugarcane scale does not necessarily indicate an inherent lack of adaptability.

In conclusion, it has to be stated that these parasites are widely distributed, and have a good searching ability, and thus appear to be fairly effective natural enemies worthy of trial in areas where scale insect is a problem.

Adults of the Coccinellid predator C. nigrinus are large in size and incapable of attacking the different stages of the scale that remain sheltered below the leaf-sheaths on the sugarcane stem (Greathead, 1975). P. horni has been abundant from the outset and has remained so. It is a small predator and is able to reach scales far below the adherent leaf-sheaths but does not seem to have much impact on the host population.

It is observed that locally low winter temperatures as well as high summer temperatures and low humidities, caused high mortality of various stages of the predators, greatly reduced the reproductive potential of adult females, and even caused extermination in some areas.

C. nigritus and F. horni are voracious feeders, both as a larva and an adult. They feed almost continuously throughout the day remaining in an area until most Coccids in their vicinity have been eaten. Neither species has shown great searching ability, but the high reproductive capacity of the scale insect, with which they are usually associated has perhaps reduced the need for this.

Saniosulus nudus is very common and wide spread on Melanaspis. Observations have shown that the mite prefers scales where crawlers have already been laid and feeds on these. Apparently this mite is not an important predator on scale insect. It builds up very uncommonly on old infestations and can only then cause considerable mortality.

A mere compilation of natural enemies of M. glomerata existing can be misleading as an indication of their overall importance, for some species will not be regular enemies and others may be handicapped by their own natural enemies. Much of the aspects of biological control in their wider sense are still very much in the experimental stage, and to what extent they will in future be applicable to scale insect of sugarcane is a matter of conjecture. With the more useful aspects of biological control, there are, however, still many possibilities for increased control of scale insect and these should certainly not be ignored.

## 5.7 POTASH NUTRITION ON SCALE INCIDENCE

The effect of potassium on the incidence of sugarcane scale insect is presented in Table 20. The results indicated that the incidence of scale insect was found to be reduced due to enhanced Potash application.

Decrease in scale incidence at high level of potash application in the sugarcane crop might offer mechanical resistance or barrier against the crawler establishment and further development. The results are in confirmity with Vaithilingam and Raghunathan, 1977 and Mariau and Julia, 1977. The reduced incidence of the scale insect is also in consonance with the findings of Stapel (1958) who found reduced aphid incidence in sugarbeet due to higher potash levels.

The possible reason for the reduction of scales may be due to the fact that increased K produces a better proteogenesis, a physiological phenomenon correlated with deamination of the amino acids and reducing sugars in the sap which are otherwise favourable for the reproduction of sucking pests (Chabossou, 1972, Subramanian and Balasubramanian, 1976). It may also be possible that some other bio-chemical alterations in the availability of essential amino acids may lead to the reduced incidence of pest. Study of Planococcus citri infestations in Trinidad (Fennah, 1959) demonstrated that addition of nitrogen to the soil around Cacao

hosts caused a dramatic increase in the abundance of mealy bugs. The addition of potassium caused a decrease, and the addition of phosphorus effected no change.

There is no response to application of potash to the sugarcane crop in the delta districts. However, it is claimed that application of potash is helpful in areas where water is a limiting factor.

From the results obtained it can be concluded that the application of potash at 168 kg/ha at planting gives drought and scale resistance with better juice quality. Hence application of potash at 168 Kg/ha in drought prone areas where scale insect is a problem will be a good management approach for this pest in Krishna District.

With the more useful aspects of agronomical practices there are however, still many possibilities for increased control of scale insect and these should certainly not be ignored.

SUMMARY

## CHAPTER VI

## SUMMARY

Sugarcane is one of the most important commercial crops of Andhra Pradesh. One of the serious pests affecting the sugar / gur recovery of sugarcane is scale insect, Melanaspis glomerata Green, which acts as a potential danger to the sugarcane grower and the sugar/gur industry.

Laboratory and field studies were carried out on scale insect and the summary of results obtained during these investigations are presented below:

1. Investigations on the losses from the infestation of scale M. glomerata on CoA 7602 indicated that the losses to be perceptible only when the extent of incrustation was more than 0.5 gram per cane. With the growth of cane, the population intensity also grows up, hence it is suggested to cane growers in the problem areas, to harvest the infested fields particularly ratoons as early as they can to minimise loss in sugar recovery.

2. Ten Sugarcane (Saccharum sp) varieties were evaluated for resistance to Melanaspis glomerata (Green) in field trials. Significantly less (5% level) node damage by the scale insect occurred with CoC 671, CoA 7701, Co 6907 and Co 7219 than with the varieties Co 975 and CoA 7602. Unlike CoA 7602 and Co 975 which are tight sheath clasping varieties, in the moderately resistant selections CoC 671, CoA 7701 and Co 6907 sheath clasping is loose. Among the factors that influence scale incidence to an appreciable extent leaf sheath (3-6) moisture in the

maturity phase (300-330 days) was found to be important one. A subsequent field evaluation of moderately resistant Co 6907 and highly susceptible CoA 7602 supported these findings.

3. Studies on the effect of some granular insecticides on sugarcane scale insect when applied in early vegetative phase at two concentrations indicate that:

(a) Aldicarb closely followed by disulfoton at 2.5 Kg a.i. per hectare proved very effective for control of this pest till harvest. Carbofuran at the same dose was slightly inferior. Lower dose of aldicarb and disulfoton also gave satisfactory control, but percentage control was better in higher doses.

(b) Aldicarb closely followed by disulfoton at 2.5 kg/a.i./ha are found to be the best in recording the maximum brix, juice sucrose and purity over lower dosages of aldicarb, disulfoton and Carbofuran.

(c) Highest yields were obtained in plots treated with aldicarb closely followed by disulfoton at 2.5 kg. a.i./ha. Among the other treatments Carbofuran (2.5 kg), aldicarb and disulfoton (1.25 kg a.i./ha) and detrashing + 0.1% malathion spray recorded the maximum yields.

(d) The results also suggest that detrashing of dried leaves once in July - August and followed by 0.1% malathion spray is beneficial to reduce the scale incidence to a considerable extent.

(e) Good monetary returns and cost benefit ratios were obtained in aldicarb 2.5 kg a.i./ha followed by disulfoton 2.5 kg a.i./ha treatments. Therefore, these insecticides can be used in their granular formulation in the early vegetative phase of the crop for control of scale insect.

(f) Sett treatment with malathion 0.1% was found to be both effective and economical in checking the pest. As the method is harmless to natural enemies, it is recommended as one of the components of integrated pest management for scale insect programmes.

4. Studies were undertaken to assess the effects of four insecticides viz., malathion, endosulfan, dimethoate and methyl demeton with two concentrations of each on the adults of C. nigrinus.

(a) It was observed that 'high' (0.15 %) and 'low' (0.1 %) concentrations of the four insecticides found to cause greater mortalities, when released immediately after spraying; however, the residual toxicity of these insecticides to predators differed considerably at 7 days after spraying.

(b) It was further observed that dimethoate and methyl demeton brought about the maximum mortality and endosulfan the lowest, while malathion was intermediate in toxicity to the lady bird beetle. Since all the insecticides tried are recommended for the sugarcane pest control, malathion and endosulfan may be preferred over other in view of their low toxicity to the predatory beetles.

(c) Studies concerned with the effect of pesticides on the fecundity of C. nigrinus reveal that endosulfan closely followed by malathion recorded maximum number of eggs under 'low' doses (0.1%). Dimethoate and methyl demeton had a marked adverse effect on the fecundity of the predator.

(d) From the results it is concluded that malathion

0.1 per cent could be used to keep infestation of scale in check, and later in the season C. nigritus could be released without the risk of high mortality. Releases would have to be delayed at least 7-10 days after the spraying.

5. Results on the effects of the application of malathion on scale insect and its Encyrtid parasite (A. mayurai) indicate that:

The degree of parasitism in sprayed and un-sprayed fields did not reveal any evidence of reduction in the rate of parasitism, indicating that application of 0.1 per cent malathion has no effect after one week, on the emergence of the parasites. On the contrary the degree of damage by Melanaspis in malathion sprayed fields was significantly less than in unsprayed fields. On the basis of present studies, endosulfan and malathion could be used for scale control along with C. nigritus/ or A. mayurai in the integrated approach.

6. The natural enemies of M. glomerata in Krishna district were investigated. Two Coccinellid predators (Chilocorus nigritus F., Pharoscymnus horni W., a mite, Saniosulus nudus S., and five Hymenopterous parasites (Anabrolepis mayurai N & S, A. bifasciata, Mycroterys sp., Azotus delhiensis Lal and Phycus sp. were found attacking scale insect. Among the parasites recorded, A. mayurai account for nearly 80 percent of the parasite population, while the percentage of parasitisation by other species was low. Feasibility and significance of the effective natural enemies for practical utility have been discussed.

7. The effect of Potassium on the incidence of scale insect indicated that the incidence of scale was found to be reduced due to enhanced Potash application. Hence application of Potash at 168 kg/ha at planting can be a good management practice for the control of scale insect in drought prone areas.

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\*Original not seen.

## APPENDICES

A P P E N D I X - I

Table showing cane and encrustation weight of Healthy and Infested canes\*

Variety : CoA 7602

Sl. No.	Percentage of attack (on node basis)	Av. wt. of cane (Kg.)	Av. wt. of encrustation (gm)
1	1 - 10	1.85	0.65
2	10 - 20	1.70	0.70
3	20 - 30	1.60	0.90
4	30 - 40	1.65	1.20
5	40 - 50	1.45	2.20
6	50 - 60	1.50	2.30
7	60 - 70	1. 20	2.50
8	70 - 80	1.10	2.80
9	80 - 90	0.80	2.85
10	90 -100	0.70	2.90
	0 (No attack)	1.80	0

\*Average of 50 canes and  
4 replications.

A P P E N D I X -II

MATERIOLOGICAL DATA.

Month	Year	Mean Temp in °C		R.H. percentage	Rain Fall in mm
		Min.	Max.		
January	1981	18.1	30.4	93.2	2.2
February	"	19.6	34.7	95.0	-
March	"	22.7	35.5	91.0	-
April	"	25.6	37.1	85.0	0.4
May	"	27.0	40.3	80.8	4.7
June	"	27.7	39.7	70.8	50.6
July	"	25.7	35.2	89.2	6.3
August	"	25.3	33.4	87.3	2.5
September	"	25.4	32.8	92.2	4.2
October	"	24.1	34.2	93.1	0.2
November	"	20.8	31.9	85.8	-
December	"	19.1	31.1	87.9	-
January	1982	18.2	32.3	95.6	-
February	"	21.0	35.7	94.4	-
March	"	24.1	37.6	90.1	-
April	"	25.8	39.5	85.3	-

V I T A

I, T.A.V.S. RAGHUNATH, was born on July 23rd, 1955, to Manga Tayar and Seshavataram, in Kakinada, East Godavari District, Andhra Pradesh. I obtained my B.Sc., degree with distinction in 1977 and M.Sc., degree with first in first division in Agricultural Entomology from Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad in 1979. I worked for Ph.D., degree in 'Biological control' under the able guidance of Dr. B.H. Krishnamurthy Rao, Dean of Agriculture, Andhra Pradesh Agricultural University.

I am the recipient of Junior and Senior Fellowships of Indian Council of Agricultural Research' in Entomology during M.Sc. (Ag) and Ph.D., respectively. I was awarded the Memorial Gold Medal of Prof. V. Tirumala Rao (Retd. Prof. A.P.A.U.). Besides, I was also awarded the "Fourth All India Sugarcane Workers Conference Prize" for having submitted a thesis on the aspect of Sugarcane in M.Sc. (Ag) course and secured maximum O.G.P.A. at the post graduate level. I won several merit certificates during my educational career in different fields.

I have been a member of the Entomological Society of India, New Delhi, Indian Science Congress, Calcutta, Entomological Society of India, Hyderabad branch, and a member in several journals. I have published over twenty five research papers in various reputed Indian journals.