BIOLOGY OF COWPEA FLOWER THRIPS AND HOST PLANT RESISTANCE

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ABSTRACT

Biology of cowpea flower thrips Megalurothrips sjostedti, was studied under field conditions.

Population studies showed that the trend of thrips populations was closely tied with the flowering cycle of the cowpea crop. Peak thrips populations coincided with peak flowering of the crop. The seasonal abundance of thrips was mainly governed by weather factors. Thrips were found to oviposit mainly in the calyx of the cowpea flower.

Evaluation of different sampling methods for thrips on cowpea indicated that water traps were most consistent. An artificial infestation method was developed for evaluating resistance of cowpeas to flower thrips in the screenhouse.

Comparative yield studies without protection against flower thrips revealed a superior performance of cowpea cultivar TVx 3236 over other cultivars.

The first phase of a negative field screening of cowpea germplasm showed that further sources of resistance to flower thrips were apparent in some accessions.

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DEDICATION

This work is dedicated to my parents for their patience and understanding.

CERTIFICATION

We certify that this work was carried out by Mr. A. B. Salifu in the Department of Zoology, University of Ghana, Legon and at the International Institute of Tropical Agriculture, Ibadan, Nigeria.

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CHAPTER ONE

1. INTRODUCTION

1.1 Importance of cowpea.

The cowpea, Vigna unguiculata (L.) Walp., is one of the food legumes which are important sources of nutrient and provide supplementary proteins to diets based on cereal grains and/or starchy foods (Aykroyd and Doughty, 1964). The amino acid profile of cowpea complements that of cereal grains and as a consequence cereal and cowpea combined provide protein of a higher biological value than either alone (Dema, 1963).

1.2 Production areas; cultivation practices

Cowpeas thrive well in semi-arid and humid tropical regions that are located within latitudes 0^{o} and 30^{o} North or South of the equator, with an annual rainfall of 250-1000mm (Sinha, 1977). Although cowpeas are grown throughout the lowland tropics most of the total world production comes from West Africa and the Northeastern regions of Brazil, which each produces around 1.0 tons of cowpea seed annually (Summerfield et al., 1974). It is estimated tnat cowpea production (in millions of hectares) is over 4.8 in West Africa, about 1.0 in East Africa, 0.85 in India, 0.6 scattered over Southeastern Asia, close to 1.5 in Brazil and Latin America and about 0.2 in the United States of America (Singh and van Emden, 1979). Nigeria is

a leading producer of cowpeas. Between 1971-1975 out of a mean annual world cultivated area of 4,489,800 hectares Nigeria alone cultivated 81.1% of the total area, and produced 75.0% of the mean annual world production of 1,129,400 metric tons for the same period.

In African traditional cultivation systems cowpeas are often cultivated both as a mixed crop and in monoculture. In Northern Nigeria where the bulk of Nigeria cowpeas are produced, small scale farmers intercrop cowpeas with such crops as sorghum, millet, cotton and groundnuts (Booker, 1964; Raheja, 1978). In Tanzania farmers usually intercrop cowpeas with maize and millet (Kayumbo, 1975). Cowpeas have been shown to increase yield of millet when inter-planted at low densities of 5,980 and 11,960 plants per hectare in Kano, Nigeria (Steele, 1972). In Southwestern Nigeria most of the crop is grown as late season crop by local farmers who grow daylength sensitive indeterminate cultivars during the months of July to September and harvest in November-December. However, early season daylength neutral determinate cultivars are sometimes grown by planting in April or early May and harvesting late July or August (Nanju, 1978).

1.3 Food value and utilization of cowpeas

The nutritive value of cowpea seed compares favourably with that of other plant and animal derived food sources. The protein

content of cowpea seed is high, usually ranging from 19 to 26%. The protein is high in the amino acid lysine, but, like other legume seed proteins, is deficient in the sulphur-containing amino acids cystine and methionine. The nutritive value of cowpea seed can be increased by cooking to lessen the activity of such heat labile antinutritional factors as haemagglutinins and trypsin inhibitors.

Proximate analysis of the cowpea seed shows that it contains 23.4% of protein 1.3% of fat and 56.8% carbohydrates (Purseglove, 1968). It contains about 342 calories per 100 g and all essential amino acids in sufficient amounts for growth (Oyenuga, 1968). Proteins provided mainly by the cotyledons ranges in concentrations from about 17 to 40% (Bressani and Elias, 1980). The vegetable proportion contains 3.31 g of protein per 100 g while the lysine, methionine and tryptophan content are 198 mg, 20 mg and 33 mg per 100 mg respectively (FAO, 1970). Vitamin contents include Vitamin A (200-300 IU), Vitamin C (40 IU), Vitamin D (26-78 µg/100g) and Vitamin E (3.07 - 5.07µg/100g) (Ester and Munsell, 1937; Oyenuga and Ogunmodede, 1968).

Apart from their use in soups cowpeas are used in a variety of culinary preparations. In many parts of west Africa some of the different 'bean' foods include roasted corn and cowpea; cowpea stew and fried plantain,'moin moin'and several others (Dovlo et al., 1975). Cowpea leaves and pods may be used as vegetable in some countries such as India, China and Uganda. It may also be used for livestock feed, green manure and soil erosion control. In

subsistence agriculture on small farms the nitrogen-fixing ability of cowpea is important.

1.4 Relevance of the study

Notwithstanding the importance of cowpea as a source of protein for the developing nations of the world, yields are still below expectation in such areas. Insect pests and diseases are a major constraint to increased production of cowpeas; (see chapter 2 for literature review). This is aptly demonstrated by spectacular increases in yield following insecticide application (Booker, 1964, 1965; Taylor, 1968; Koehler and Mehta, 1972; Kayumbo, 1975). Of paramount importance among the numerous cowpea pests is the cowpea flower thrips Megalurothrips sjöstedti (Trybom.) (Thysanoptera, Thripidae). This tiny black insect infests cowpea flower buds and open flowers. Severe infestations can lead to total yield loss (Singh and Allen, 1980).

Although the pest status of M. sjöstedti had long been established not much work has been done on it, especially in the area of host plant resistance. Effective host plant resistance investigations requires a thorough knowledge of the biology of the pest vis-a-vis the host plant. Therefore the objectives of the present study were extended to include biology studies.

1.5 Objectives of the study

The objectives of the present study were defined to include the following:

1. Studies on biology of flower thrips Megalurothrips sjostedti (Trybom.).

2. Evaluation of different sampling methods for flower thrips on cowpea.

3. Development of a screenhouse screening technique for evaluating resistance to flower thrips.

4. Comparative yield of cowpea cultivars without protection against thrips.

5. Cowpea germplasm screening for resistance to flower thrips.

CHAPTER TWO

2. REVIEW OF LITERATURE

2.1 Origin of cowpea

The cowpea, Vigna unguiculata (L.) Walp., has been cultivated since Neolithic times. One of the earliest works with the origin of crop species was written by de Candolle in 1886. He stressed the importance of the presence of wild forms of the crop plant at the origin. Vavilov (1951) considered that the area of maximum diversity of a crop plant is also likely to be the centre of domestication of the species. The centre of origin of cowpea is a matter of controversy. Nevertheless the distribution of the wild cowpeas, which are found only in Africa is one of the strongest lines of evidence favouring Africa as the origin of the crop. This observation was the main criterion used by Piper (1913), Dalziel (1937), Vavilov (1951), Burkill (1951), Sauer (1952), Cobley (1956), Stanton (1966), Verdcourt (1970), Steele (1972), Westphal (1974), Harlan (1975) and Rawal (1975), all of whom concluded that cowpeas were domesticated in Africa. Within Africa some authors favoured Ethiopia as the region of origin (e.g. Vavilov, 1951; Steele, 1972) but others suggested West Africa (e.g. Piper, 1913; Rachie and Roberts, 1974; Rawal, 1975).

2.2 The cowpea pest complex

Many insect pests attack all parts of cowpea plants at every stage of growth as well as seeds in storage. Various workers have attempted to classify the pest complex on cowpea so as to show their relative importance on the crop. Booker (1963) divided cowpea pests into major and minor pests of preflowering, flowering and post-flowering phases. Under this classification the foliage beetle Ootheca mutabilis (Salb.) is regarded as a pre-flowering pest, the legume pod borer Maruca testulalis (Geyer), a flowering pest and the pod sucking bug Anoplocnemis curvipes F.as a post-flowering pest. Taylor (1964) further expanded Booker's (1963) classification and put the pest complex into four major groups. (a) The root-feeding species. (b) The leaf and stem-feeding species. (c) The flower-feeding species. (d) The pod and seed-infesting species.

In a recent review Singh (1980) gave a comprehensive overview of the cowpea complex. The time of infestation relative to crop phenology was taken into account (Fig. 2.1). Three main groups are identifiable under this classification:

a) Those pests which are common throughout the vegetative growth.

b) Those which infest at the appearance of flowers and

c) Pests which are prevalent throughout the reproductive period.

Pests in the first category include leafhoppers, aphids and beetles which

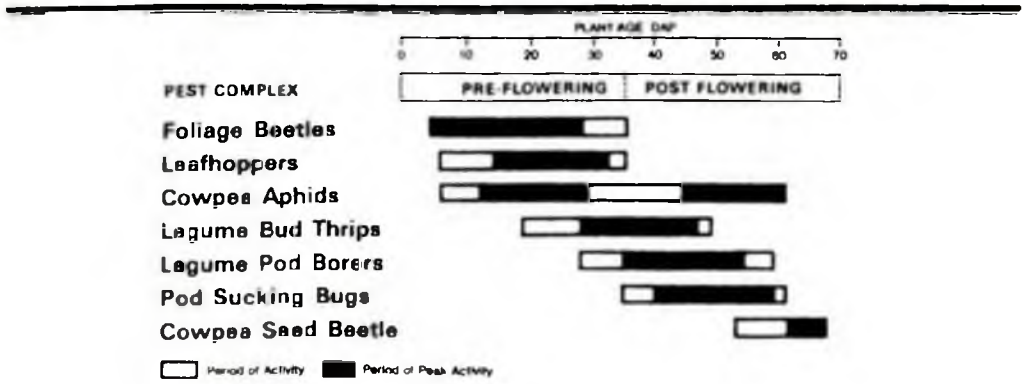

Fig 2.1 The occurence of selected pests of cowpeas in Africa shown according to the development of the crop (DAP = days after planting)(SINGH, 1980).

not only feed on leaves but in some cases are also vectors of viruses.

Leafhoppers:

Leafhoppers belonging to the genus Empoasca are widely distributed in the tropics and subtropics. Empoasca kraemeri Ross and Moore is a major pest of cowpea in Central and South America. E. kerri Pruthi is a major pest of cowpea in India. E. fabae Harris is found on cowpea in the United States, but is of no economic importance. E. biguttula (Shiroki) and some other Empoasca spp. are minor pests of cowpea in Southeast Asia and Australia. E. dolichi Paoli is found in West Africa and some other Empoasca spp. infest cowpea in East Africa.

Leafhoppers infest cowpeas at seedling stage. Both nymphs and adults infest leaves and suck the plant sap. The damage symptoms are characterised by yellow discoloration of the leaf edges followed by cupping of the leaves. Under heavy infestation the leaves dry and fall off, the plants are stunted and may even die. However the plants frequently recover from severe leaf damage without reduction in yield, although flowering is delayed by about a week (Singh and van Emden, 1979).

Aphids

Aphis craccivora Koch, is the main aphid pest of cowpea. It is considered a major pest of cowpea in Asia and a minor pest in Africa. Cowpea aphids infest the crop at the seedling stage and the direct damage to the host plant is by the removal of plant sap. An indirect and often more serious when populations are small is transmission of cowpea aphid-borne mosaic. Large numbers of aphids can cause distortion of leaves, and stunted plants with small poorly nodulated root systems. Yield is reduced and in extreme cases the plant is killed (Singh and van Emden, 1979).

Foliage beetles:

The cowpea leaf beetle, Ootheca mutabilis (Sahlberg), is considered a major pest of cowpea in Africa. The adult beetles feed on the leaves of young cowpea seedlings. When the pest population is low, there is no significant loss in yield due to feeding since the cowpea plant can compensate to a remarkable extent for lost vegetative tissues (Ezedinma, 1965, 1973). When populations are high, normally the seedlings are totally defoliated, which cause plant death. The adult beetles are also vectors of cowpea (yellow) mosaic and transmit the disease even at low populations.

The foliage beetle, Medythia quaterna (Fairmaire) is often found in Africa, feeding on young leaves of cowpea seedlings. However, the numbers have not been large enough to cause economically important

yield losses. Like the leaf beetles foliage beetles are important vectors of cowpea (yellow) mosaic virus.

The second category of the pest complex - those pests which infest flower buds and open flowers, comprise thrips, lepidopterous larva and beetles. Infestations at this stage can lead to serious yield losses.

Thrips:

Flower thrips, Megalurothrips sjöstedti (Trybom.) is a major pest of cowpea in Africa and is often responsible for total yield losses. The shiny black thrips feed and lay eggs on developing flower buds. Severely infested plants appear diseased and do not produce any flowers (Singh 1977a). Flower buds that escape damage and form flowers may be infested later. These flowers are distorted, malformed and discolored and fall off when the thrips infestation is severe (Taylor, 1969).

Blister beetles:

A number of species of the genus Mylabris and the genus Coryna do considerable damage to cowpea. Adult beetles feed on flowers and flower buds; often their damage is sporadic and serious. Mylabris affinis Olivier, Mylabris farguharsoni Blair, Mylabris amplectens Gerstaecker, and Coryna apicicornis (Guerin) are some of the common

species of blister beetles found in Africa. Mylabris postulata (Thunberg) and Mylabris ceylonica (Pic) are common in Asia.

Lepidoptera:

A large number of lepidopterous pests infest cowpea at both flowering and podding stage. Legume pod borer, Maruca testulalis (Geyer), is found throughout the tropics of Central and South America, Asia, and Africa (Taylor, 1978). It is a major pest of cowpea in Africa and can cause severe yield losses ranging up to 60% (Singh and Taylor, 1978; Taylor, 1967, 1968). The larvae initially feed on young, tender shoots and peduncles, and later when the flower buds and flowers are formed, they prefer to feed on the floral parts and green pods.

The other important, widely distributed lepidopterous pests that attack flower buds, flowers, and green pods in tropical Asia and Africa are African bollworm, Heliothis armigera (Hubner), the Egyptian leafworm, Spodoptera littoralis (Boisduval). Serious sporadic damage from these pests has been recorded on cowpea at some locations. They can be considered as minor or potential pests.

The third group of cowpea pests which are most important throughout the reproductive period are lepidopterous larvae and bugs, which suck pods.

Pod-sucking bugs:

Pod-sucking bugs particularly several coreids in the genera Acanthomia, Riptortus and Anoplocnemis, are major pests of cowpea in Africa and are of minor importance in Asia. Green stick bugs, Nezara viridula (L.) and other related species of Nezara are found in Central and South America, Asia and Africa. The various pod-sucking bugs suck the sap from developing pods. Infested pods shrivel, dry prematurely and seeds do not develop, resulting in serious yield losses (Singh, 1980).

The cowpea curculio, Chalcodermus aeneus Boheman, is the most serious pest in the United States and Central and South America (Russell and Chalfant, 1979). The adult weevils damage the green developing pods by direct feeding and by ovipositing the eggs; which results in the pod and seed puncture or the characteristic 'sting' (Russell and Chalfant, 1979).

Cowpea storage weevil:

Callosobruchus maculatus (Fab.) is a storage pest of worldwide importance. It is a field to-storage pest. Eggs are laid on the seed surface. After hatching the larvae bore into the seed and complete their development within them. Adults emerge from the seed through characteristic holes made by larvae. Severe infestations can lead to grain losses of more than 80% (Caswell, 1978, unpubl.). C. chinensis is a minor storage pest of cowpea.

2.3 Cowpea diseases

In the savannas of Africa where most cowpea crops are grown, insect pests are important. In the humid forest belt, diseases are more important. Viruses, fungi and bacteria account for most of the diseases of cowpea (Singh and Allen, 1980).

Viruses:

Seed-borne infections are frequent in legumes (Pathak, 1974). There are some 12 major viruses infecting cowpeas. These include cowpea (yellow) mosaic, cowpea severe mosaic, cowpea mottle, southern bean mosaic, cowpea aphid-borne mosaic, cowpea golden mosaic and others (Singh and Allen, 1980). Their geographical distribution is often very wide (Pathak, 1974), and include Africa, tropical America, some parts of Asia and others are worldwide (Singh and Allen, 1980). Natural infections of cowpea often involve virus mixtures (Kuhn, 1964; Taylor, 1968), which may lead to synergism (Fischer and Lockhart, 1976; Harrison and Gudauskas, 1968) or possibly to cross-protection. In general viruses cause slow growth of infected plants and yield losses of 60 - 100% are common (Chant, 1959; Singh and Allen, 1980).

Fungi:

More than 40 species of fungi are pathogenic to cowpeas. Singh and Allen (1980) gave a comprehensive account of the aetiology, seed transmission, geographical distribution and economic importance of the major fungal diseases of cowpeas. Seedling mortality in cowpea is commonly caused by Rhizoctonia solani and Pythium aphanidermatum. These fungi are prevalent in Nigeria and can cause up to 75% loss in crop stand (Williams, 1975). Stem diseases root and foot rot are caused by various fungi among which are Colletotrichum lindermuthianum, Pythium aphanidermatum, Phytophthora vignea, Sclerotium rolfsii and Fusarium solani. The distributions of these fungi are confined to Africa, India, Brazil and some parts of North America and Australia (Singh and Allen, 1980). Stem and root infections reduce yields up to 30% (Singh and Allen,1980). Cowpea leaf spots caused by Cercospora canescens and C. cruenta, and leaf blight caused by Rhizoctonia solani are worldwide in their distribution. These are also responsible for yield losses of between 20-40% (Singh and Allen, 1980). Minor fungal diseases include premature senesce, stem canker, and ashy blight caused by Macrophomina phaseolina (Luttrell and Weimer 1952; Williams, 1975).

Bacteria and other pathogens

Few bacterial pathogens of cowpea have been described or studied in detail. Pseudomonads are seldom reported from cowpea crops but have occurred in Brazil, Ethiopia (Allen, unpublished) and U.S.A. (Gardner, 1925). Bacterial pustule occurs in Nigeria (Williams, 1975), Tanzania and Brazil. Bacterial blight and canker caused by Xanthomonas vignicola is a widespread and important disease in tropical Africa, America and India (Singh and Allen, 1980).

Among the numerous nematodes which invade cowpea roots the most important species are the root-knot nematodes (Meloidogyne incognita, M. javanica and M. arenaria) all of which are widespread throughout the tropics (Singh and Allen, 1980; Caveness, 1973).

2.4 Yield losses in cowpea

Pests and diseases coupled with poor agronomic practices are major constraints to increased cowpea production in the tropics (Kayumbo, 1975). Other yield reducing factors include a high rate, 70-80%, of flower abscission due mainly to physiological factors (Ojehomon, 1968, 1970) and infestations by nematodes (Sellschop, 1962; Caveness, 1973).

Cowpea seed yields in developing countries are low compared with yields in the developed countries (FAO, 1971, 1974, 1975). It is estimated that the average yield of the crop grown in monoculture

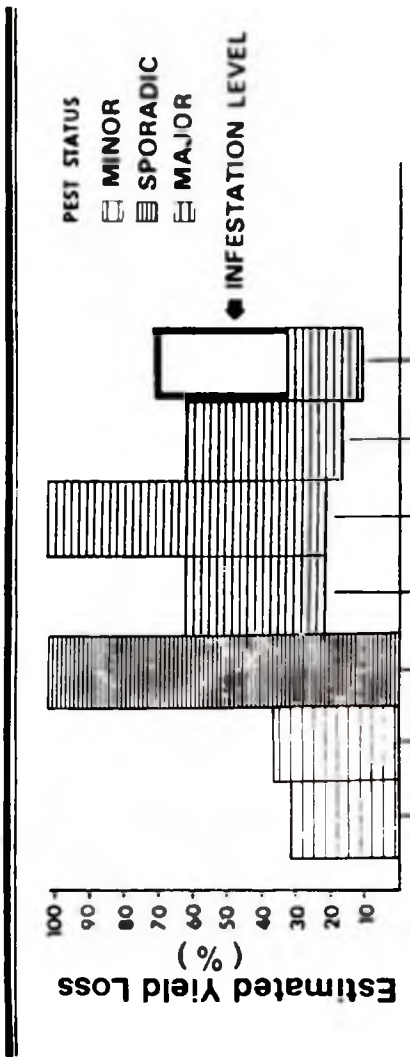

Fig. 22 Estimated yield losses and pest status of selected cowpea pests in Africa.(SINGH, 1980).

is about 1500 kg/ha in the United States, 650 kg/ha in South America and Asia and is often below 400 kg/ha in Africa (FAO, 1971, 1974, 1975). Seed yields particularly in West African environments are very small, 100-200 kg/ha (Ebong, 1965; Ojehomon, 1970). These yields are well below the expected average obtained by Booker (1964). Cowpea yield losses have been investigated by various workers (e.g. Booker, 1964, 1965; Taylor 1968; Koehler and Mehta, 1972; Kayumbo, 1975). Figure 2.2 shows the estimated yield losses due to selected cowpea pests (Singh, 1980).

2.5 Pest status and distribution of thrips, Megalurothrips sjöstedti

It has been well-established that flower thrips Megalurothrips sjöstedti (Trybom.) is a major pest of cowpea and other grain legumes throughout tropical Africa (Koehler and Mehta, 1972; Okwakpam, 1967; Taylor, 1967, 1968; Singh and Taylor, 1978). In Nigeria it is perhaps the most important of the four species - Frankliniella schultzei (Trybm.), Haplothrips gowdei Franklin, Sericothrips occipitalis Hood and Megalurothrips sjöstedti - recorded on cowpea (Okwakpam, 1965, 1967). Moulton (1930) recorded M. sjöstedti on groundnuts (Arachis hypogea) and Lantana camara.

Taylor (1969) observed M. sjöstedti feeding injuries to be characterised by the distortion, malformation and discoloration of floral parts and suggested that these injuries particularly on

anthers and filaments may lead to premature loss of pollen and decrease in pollination and seed set. Okwakpam (1967) suggested that M. sjöstedti might be responsible for premature shedding of flowers. Phelps and Oosthuizen (1958) stated that M. sjöstedti was present in large numbers within the flowers of cowpeas and may be responsible for flower drop as well as withering and bleaching of the flower petals.

Certain levels of infestation of thrips lead to flower and fruit drop in a variety of crops. Davidson and Andrewartha (1948) estimated that a population density of 40 thrips (Thrips imaginis) per flower can cause flower shedding in apples and Carlson (1964) has shown that feeding injury by the onion thrips Frankliniella occidentalis (Pergande) causes premature loss of pollen and decreased pollination and seed set. He suggested that 10 thrips per flower was sufficient to cause flower injury. Fagade (unpublished), recorded a mean of 96 and a maximum of 350 of M. sjöstedti per flower at the peak of flowering in cowpea in Southern Nigeria. Strassen (1960) also suggested that M. sjöstedti is probably a vector of a virus on beans, but this contention has been dismissed (Allen and van Damme, 1981).

M. sjöstedti is widely distributed in Africa and has been recorded from Gambia, Ivory Coast, Cameroun, Equatorial Africa, Zaire, Uganda, Tanzania, Zimbabwe, Namibia and Republic of South Africa (Strassen, 1959, 1960), Ghana and Togo (van Halteren, 1971, Appert, 1964).

2.6 Biology of thrips

2.6.1 General

There are usually 4 or 5, in rare instances only 3, instars between the egg and adult (Lewis, 1973). The first 2 or 3 feeding instars are called larvae and the later non-feeding ones prepupae and pupae. Imms (1960) and Lewis (1973) gave a general account of the morphology of the various larval and pupal instars of thrips.

Mature eggs of thrips are large in relation to the thrips abdomen so females usually contain only a few ready for laying at a time. The eggs of the suborder Terebrantia are cylindrical, slightly kidney-shaped with smooth delicate, pale white or yellow shells. Tubuliferan eggs are oval, either symmetrical or constricted at the top, and often have a pink,yellow or darkly coloured shell sculptured with pentagonal or hexazonal reticulations (Lewis, 1973). Most Terebrantia lay their eggs singly in an incision made in the plant tissue by the ovipositor. However, all Tubulifera, which have no saw-like ovipositor lay their eggs on flowers and leaves, (Lewis, 1973).

2.6.2 Megalurothrips sjöstedti

Except for the work of Okwakpam (1978) the biology of M. sjöstedti is not completely known. Okwakpam (1978) provided a detailed account of the morphology of the various immature instars. He observed 5 instars - 3 larval instars, prepupa and pupa. Total developmental period averaged 18.3 days at a temperature range of 21^{o} - 25^{o}C. The population dynamics of M. sjöstedti was studied by Taylor (1969, 1974), in which he observed two peak populations which each coincided with peak flowering of cowpeas.

2.7 Sampling of thrips

2.7.1 General

Sampling techniques of thysanoptera on foliage or flowers have been performed extensively by different workers. McGregor (1926) described a very simple technique in which infested foliage was shaken over a greased paper on which the thrips fell and were trapped, and were later counted. In all subsequently described methods samples of foliage or flowers were brought back to the laboratory for extraction, permitting the use of a range of extraction techniques. Evans (1933) later described a chemical repellency method in which Thrips imaginis Bagnall, was induced to leave rose blossoms by the slow diffusion of turpentine vapour; the thrips moved on to a filter paper in response to a positive phototropism and died there. Le Pelly (1942) developed his own for estimating Diarthrothrips coffeae Williams in which he rinsed thrips from leaves with ethanol, and then filtered them on to specially prepared filter papers. Taylor and Smith (1955) tested Evan's technique and found it unsatisfactory while Lewis (1960) used Evan's method in principle with some degree of success. Höerner (1947) and Shirck (1948) among several others used an increase of temperature to cause movements of thrips downward into a dilute detergent wash to extract thrips from flowers, the vegetable matter being skimmed off after agitation and the jar placed over cross section paper on which thrips were counted. Bullock

(1965) extracted Thrips nigropilosis from samples of foliage using a benzene/water interphase. Lewis (1959) sampled thrips using water and sticky traps. Southwood (1966) classified the different methods of estimating thrips populations on plants into three:

a) Washing methods usually with a liquid.

b) Mechanical method in which thrips are knocked off the plants.

c) Irritation methods that rely on the vapours of chemical or heat to drive the thrips off the plant.

Ota (1968) tested these methods using either 70% alcohol or 0.1% detergent solution (Triton X - 700) as washing solution.

2.7.2 Megalurothrips sjöstedti

Taylor (1969, 1974) sampled M. sjöstedti using a suction trap. Okwakpam (1978) tried the use of sticky and water traps to sample M. sjöstedti from cowpeas. At the International Institute of Tropical Agriculture (IITA) the usual method of sampling thrips is the washing method, which uses 30% alcohol. Samples are returned from the field in glass vials that contain flower samples in alcohol.

2.8 Host plant resistance

Painter (1951) defined host plant resistance as the relative amount of heritable qualities possessed by the plant that influence the ultimate degree of damage done by the insect. In practical agriculture it represents the ability of a certain variety to produce a large and better quality crop than ordinary varieties at the same

level of insect populations (Painter, 1951).

Beck (1965) has defined host plant resistance to insect attack as the "collective heritable characteristics by which a plant species, race, clone or individual may reduce the possibility of successful utilization of that plant as a host by an insect species, race, biotype or individual". Implicit in this concept of resistance is that the factors conferring resistance are genetically determined, and there is therefore the possibility of genetic selection for improvement in host resistance.

Host resistance could be due to the nutritional status of plants or to morphological and anatomical factors or to secondary substances, or more probably a combination of these factors. Painter (1951, 1958) proposed three broad characterisations of the mechanisms of resistance:

Non-preference; when a plant possesses factors that render it unattractive for insect pests for their oviposition, feeding or shelter.

Antibiosis; when the plant adversely affects the insect feeding on it. The effects on the insect take the form of reduced fecundity, decreased size, abnormal length of life and increased mortality.

Tolerance; a plant is tolerant if despite supporting a population large enough to severely damage susceptible hosts, it suffers little damage.

The concept of host plant resistance is comparatively new in developing countries. The vast majority of breeding for insect resistance has been carried out especially in the United States as exemplified in the work of Painter (1951, 1958) and the reviews of Beck (1965), Sprague and Dahms (1972) and Maxwell et al. (1972). Maxwell et al. (1972) reviewed 555 papers out of some 1400 which covered works between 1958 and 1971. Kennedy et al. (1975) state that work on insect resistance is in progress on almost every major crop in the U.S. and this has led to the release of 100 varieties and inbreds of crop plants carrying resistance to more than 25 insect species (Sprague and Dahms, 1972).

2.9 Host plant resistance in cowpea

The world germplasm of cowpea is maintained at the International Institute of Tropical Agriculture (IITA) and this has enabled entomologists there to aggressively screen the germplasm for resistance to the pests in Africa (Singh, 1980).

2.9.1 Leafhopper resistance

Resistance to E. dolichi has been extensively studied at IITA. A world germplasm collection of about 4000 cowpea cultivars has been screened. Four cultivars, TVu 59, TVu 123, TVu 662 and TVu 1190E were rated resistant (Singh, 1977b). TVu 1190E was described as VITA-3 due to its high level of resistance to leafhoppers and additional important characteristics such as multiple disease resistance and resistance to Meloidogne incognita (Singh, et al. 1975). The mechanism of resistance in VITA-3 has been identified as tolerance (Raman et al. 1978).

2.9.2 Aphid resistance

By screening in the greenhouse four cultivars (TVu $408P_2$, TVu 410, TVu 801 and VITA-1), that also have multiple resistance to several foliar diseases were identified as resistant to cowpea aphid The mechanism of resistant in TVu $408P_2$, TVu 410 and TVu 801 identified as antibiosis and VITA-1 was found to tolerate aphids (Ansari, 1978, unpublished).

2.9.3 Resistance to lepidopteran pests

Legume pod borer, Maruca testulalis (Geyer) is the major lepidopteran cowpea pest in Africa. Resistance to this pest has been studied at IITA. By screening 2800 cowpea cultivars at IITA, two cultivars (TVu 946 and TVu 4557) were identified as resistant to

M. testulalis damage to stem and peduncles. Both these cultivars have additional important characters that make them less susceptible to flower and pod damage. TVu 4557 has been described as VITA-5 (Singh et al.,1976). The mechanism of resistance to stem and peduncle damage in these two cultivars has been identified as antibiosis (Usua 1975 unpublished, Singh,1977b; Singh , 1978).

2.9.4 Resistance to pod sucking bugs

Khaemba (1978, unpublished) screened about 3400 cowpea cultivars for resistance to the pod-sucking bug complex at IITA. Preliminary results indicated VITA-4, and five other cowpea cultivars had comparatively less damage than other test cultivars in the field.

2.9.5 Resistance to flower thrips

A germplasm of over 4000 cowpea cultivars have been screened for sources of resistance to flower thrips, M. sjostedti. TVu 1509 was identified as moderately resistant (Singh,1977b). The mechanism of resistance to thrips damage in TVu 1509 was identified by Roesingh (1980) as antibiosis. Two other early-maturing cultivars ER-1 and ER-7 which are susceptible in greenhouse tests, consistently escaped thrips damage in field trials due to early flowering and/or to profuse flowering (Singh, 1978; Singh and Allen, 1980). Recently a cross was made between resistant TVu 1509 and high-yielding Ife

Brown (TVu 3629) resulting in four cowpea cultivars (TVx 3236 series) which have even higher levels of resistance than TVu 1509 with higher yield potential and comparatively superior agronomic characters (Singh, 1980).

Research into locating sources of resistance to the major cowpea pests is still in progress.

CHAPTER THREE

3. STUDIES ON THE BIOLOGY OF FLOWER THRIPS ON COWPEA

Studies were made on some aspects of the biology and behaviour of thrips as they occur in the cowpea crop. A basic pre-requisite for effective host plant resistance studies is a knowledge of the seasonal population fluctuations of the insect species involved. Thus the seasonal abundance of M.sjostedti was monitored throughout the year. The possible occurrence of other thrips species on cowpea was also investigated.

3.1 Materials and methods

3.1.1 Thrips population studies

Four (4) cowpea cultivars were used in the study, namely: TVu 1509, Ife Brown (TVu 3629), TVx 3236 and VITA-6. Plots consisted of 4 rows 5 m long and 0.75 m apart. Distance between plants was 0.20 m and 1.25 m between adjacent plots. There were four replications laid out in a completely randomised design.

Samples of thrips were taken at 37, 42, 47, 52, 55 and 60 days after planting (DAP). Sampling was confined to the two central rows

and involved a random collection of one peduncle per plant at 37 and 42 DAP and one flower per plant on the other DAPs. Each time ten plants were selected at random from each replicate and a sample was taken by gently enclosing a peduncle head or flower in a 5.2 x 2cm glass vial containing alcohol (30%) (Plate 3.1). Peduncles or flowers were then chipped off with a fine pair of scissors. Samples were normally taken between the hours of 0730 and 0830 with least possible disturbance to the foliage.

A record was kept on the number of peduncles and flowers produced per plant sampled at each DAP.

3.1.2 Counting of thrips

All thrips samples were counted after 24 h. The contents of each vial were emptied into a transparent square gridded plastic petri dish and racemes or flowers dissected. After this the petri dish with its contents were placed under a microprojector and thrips counted. Both adults and immatures were counted. Thrips populations were expressed as number per peduncle and number per flower for each of the four cultivars.

PLATE 3.1: Procedure of taking samples in alcohol.

3.1.3 Identification of species

Samples of thrips were collected to prepare microscopic whole mounts to identify the thrips species infesting the cowpea crop.

Two extra samples from each replicate were collected in vials containing an alcohol-glycerine-acetic acid mixture (AGA) (10 parts:1 part:1 part). AGA keeps thrips in a better condition for microscopic mounting than alcohol alone (Mound and Pitkin, 1975).

3.1.3.1 Permanent mounting

Specimens to be mounted were transferred from the AGA mixture into alcohol (50%) and kept for 30 min. After this they were bleached by boiling in KOH (10%) for about 5 min. From KOH the specimens were washed in alcohol (50%) and then transferred to alcohol (60%) for 24 h.

After the 24 h period specimens were dehydrated through a series of alcohols: 70% - 60 min; 80% - 20 min; 95% - 10 min; and absolute - 5 min. To avoid undue damage to the appendages of specimens, alcohols were removed with a pipette rather than lifting out each specimen and transferring them into a new dish. To accelerate dehydration distended specimens were pierced with a fine needle through the sternal region during the dehydration process. Appendages were also constantly spread. Specimens from absolute alcohol were finally cleared in clove oil before mounting on microscopic slides.

Specimens were mounted individually, ventral side uppermost on a 16 mm cover slip in drops of neutral Canada balsam. It was easier to lower a slide than it is to lower a cover slip held with a forceps onto a drop of balsam on a slide. Mounted specimens were labelled and oven-dried at 40°C for two weeks.

Identification of specimens was based on Okwakpam and Youdeowei's (1980) key to identification of thrips infesting edible legumes in Nigeria.

3.1.4 Oviposition sites

M. sjöstedti is found mostly in flower buds and flowers, but it is not unusual to find them in terminal bud leaflets. These plant parts were separately examined for instances of oviposition, on cowpea cultivar VITA-7.

Twenty samples each of racemes, (consisting of young flower buds), flowers and terminal bud leaflets (consisting of very young trifoliates) were collected from the field in petri dishes. Back in the laboratory, flowers were dissected into their component whorls. Each of the different plant parts were separately cleared in lactophenol solution by boiling for about 7 min. After clearing they were immersed for about 6 h. in a lactophenol solution containing a few drops of acid fuchsin to stain any thrips eggs embedded in the plant tissue. The various plant parts were then examined under a binocular microscope and the number of eggs counted. The investigation was replicated five times, so that in

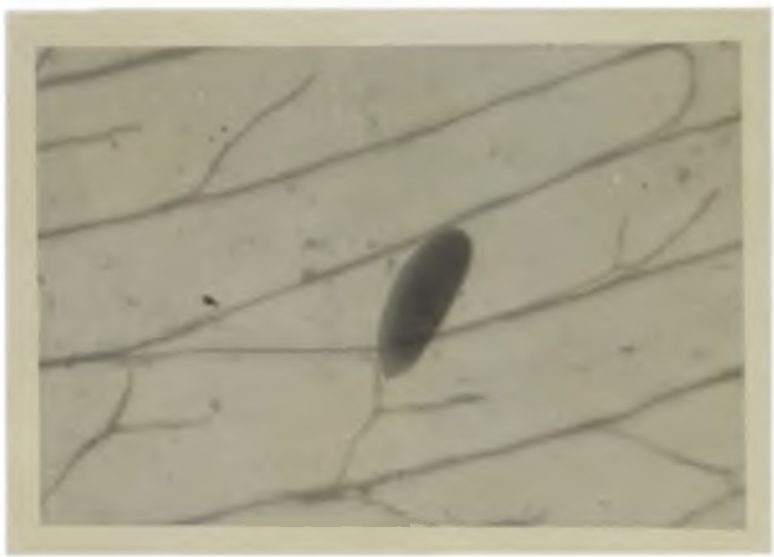

PLATE 3.2: An egg of Megalurothrips sjostedti lodged in the petal tissue of a cowpea flower x 520.

all a total of 100 units each of racemes, flowers and terminal bud leaflets were examined.

3.1.5 Seasonal variability in thrips populations

Cowpea cultivar VITA-6 was planted at a 10-day interval from the last week of August 1981 to August 1982. Plot sizes were 3 rows, 4 m long, 0.75 m apart. Each planting was separated from the previous one by a strip of bush fallow so as to minimise theincidence of migration of thrips between contiguous plantings.

Samples of thrips were taken at 47 DAP for each planting. This period coincided with peak flowering. The reason was to eliminate the effect of crop phenology on thrips populations. Each time a random collection of 20 flowers were made in glass vials containing alcohol (30%). Samples were taken back to the laboratory to count thrips. The mean number of thrips per flower for each month was obtained by first pooling the counts from plantings whose samples were obtained during that particular month and then finding the mean. Mean number of thrips per flower were plotted against the months of the year to obtain an annual population trend. Records of mean monthly temperature and rainfall were kept.

3.1.6 Effect of rainfall on thrips populations

To determine whether rainfall influenced thrips populations, extra plantings were done prior to the onset of rains during the period April - June, 1982.

Between 48 - 60 DAP, ten samples of flowers were collected 30 min. after any heavy down pour during the day. Corresponding samples were taken at mid-day on bright sunshine days. A total of ten such pairs of samples were taken. Data was subjected to a paired sample t-test to determine if there was any significant difference.

3.2 Results

3.2.1 Population studies

The population trend of M. sjöstedti and the age of the cowpea crop for the four cultivars of the test are illustrated in Figures 3.1, 3.2, 3.3 and 3.4. In all cases M. sjöstedti increased rapidly from 37 DAP to between 50 and 55 DAP which coincided with peak formation of floral buds and open flowers. The increasing floral structures provide shelter and feeding sites.

3.2.2 Identification of species

Four different thrips species were collected on the cowpea crop. However only three were identifiable with Okwakpam and Youdeowei's (1980) key. The identified species were Megalurothrips sjostedti (Trybom.); Frankliniella schultzei (Trybom.) and Sericothrips occipitalis Hood. The first two were collected from flower buds and flowers while the latter one in addition to the unidentified species were collected from foliage. The four thrips species are illustrated in Plates 3.3, 3.4, 3.5 and 3.6. The unidentified species is being sent to the British Museum for identification.

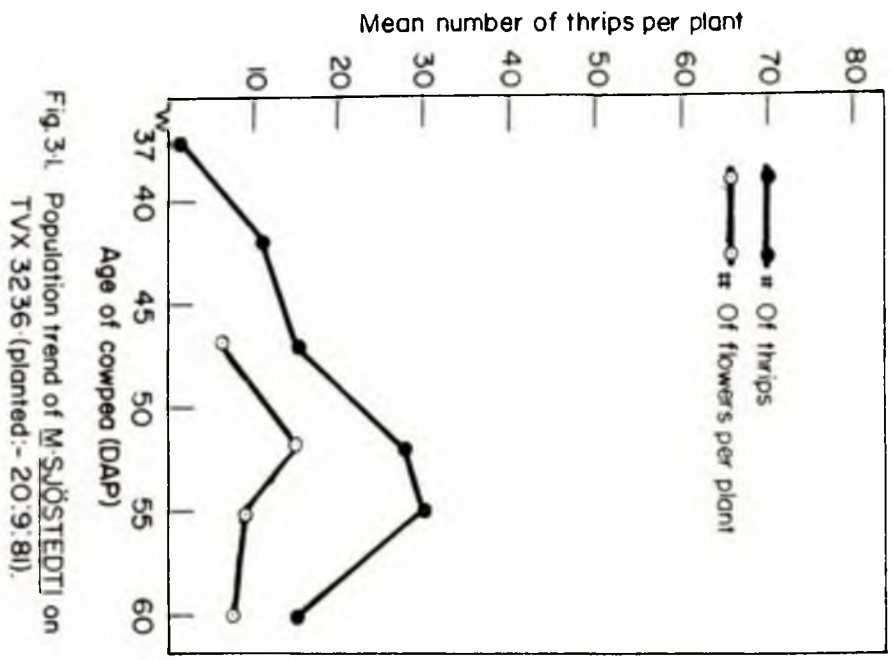

Fig.3.1. Population trend of M.SJÖSTEDTI on TVX 3236 (planted:- 20.9.81).

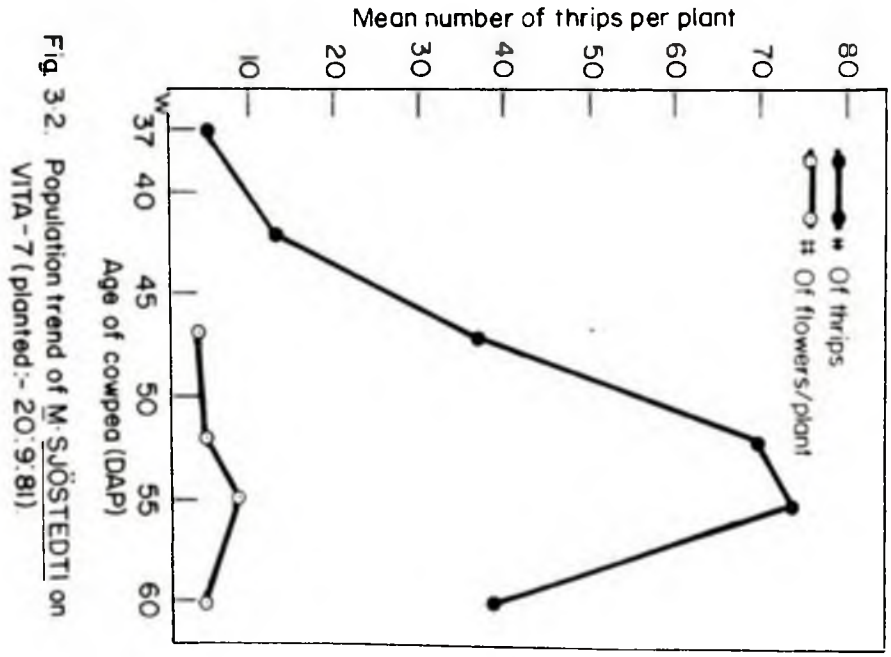

Fig. 3.2. Population trend of M.SJÖSTEDTI on VITA-7 (planted:- 20.9.81).

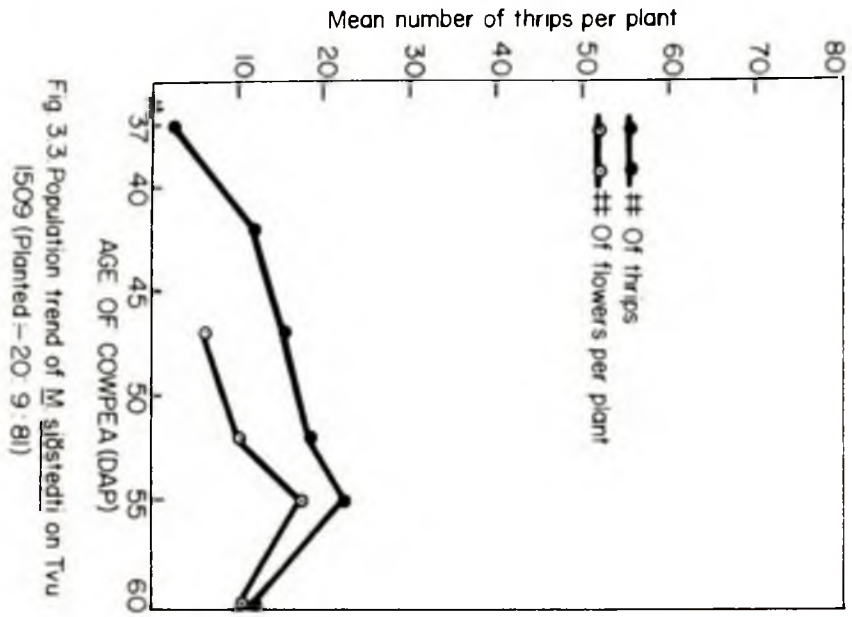

Fig 3.3 Population trend of M. sjostedti on Tvu 1509 (Planted – 20 9 81)

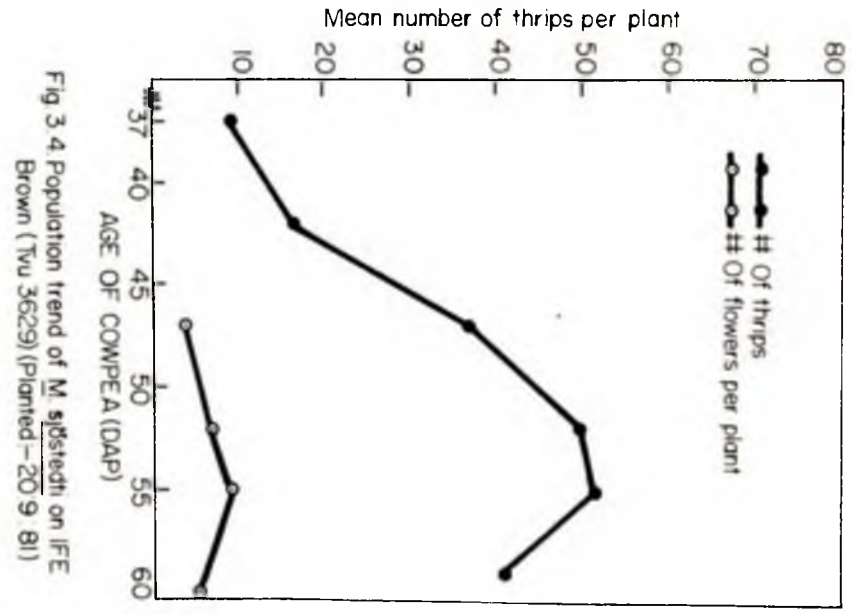

Fig 3.4 Population trend of M. sjostedti on IFE Brown (Tvu 3629) (Planted – 20 9 81)

3.2.3 Oviposition sites

The mean number of eggs recorded from the various plant parts are summarised in Table 3.1.

Table 3.1: Mean number of eggs of *M. sjöstedti* deposited in various parts of the cowpea plant (N 20 in each replication).

Plant part	Replication					Overall mean ± S. E.
	1	2	3	4	5	
Racemes	25	26	24	35	20	26.0 ± 2.5
Flower						
a) Calyx tube	25	21	23	29	15	22.6 ± 2.3
b) Corolla	7	6	5	8	7	6.6 ± 0.5
c) Stigma tube	0	0	0	0	0	
Terminal leaflets	8	5	7	6	9	7.0 ± 0.7

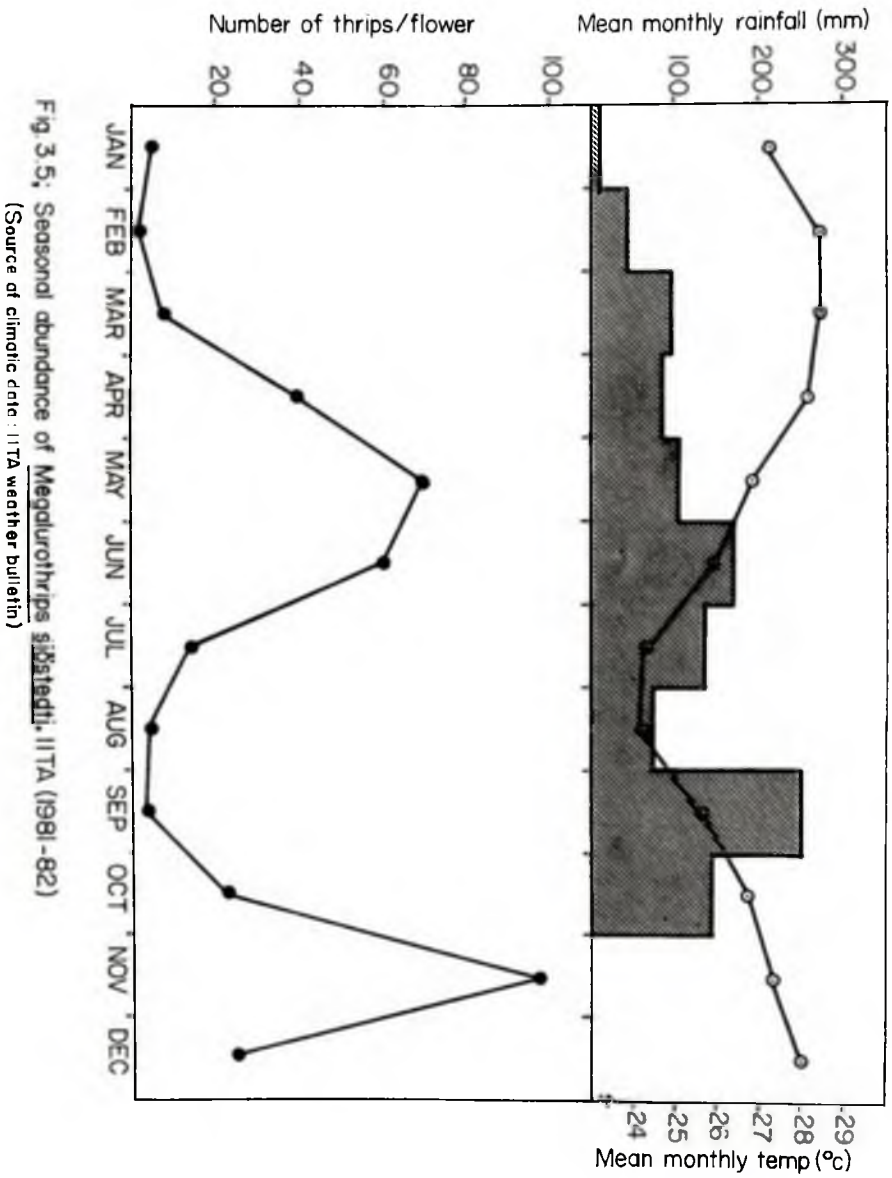

Fig.3.5: Seasonal abundance of Megalurothrips sjostedti. IITA (1981-82)
(Source of climatic data: IITA weather bulletin)

PLATE 3.3: Megalurothrips sjöstedti (Trybom.) x 270.

PLATE 3.4: Frankliniella schultzei (Trybom.) x 270.

PLATE 3.5: Sericothrips occipitalis Hood. x 270

PLAIE 3.6: Unidentified sp. X. x 270.

3.2.4 Seasonal abundance of thrips

The seasonal population trend of M. sjöstedti is shown in Figure 3.1.

Thrips were found throughout the year. Two population peaks were observed in November and May. The population built up rapidly following the break in rainfall; then fell suddenly towards December. Populations remained very low from January through February to March. As the second phase of rains set in populations began rising and reached a second peak in May. There was a gradual fall in numbers from June to August. In general population peaks coincided with the cowpea cropping seasons.

There was a significant difference ($t = 3.67$, $n = 10$, $P < .05$) between the mean number of thrips per flower collected after heavy rains ($\bar{x} = 17.2 \pm 1.4$) and mean number of thrips per flower collected on sunny non-rain days ($\bar{x}$ 31.5 $\pm$ 2.6) when compared by a paired t - test.

3.3 Discussion

3.3.1 Population studies

It appears that the population trend of M. sjöstedti was largely determined by the flowering cycle of the cowpea crop. The overall mean number of thrips per flower for the different cultivars TVu 1509, TVx 3236, VITA-6 and Ife Brown were 14.5, 16.8, 40.4 and 31.5 respectively during the first planting. They were 23.1, 25.5, 38.4 and 43.5 in that order during the second planting. Taylor (1969) recorded an even larger population means of 54 and 63 thrips per flower in early and late crops respectively of

cowpea in Ibadan. The two cultivars TVu 1509 and TVx 3236 consistently showed lower populations found on them, when compared to Ife Brown and VITA-6. Some factors probably were present in TVu 1509 and TVx 3236 that accounted for the lower populations. It is likely that the lower thrips populations enabled a higher number of flowers to be produced by these two cultivars (Figs. 3.1 and 3.3).

After about 60 DAP a decline in population was observed in all cultivars. Thrips probably started migration to fresher host plants from senescing cowpeas. Taylor (1974) actually reported that build up of populations of M. sjöstedti on pigeon pea (Cajanus cajan)arose from the emigration of thrips from senescing cowpeas. Hurst (1964) reported that movements of Thrips tabaci Lind. into onion fields lessened as other plants became lush and onions approached maturity. The overall observation which perhaps is very significant is the concurrence of rising thrips populations with anthesis which in cowpea is the most vulnerable stage to damage due to M. sjöstedti. Thrips populations became very apparent at 37 DAP in all cultivars. 37 DAP then appears a critical stage at which chemical intervention should be initiated to prevent further infestation and population build up and consequent damage. Singh (1975) suggested that the first insecticide application should be done at 35 or 40 DAP to control M. sjöstedti in flower buds and flowers. However for early maturing cultivars this 37 DAP plan may be too late; instead timing control to synchronise with the appearance of the first floral buds may be a more practical alternative. The same alternate

suggestion is recommended for late flowering cultivars, in which case the 37 DAP plan is too early.

A second insecticide application would be needed between 50 - 55 DAP, when populations reach their peak.

3.3.2 Oviposition sites

An average of 26 eggs was found in racemes of young flower buds. The terminal leaflets had an average of 7 eggs lodged in them. More than 90% of the total number of eggs laid in flowers were located in the calyx tube. Okwakpam (1978) found a similar frequency. The corolla was another floral whorl in which eggs of M. sjöstedti were laid. There were no eggs embedded in the stigma tube tissue.

The distribution of eggs in the various floral whorls was not significant (χ^2 0.08, $p < .001$). However it is still apparent that female thrips show preference in the type of floral tissue in which they insert their eggs. Compared to the corolla tissue the calyx tissue is more succulent and probably more nutritious. Thus eclosing larvae with rather fragile mouthparts can start feeding with minimum difficulty. The cell layers in the calyx also appear more dense but less closedly packed (Roesingh, 1980). The reasons for inserting eggs in such a tissue is not far-fetched. The eggs can be concealed deep enough to escape from the actions of parasites, predators and physical environmental hazards.

Eggs were encountered in terminal leaflets in all replications of the test. However these eggs could not be specifically designated as being those of M. sjöstedti. The observation is confounded by the

occurrence of Sericothrips occipitalis in cowpea terminal leaflets. This leaf-feeding species lays all its eggs in leaf tissue (Okwakpam, 1978). All the same some of the eggs could be those of M. sjostedti.

3.3.3 Seasonal variability in thrips populations

The seasonal variation in thrips populations would appear to be related to climatic conditions. In the field, the effects of temperature and rainfall, the two most important weather factors affecting thrips are interdependent. Andrewartha and Birch (1954) related the annual fluctuations in the maximum density attained by Thrips imaginis to density-independent factors of the environment, notably weather changes. When rainfall is heavy the effect on populations is drastic. Two days of heavy rain with hail washed about 70% of the populations of Thrips tabaci from an onion crop (Harris et al, 1936; Harding, 1961). In South Africa a sudden heavy downpour washed many thrips especially larvae from the upper surfaces of citrus leaves and thrips eventually died (Hall, 1930).

The low start in population numbers in September could then be associated with the heavy rains that abounded during this time of the year. Thrips were mechanically dislodged from plants. The number of thrips sampled from plants following rainfall and without rain confirmed this. Warm, dry weather with light showers enhances thrips activity (Hurst, 1964). Mortality caused by heavy rain washing individuals from plants is expected to be less during this period. The period April-May-June

witnessed a mean temperature of about 26.5°C, a temperature not different from that found to be optimal for the development of M. sjöstedti (Okwakpam, 1978). Rainfall was not so heavy compared to the previous season in November. It appears then that harshness of environment was minimal during this period. Coupled with availability of food and shelter (provided by cowpea during the cropping season), these factors are expected to enhance breeding and consequently, a rise in population numbers.

Temperature through its effect on the rate of development largely determines the number of generations produced each season. The rate of development of insects at different constant temperatures does not increase proportionately with rising temperature throughout the range suitable for development. It is faster at temperatures in the median part of the range and slower at the cooler and warmer extremes. The relationship is best described by a logistic curve (Davidson, 1944; Andrewartha and Birch, 1954). Fewer measurements have been made on thrips with necessary precision and at enough different temperatures to show the dependence of rate of development on temperature. However, enough data has been collected for Heliothrips haemorrhoidalis (Rivnay, 1935) to show this relationships. Rivnay showed that from egg to pre-oviposition a peak temperature which was optimal for development was 27.5°C. Above this development was markedly retarded. Temperatures of above 28°C were generally encountered during the February-

March period. Thus excessive heat may have contributed to the rather low populations observed during that period.

Nutritional factors play an important part as regards seasonal population changes of thrips on host plants. Fennah (1963) associated a rise in populations of the cocoa thrips Selenothrips rubrocintus on cashew to the increase of certain amino acids in the leaves during the dry season. The possibility of a similar interaction prevailing in the population dynamics of M. sjöstedti should be considered.

CHAPTER FOUR

4. EVALUATION OF DIFFERENT SAMPLING METHODS FOR COWPEA FLOWER THRIPS

The development of sound procedures for sampling of insect populations is a prerequisite for effective utilization of the information so obtained in pest managment strategies. Formulation of such strategies will require accurate density estimates to determine the pest impact. Likewise sampling will provide the basis for decision making and implementation of tactics in the field.

The usual method of sampling cowpea flower thrips Megalurothrips sjöstedti at IITA involves the harvest of plant parts, namely peduncles and flowers. However, such removal of plant parts may not be desirable because it also harvests and removes from the population a relatively large proportion of individuals as well as disrupting the normal growth of plants. This study was therefore designed to evaluate other potential methods that could be useful in sampling thrips from cowpeas.

4.1 Materials and methods

Five different sampling methods were evaluated and these were:

1. Water trap
2. Sticky trap

3. Sweep net
4. Racemes or flowers collected in alcohol (30%).
5. Direct counts through jarring plants to dislodge thrips on white counting boards.

The experiment was carried out on a plot 35 m x 25 m in an experimental contour that was bordered by pigeon peas. Pigeon peas served as spreader from which thrips were expected to infest cowpeas. Cowpea cultivar VITA 6 was used. Inter-row spacing was 0.75 m and inter-plant distance within rows, 0.20 m. Plants were thinned down to one plant per hill, ten days after planting (DAP). Sampling commenced at 39 DAP. This was then carried out at 4-day intervals for 3 weeks. To avoid discrepancies due to climatic and seasonal factors, samples were normally taken on the same day.

4.1.1. Use of water traps:

Water traps were obtained from white rectangular laboratory pans of approximately 522 cm^2 in surface area (29 cm x 18 cm x 6 cm). White was selected to reflect all colors. Each of the five pans was filled with clear tap water to about 2 cm below the rim. A few drops of detergent were added to the water so that thrips sink and do not drift to the edges and escape. Two drops of formaladehyde (40%) were added to prevent algal and fungal growth.

In the field water traps were placed randomly on laboratory tripod stands just below vegetation level, a height of about 22 cm above ground (Plate 4.1). This height was progressively increased as

PLATE 4.1: A water trap mounted in the field

PLATE 4.2: A sticky trap mounted in the field.

the crop increased in height. The traps were mounted in the field in the morning around 0700h and allowed to stay for about 9-10 h. At the end of this period traps were carefully returned to the laboratory where thrips and other insects were sorted and counted. An illuminated bench-side lens was used for this exercise.

4.1.2 Use of sticky traps

Glass boiling tubes 15 cm long and 3 cm in diameter were used as cylindrical sticky traps. TREE TANGLE FOOT, manufactured by the Tanglefoot Company of Michigan, U.S.A. was used as sticky material.

The glue was applied evenly on the test tubes' exterior using a paint brush. The tubes were supported in the field at vegetation level on upright wooden pegs whose upper portions were wrapped in paper napkins. Napkins were to check test tubes from slipping about the wood pegs, (Plate 4.2). Sticky traps were also left in the field for about 9-10 hours after which they were removed and taken back to the laboratory for examination and counting of thrips.

4.1.3 Use of sweep net

A very fine nylon mesh aerial net with a subcircular diameter of 30 cm and tapering down to 10 cm at the bottom was used for making collections. The handle, made of light weight aluminium was 80 cm long.

Sampling was carried out in units of 10 sweeps to the sample. 10 samples were taken on each sampling day, between 1200 and 1300 h. An attempt was made to sweep at a constant rate, with minimum damage to the crop. A sweep was taken with each alternate step. To avoid sweeping the same area twice, a route of traverse as shown in Figure 4.1 was followed. The lines of traverse in sweeping were sufficiently far apart (3 rows) that there was no possibility of over-lapping in the actual areas swept.

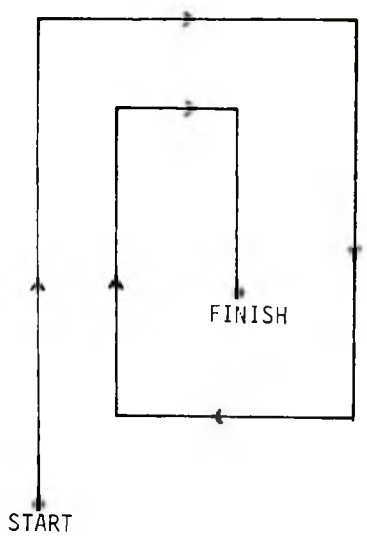

Fig. 4.1: The line of traverse along which the collection was made.

After taking each sample, the catch was put in a wide circular plastic pan, the inside of which was lined with thick white cardboard paper. The paper was to protect the pan from damage due to

PLATE 4.3: A jarring board.

PLATE 4.4: Jarring board in use.

ethyl acetate. The insects were inactivated using cotton bolls of ethyl acetate. These were dropped into the container and a lid applied. Thrips were sorted and counted.

4.1.4 Use of alcohol (30%)

Sampling using alcohol involved random collections of one raceme or one flower per plant, depending on the age of the cowpea crop. At each sampling time ten plants were sampled. The method developed by Lewis and Taylor (1967) was adopted for selecting plants to be sampled. In this method the number of rows (R) were counted, their lengths (L) measured and the total length of row (R x L) was computed. This (R x L) was divided by the required number of units for the sample. This gave the unit row length (4.1 m). Then beginning in the middle of the plot, a unit row length was estimated off in one direction and a plant chosen at this spot. A sample of one raceme or one flower per plant was then sampled as described in section 3.1.1., of Chapter 3.

The process was repeated, working along the row to the end and doubling back along the next row. Any partially completed unit row length was carried over into the next row, until the tenth and last sample was obtained. From each plant the number of racemes or flowers per plant was recorded.

Samples were taken to the laboratory to count thrips. The process of counting thrips was similar to that described in section 3.1.2 of Chapter 3.

4.1.5 Direct counts through jarring

Jarring boards were fashioned using rectangular pyrex boards of dimensions 41cm x 30 cm with a thickness of about 2 mm. Cotton lint cloth of equal dimensions was glued to one face of the boards. By means of thin yellow paper strips, the lint surface was divided into six grids of 100 cm^2 each to enable easy counting of thrips.

In taking a sample, the board was placed beneath a plant chosen a random as described in section 4.1.4. The plant was then brought together and inclined over the board and then tapped five times with the hand (Plate 4.3). Any thrips present on the plant were dislodged which were temporarily entangled in the fibres of the lint and quickly counted. With this method an estimate of the number of thrips per plant was recorded directly.

4.1.6 Sampling efficiency

The efficiency of each of the five methods was computed on basis of the Relative Variation statistic (RV) (Pedigo et al., 1972) where

$$RV\ (\%) = (SE/\bar{x})\ (100)$$

where SE is the standard error of the mean = $S/\sqrt{n}$ and S is the standard

deviation. Since the standard error of the mean decreases with n, the method that produces the lowest RV is the most desirable. The results of the test are summarised in Table 4.1.

4.2 Results

4.2.1 Crop growth and sampling efficiency

Both the cowpea plant and thrips that live in it change through the cropping period. As the plants grow, they provide more places for thrips to disperse. The combined effects of plant growth and thrips dispersal therefore may greatly affect the efficiency of the sampling methods. This phenology is likely to influence sampling in the following ways:

1. When plants are young and the canopy open, all methods may be expected to be relatively efficient.

2. As the canopy begins to close the sweep net tends to sample on the upper parts of plants and so become less efficient.

3. When plants begin to senesce all methods may provide inadequate estimates of populations.

The effects of these factors were noted alongside the results of this experiment.

Table 4.1: Relative efficiency of 5 sampling methods for cowpea flower thrips.

Sampling method	Days after planting (DAP)									
	39		43		47		51		55	
	*$\bar{X}$ ± S.D.	**RV	$\bar{X}$ ± S.D.	RV	$\bar{X}$ ± S.D.	RV	$\bar{X}$ ± S.D.	RV	$\bar{X}$ ± S.D.	RV
Alcohol	1.6 ± 0.4	40.0	1.8 ± 0.4	35.9	8.9 ± 1.0	30.7	5.5 ± 0.9	26.1	4.0 ± 1.1	28.6
Water traps	89.3 ± 11.9	21.1	78.8 ± 4.1	8.1	60.3 ± 3.6	9.5	118.3 ±12.8	17.2	31.3 ± 4.8	17.9
Sticky trap	9.2 ± 1.9	20.4	6.2 ± 0.8	17.2	37.2 ± 6.0	22.8	29.6 ± 5.7	27.3	4.8 ± 0.6	24.3
Jarring	1.8 ± 0.6	35.8	6.0 ± 1.5	24.3	19.7 ± 3.1	25.9	20.4 ± 3.2	15.5	0.5 ± 0.2	44.7
Sweeping	2.6 ± 0.7	29.8	9.3 ± 0.9	30.0	21.8 ± 3.2	34.8	16.5 ± 3.4	20.5	19.6 ± 5.1	25.9

*Mean number of thrips of simultaneous samples.

**Relative variation (%)

Table 4.1 shows the relative efficiency of the five methods that were investigated. According to Southwood (1966) an RV of about 25 is probably sufficient for most pest management purposes. Thus in this study an RV of 25 was considered as a basic criterion of acceptable variability.

4.3 Discussion

From the results most techniques were within the realm of sufficiency for the variability criterion. However more confidence can be placed in the water trap than in the other methods. The water trap was most consistent, with a mean RV of 14.8. It also sampled a fair proportion of the populations, thus it actually gave a true picture of the infestation level. The method may be acceptable for further population studies. Thrips caught in water traps were easily collected in a readily identifiable condition. The relative efficiency of white water traps were investigated by Lewis (1959). He stated that catches were less consistent at higher levels and went further to suggest that they be used at vegetation level where the wind speed is low and where their angular outline will cause least turbulence in the air flowing past them. Figure 4.2 shows the proportion of other insects and arachnids caught by the water trap. There was a high preponderance of diptera, followed by hymenoptera. The efficiency of water traps is known to depend on the activity of insects (Lewis, 1959). It is therefore not unexpected that more diptera and

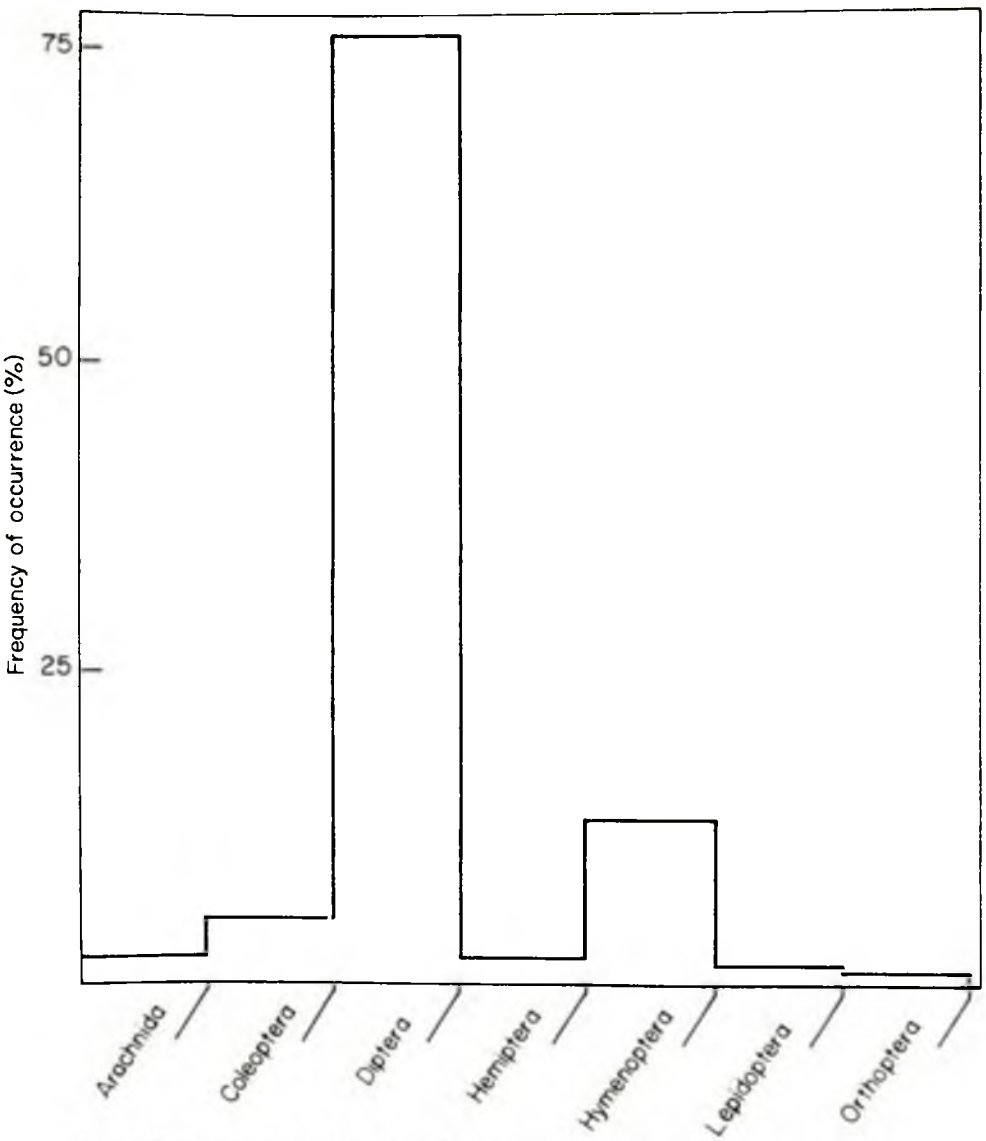

Fig 4 2 Frequency distribution of other arthropods caught by Water traps

hymenoptera were caught - the two groups are active fliers. The proportions of hemipteran and lepidopteran insects were rather low. During the experimental period the major pod-sucking hemipteran pests were scarce. In addition the sampling regime ended at a point (55 DAP) when populations of these insects had just began to rise. Water traps were mainly mounted during daylight. Most lepidoptera are nocturnal and hence the low proportions encounted were partially justified. Most coleoptera caught were chrysomelids plus a few bruchids. There was a sudden outbreak of Zonocerus variegatus at some point during the experimental period. This insect accounted for the orthopterans recorded in the experiment.

It appears that the water trap holds promise as a tool for faunal surveys in cowpea entomology. However, as far as thrips are concerned, one pertinent observation cannot be overlooked. The larvae of thrips are mostly confined to the interior of flower buds and open flowers. Therefore the water trap tend to underestimate total population by omitting the immatures. This can affect the efficiency of trapping.

One other method that held promise was the use of sticky traps. RVs obtained from this method were identical to those obtained by use of water traps. Sticky traps have been evaluated for sampling thrips (Lewis, 1959). Counts were reasonably consistent, but were laborious to sort. Compared to water traps at higher levels they showed greater precision. Taylor (1962) showed that if the wind

speed was known the catches of small insects on cylindrical sticky traps could be converted to a measure of aerial density. Based on this observation sticky traps would be chosen in preference to water traps because the relationship between wind speed and the catch of the water trap is likely to prove less simple than that for the sticky trap. From the results of Table 4.1 however, one obvious advantage of the water trap over the sticky trap stands out. When thrips populations are sparse, the water trap still makes catches when the sticky trap barely does so. Like water traps sticky traps may also omit the immatures of thrips.

The sweep net is perhaps the most widely used equipment for sampling insects from vegetation. Its advantages include simplicity and speed (Southwood, 1966). However in this experiment these advantages were outweighed by large departures from the variability criterion set for sampling efficiency. The method is thus unreliable. Large variations between sweep net samples were noted by Gray and Treloar (1933) who swept Anaphothrips obscurus from alfalfa, taking 25 sweeps per sample. The mean coefficient of variation for 40 samples was ±74.9%; 50 sweeps decreased the value to ±47.8%, 100 to ±36.9% and 200 to ±24.1%. Thus to attain acceptable variability as defined in this experiment will mean taking more than 200 sweeps to the sample. In practical pest management terms this seems unrealistic. From this experiment an inference may be that sweeping provides a much less precise estimate for a similar amount of effort when compared to the other methods under the test.

Sampling thrips by picking racemes and/or flowers in alcohol was not a good procedure on basis of the variability criterion. However, unlike the other methods this procedure samples both adults and immature stages, simulataneously. Considering the fact that both adults and immatures do the damage to cowpeas, the disadvantages of the alcohol procedure of a larger variability and disruption of normal growth, may be outweighed by its ability to catch both forms of the insect.

CHAPTER FIVE

5. DEVELOPMENT OF A SCREENHOUSE SCREENING TECHNIQUE FOR EVALUATING RESISTANCE TO FLOWER THRIPS BY COWPEAS.

The International Institute of Tropical Agriculture maintains a cowpea germplasm collection of over 12000. In order to screen a large collection as this, reliable and rapid field screening techniques are required. However field techniques which rely on natural infestation are often beset with some deficiencies (Guthrie, 1980; Ortega et al. 1980). Therefore material selected from the field under natural infestation will have to go through an ultimate screen using artificial infestation methods. The purpose of this study was to develop a screenhouse screening technique that could be utilized in evaluating resistance of cowpeas to flower thrips, Megalurothrips sjöstedti. In addition an attempt was made to determine possible correlation between thrips infestation and damage severity.

5.1 Materials and methods

5.1.1 Screenhouse screening

Screening methods were developed at one level only: Single caged potted plants. Five cowpea cultivars were used in the test and these were TVu 1509, TVx 3236, Ife Brown (TVu 3629), VITA-6 and TVu 76.

TVu 1509 and TVu 76 were included as resistant and susceptible checks. The experiment was laid out in a completely randomised design.

Each of the five cultivars was sown separately in ten 17.8 cm diameter plastic pots in the open. Ten days after planting (DAP) plants were thinned to one plant per pot. At 13 DAP plants were sprayed against aphids with dimethoate 40 EC at the rate of 50 g.a.i./ha. When plants showed signs of flower bud initiation, they were transferred into a screenhouse. In the screenhouse plants were each caged with fine nylon mesh bags supported by thin aluminium rods that had been pushed into the soil in the pots. Bags were further secured to the rim of pots with rubber bands (Plate 5.1). When peduncles had elongated to about 2 cm, each plant was infested with a total of 30 adult *M. sjöstedti* collected from a field nursery.

At seven days after infestation (DAI) each replicate of each cultivar was visually rated for thrips damage. This consisted of stipule browning, bud browning and abscission, flower abscission and distortion. Rating was based on a scale of 1-5, representing slight to heavy damage. The rating chart is summarised in Table 5.1. A damage severity index for each cultivar was obtained by finding the sum of all indices for the ten replications and dividing by the number of replication. After rating samples of two racemes per plant from each cultivar were taken in vials of alcohol. Back in the laboratory racemes were dissected and thrips counted. Rating was repeated at 10 DAI and samples of two flowers per plant from each cultivar taken similarly.

PLATE 5.1: Caged potted plants in the screenhouse.

Table 5.1: Key for visual evaluation of thrips damage severity on cowpea.

SEVERITY INDEX	PLANT PART AND DAMAGE CHARACTERISTICS		
	STIPULES	BUDS	FLOWERS
1	All stipules with normal color, i.e. mostly GREEN.	0% abscission. No browning. Racemes with fully set healthy buds.	Normal form and color. No abscission.
2	20% of all stipules browned and dry.	Slight abscission (10% - 40%). Very few browned.	Normal form and color. Very slight abscission.
3	50% of all stipules browned and dry.	40-60% abscission. Remaining buds mostly browned.	Some abscission. Number obviously reduced, with some slightly malformed.
4	80% of all stipules browned and dry.	50-80% abscission. Remaining buds browned and dry.	Only few formed. Greater proportion malformed and discolored.
5	All stipules browned and dry.	100% abscission. Plants mostly with bare peduncles only.	None-to-very few formed. Malformed and discolored.

Both adults and larvae were recorded during counting. The experiment was repeated using the same cultivars.

5.1.2 Field evaluation of thrips damage severity

A field trial was run concurrently with the screenhouse experiments to measure thrips damage severity under field conditions. Four cowpea cultivars were used in the trial: TVu 1509, TVx 3236, Ife Brown (TVu 3629) and VITA-6. They were planted in plots 4 rows, 5 m long and 0.75 m apart. Distance between plants was 0.20 m and 1.25 m between adjacent plots. Each cultivar was replicated four times in a completely randomised design.

Relative susceptibility of the four cowpea cultivars was assessed by making a subjective visual rating of thrips feeding injury severity. A scale of 1-5 representing slight to heavy damage was used to rate 15 consecutive plants in 1 row of each cultivar in each replicate of the test. Rating was based on damage to stipules, flower buds and flowers. The rating chart is summarised in Table 5.1. Rating was done at 48 and 52 DAP respectively. At 52 DAP also 20 flowers per replicate of each cultivar were sampled to determine thrips populations.

A damage index for each cultivar was calculated by multiplying the number of plants falling into each rating class by the class number, then adding the product for each class and dividing the sum by the number of plants rated. The ratings for the four replications at each DAP were

averaged to obtain a mean index severity rating for the entire test. The results of the field test are summarised in Table 5.4.

5.2 Results

5.2.1 Screenhouse experiments

The results of the two experiments on screening technique are summarised in Tables 5.2 and 5.3. In the first experiment (Table 5.2) there was no significant difference in thrips found in racemes between TVu 1509, TVx 3236, VITA-6 and Ife Brown at 7 DAI. In terms of thrips per flower TVx 3236 compared favourably with TVu 1509. Ife Brown and VITA-6 were not different also. TVu 76 was significantly different from all other cultivars. TVu 76 was also significantly rated for thrips damage, when compared to the other cultivars of the test. There were no differences in damage severity between TVu 1509 and TVx 3236 on the one hand and Ife Brown and VITA-6 on the other.

The same trend of observations were obtained in the second experiment.

5.2.2 Field evaluation of thrips damage severity

Table 5.4 indicates the mean number of thrips per flower and the mean visual rating indices for the four cultivars.

Ife Brown and VITA-6 were significantly rated for thrips damage compared with TVu 1509 and TVx 3236. Damage index was 2.5 for Ife Brown and VITA-6. The indices were 1.0 and 1.2 for TVu 1509 and TVx 3236 respectively.

Table 5.2: 1st screening: Mean number of thrips and visual rating indices for thrips damage following infestation of caged potted cowpea cultivars with 30 adult *M. sjöstedti*.

Cultivar	*Mean Number of thrips		Damage index
	Per raceme (7 DAI)	Per flower (10 DAI)	
TVu 1509	3.4 b	6.7 c	1.8 c
TVx 3236-01G	1.5 b	8.4 c	2.0 c
Ife Brown	5.1 b	31.5 b	2.9 b
VITA-6	6.9 b	26.2 b	3.0 b
TVu 76	19.8 a	61.5 a	3.9 a
LSD @ 5%	8.6	6.4	0.9
S.E.	2.9	4.6	0.3
CV	88.7	37.9	14.3

*Means followed by the same letter are not significant at 5% (Duncan's Multiple Range Test).

Table 5.3: 2nd screening. Mean number of thrips and visual rating indices for thrips damage following infestation of caged potted cowpea cultivars with 30 adult M. sjostedti.

Cultivar	*Mean number of thrips		Damage index
	Per raceme (7 DAI)	Per flower (10 DAI)	
TVu 1509	2.9 a	3.6 a	1.2 a
TVx 3236-01G	2.5 a	10.6 a	1.9 a
Ife Brown	4.1 a	29.5 b	3.2 b
VITA-6	3.7 a	28.5 b	3.1 b
TVu 76	8.5 b	31.4 b	4.1 b
LSD @ 5%	3.6	7.3	1.1
S.E.	1.2	2.5	0.4
CV	63.0	26.8	18.3

*Means followed by the same letter are not significant at 5% (Duncan's Multiple Range Test).

Table 5.4: Severity index and mean number of thrips per flower of 4 cowpea cultivars.

Cultivar	Severity index	Mean number of thrips/ flower
TVu 1509	1.0	16.8
TVx 3236	1.2	18.2
Ife Brown	2.5	30.5
VITA-6	2.5	44.2
LSD @ 5%	0.6	5.6

On the number of thrips per flower the same significant trend was observed.

5.3 Discussion

5.3.1 Screenhouse experiments

In both experiments TVu 1509 and TVx 3236 performed better in all measurements. The rate of development of thrips appeared retarded on TVu 1509 and TVx 3236 as compared to the other cultivars. This probably points to the presence of some antibiotic factors in these two cultivars. Röesingh (1980) identified the mechanism of resistance of TVu 1509 to thrips as antibiosis. It is likely that the same compound is present in both TVu 1509 and TVx 3236, bearing in mind that TVx 3236 has TVu 1509 as one of its parents (IITA, 1980). This speculation needs further evaluation however. Compared to TVu 76, Ife Brown and VITA-6 are less more susceptible to *M. sjöstedti*.

In both experiments however, there were large variations between samples taken at 7 DAI. Coefficients of variation (CV) were within acceptable range (Southwood, 1966) at 10 DAI, in both experiments. Probably consistent samples are possible at 10 DAI and thereafter in this type of screening technique.

Two of the most important attributes of any screening methodology are precision and repeatability (Jackai, 1982). Precision is determined by low sample variability (Southwood, 1966). Most importantly, precision and repeatability are best assessed by the response of the resistant and susceptible checks to insect damage. In the method outlined here,

these checks, (TVu 1509 and TVu 76) were highly polarised in both measurements of thrips populations and degree of damage caused by thrips. The statistical analysis showed that their differences were highly significant. It would appear that this artificial infestation method expounded here could be a useful tool of separating highly susceptible from potentially useful cultivars. In addition it could be used to eliminate escapes carried over from field screening methods. Furthermore this method, like most artificial infestation methods could provide information on the mechanism of resistance which are not obtainable from field methods (Kogan, 1979).

5.3.2 Field evaluation of damage severity

In the field trial both TVu 1509 and TVx 3236 were comparatively superior to Ife Brown and VITA-6 as regards thrips infestation and degree of damage. Resistance to insects has been variously expressed in terms of plant damage, insect counts, pupal weights and oviposition preference (Painter, 1951). Based on the first two parameters it appears that TVu 1509 and TVx 3236 show some levels of resistance to flower thrips. The resistance of TVu 1509 to flower thrips has long been identified and characterised as antibiosis (Singh,1977b; Roesingh, 1980). TVx 3236 is a progeny of a cross between TVu 1509 and Ife Brown as stated in section 5.3.1. Thus it may be expressing the gene for resistance against thrips from its resistant progenitor TVu 1509.

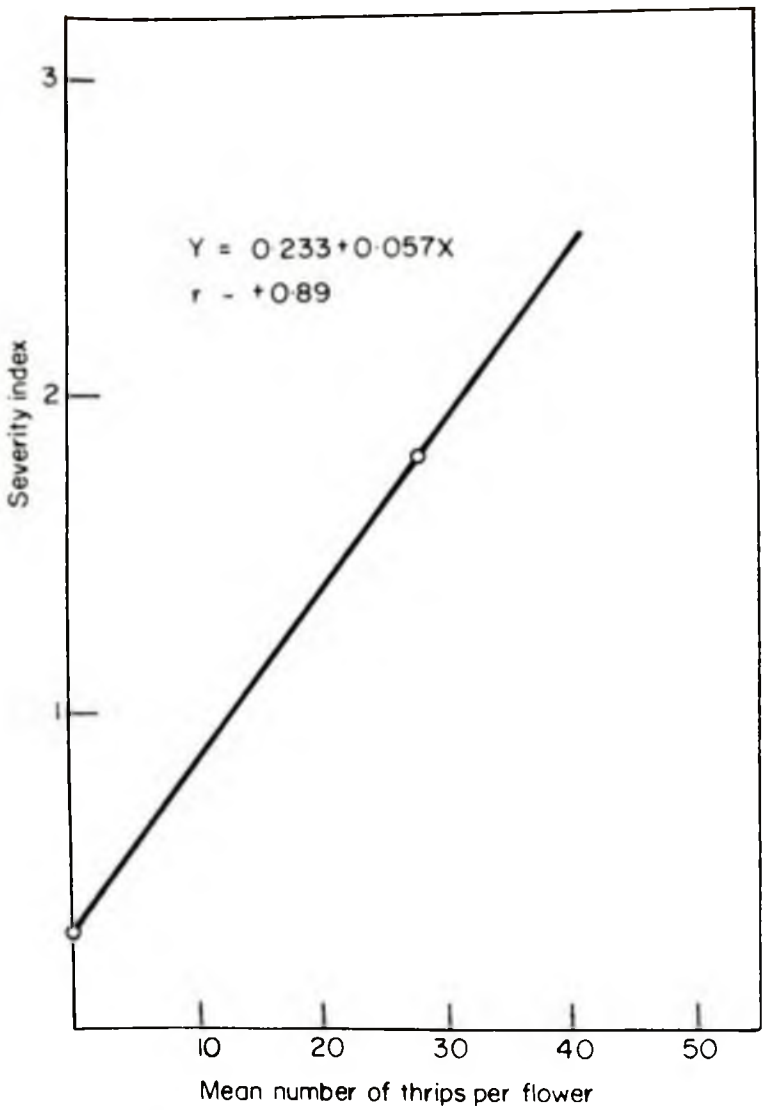

Fig. 51 Regression of thrips injury severity on number of thrips per flower (IITA, second season, 1981)

In an attempt to measure the influence of number of thrips on the damage severity of the four cultivars, the correlation coefficient andlinear regression of severity index on number of thrips per flower were computed. A non-significant ($P < .05$) positive correlation (+ 0.89) was obtained (Figure 5.1). Each unit increase in the number of thrips per flower was associated with an increase of 0.06 in damage severity ($Y = 0.233 + 0.057 X$). The computed r^2 value (0.81) indicated that about 80% of the difference in damage severity could be attributed to the number of thrips infesting flowers. However this observation is not accurate because of non-significance of the correlation coefficient. It only provides a preliminary insight as to the relationship between levels of infestation and plant susceptibility. The observation probably suggests that it is impractical to use a part of the plant to assess the relationship between whole plant susceptibility and thrips infestation pressure. Analysis using total number of thrips per plant may provide a more reliable measure of association.

CHAPTER SIX

6. COMPARATIVE YIELD OF DIFFERENT COWPEA CULTIVARS WITHOUT PROTECTION AGAINST FLOWER THRIPS, MEGALUROTHRIPS SJÖSTEDTI

Trials were conducted during the second season of 1981 and early first season of 1982, to compare the yield of different cowpea cultivars which were not protected against flower thrips. The aim of the study was to assess the utility of levels of thrips resistance shown by some cowpea cultivars.

6.1 Materials and methods

6.1.1 Second season 1981 trial

Four cowpea cultivars, TVx 3236-01G, TVu 1509, Ife Brown (TVu 3629) and VITA 6 were used in the trial. Planting was done on a flat contour and plants were thinned down to one plant per stand at ten days after planting (DAP). Plots consisted of 4 rows 5 m long, and spacing was 0.75 m between rows and 0.20 m between plants in a row. All plots were replicated four times in a randomised block design. Manual weeding was done once at 45 DAP but no fertilizer was applied.

At 53 DAP, Endosulfan (Thiodan EC) was applied at a rate of 250 g a.i./ha to check Maruca and pod-sucking bugs infestation without affecting thrips. Raceme and flower samples were taken at 42 and 48

DAP to determine thrips numbers as described in section 3.1.1 of Chapter three. All plots were harvested between 75-80 DAP. Pods were further dried in drying chambers and later machine-threshed to obtain seed weight.

6.1.2 Early first season 1982 trial

Cowpea cultivars, TVx 3236, VITA-5, VITA-6 and VITA-7 were used in the trial. Plot size was 5 rows 5 m long and spacing was 0.75 m between rows and 0.20 m between plants in a row. All plots were replicated four times in a randomised block design. Two weeks prior to the planting of the experimental material, a susceptible cultivar, TVx 7-5H was planted along the border rows to serve as a spreader. Plants were thinned down to one plant per hill at 10 DAP. There was one manual weeding at 40 DAP and no fertilizer was applied. Spreader rows were later pulled out when the experimental material was 35 days old.

Endosulfan (Thiodan EC) was again applied at 55 DAP to check Maruca and pod-sucking bugs without affecting thrips. Samples of racemes at 38 DAP and of flowers at 48 DAP were taken to estimate thrips infestation. Around 61 DAP there was a sudden rise in populations of pod-sucking bugs made up of Acanthomia tomentosicollis, Riptortus dentipes, Nezara viridula and Anoplocnemis curvipes. Another spray of Endosulfan was then applied at 65 DAP to check this infestation.

All plots were harvested between 79-82 DAP. Pods were machine-threshed to obtain seed weight.

6.2 Results

6.2.1 Second season 1981 trial

Results of the second season (1981) trial are tabulated in Table 6.1. The results indicated that there was no significant difference in yield between TVu 1509 and TVx 3236. The two cultivars also showed no differences in the number of thrips found in racemes and flowers. Similarly there was no significant difference in the yield of Ife Brown and VITA-6. Except for the number of thrips in flowers these two cultivars also showed no significant difference in thrips per raceme.

6.2.2 First season 1982 trial

The results of the first season 1982 trial are summarised in Table 6.2. There was no significant difference in number of thrips in racemes at 38 DAP, between TVx 3236, VITA-5 and VITA-6. Probably this observation suggests that the three cultivars experienced the same initial infestation levels. However all three were significantly different from VITA-7 in terms of thrips numbers at 38 DAP. There were no significant differences in number of thrips found in flowers between TVx 3236 and VITA-5 on the one hand and VITA-6 and VITA-7 on the other.

Table 6.1: Comparative yield performance of 4 cowpea cultivars. IITA 2nd season 1981 (*DOP: 30/9/81).

Cultivar	** Mean number of thrips		Yield kg/ha
	Per Raceme (42 DAP)	Per flower (48 DAP)	
TVu 1509	0.7 b	21.0 a	701 b
TVx 3236	0.8 b	20.8 a	676 b
Ife Brown	0.9 ab	26.0 a	195 a
VITA-6	1.2 a	48.7 b	213 a
L.S.D at 5%	0.4	11.2	56.3
S.E.	0.1	3.5	17.6
CV	27.0	23.9	7.8

*DOP Date of planting.

**Means followed by the same letter are not significant at 5% (DMRT).

Table 6.2: Comparative yield performance of 4 cowpea cultivars. IITA 1st season 1982 (DOP: 24/3/82).

Cultivar	*Mean number of thrips		Yield kg/ha
	Per raceme (38 DAP)	Per flower (48 DAP)	
TVx 3236	0.3 b	6.8 a	988.4 b
VITA-5	0.8 ab	16.5 a	546.4 a
VITA-6	1.1 ab	54.9 b	477.5 a
VITA-7	1.4 a	73.9 b	616.7 a
L.S.D. @ 5%	0.7	14.2	231.5
S.E.	0.2	4.4	72.4
CV	54.9	23.4	22.0

*Means followed by the same letter are not significant at 5% (DMRT).

A very high significant difference in yield was obtained between TVx 3236 and each of the three cultivars which themselves were not significantly different from each other.

6.3 Discussion

6.3.1. Second season 1981 trial

The overall results during the second season (1981) indicated that TVu 1509 and TVx 3236 were superior in terms of thrips infestation and yield when compared with Ife Brown and VITA-6. The fact that TVu 1509 and TVx 3236 had consistently less number of thrips may indicate the presence of some resistance factor. TVu 1509 was found to resist thrips infestation (IITA, 1976, 1977, 1978). In trials conducted at IITA it consistently outyielded contemporary cultivars. It suffered less damage to flower buds and flowers and less yield loss due to thrips (IITA, 1977). Thus the results obtained in this study conform with earlier findings. The mechanism of resistance of TVu 1509 to flower thrips was identified as antibiosis (Roesingh, 1980). TVu 1509 was subsequently crossed with Ife Brown, and a single selection identified as TVx 3236 was shown to combine resistance to flower thrips with good yield potential and seed quality (IITA, 1980). It is thought that TVx 3236 has an antibiotic effect, as this report and earlier investigations (IITA, 1980) have shown that this cultivar reduces thrips populations.

PLATE 6.1: A portion of the field on comparative yield trial (1st season 1982).

6.3.2. First season 1982 trials

The results during this period showed that VITA-7 was most susceptible of all the cultivars of the trials. As compared to Table 6.1 however, there was a large variability within samples taken at 38 DAP than was the case with samples taken at 42 DAP. Apparently consistent samples of thrips from racemes are obtainable around 42 DAP. Again the trial further revealed the superior performance of TVx 3236. The reasons for this have already been expounded. Apart from work carried out at IITA, various multilocational trials have confirmed this thrips resistance and higher yields of TVx 3236. It is yet another source from which other resistant genotypes could be sought through breeding.

CHAPTER SEVEN

7. GERMPLASM SCREENING FOR RESISTANCE TO FLOWER THRIPS

Megalurothrips sjöstedti is a major pest of cowpeas in tropical Africa. Severe infestations can lead to total yield losses (Singh and Allen, 1980).

The use of insecticides has been the principal method of protecting cowpeas against thrips and other insect pests. Studies conducted at IITA indicate that the use of thrips resistant cultivars in integrated control schemes can increase yields with minimum cost. This trial was therefore conducted as an addition to the on-going search for sources of resistance to thrips.

7.1 Materials and methods

A total of 3700 entries, representing a part of the over 12000 World Cowpea Germplasm maintained at IITA were screened in the field for resistance to flower thrips. The trial was conducted during the first season of 1982. Screening was done on flat experimental contours that were bordered by pigeon peas. Pigeon peas maintain a continuous population of thrips and thus serve as a spreader. Also fifteen days before the planting of the experimental material, susceptible cultivars (a mixture of VITA-7 and TVx 7-5H) were planted on 3 border rows that

run down the length of each contour. This was to ensure that adequate thrips populations were present. All accessions were planted in 3 m, single rows. When the experimental cultivars were fifteen days old, the thrips susceptible border rows were uprooted; this concentrated thrips populations across the experimental contours.

Between 45 - 55 days after planting (DAP), the test cultivars were rated visually on a 5-point scale for apparent field resistance to thrips damage. Rating was done by three independent persons and involved an independent and subjective assessment of thrips damage severity. Damage assessment was based mostly on flower and pod setting. A final rating for each accession was obtained by averaging the scores of the three persons. All accessions that were rated above 3 were pulled out. Those which were rated as apparently resistant (i.e. scores 1-3) were given an insecticide treatment to protect pods against pod-sucking bugs and Maruca damage.

7.2 Results and comments

The results of the screening exercise are summarised in Figure 7.1. Out of 3700 accessions, 11 did not germinate. 37 entries (representing 2.2% of the total entry) scored 2. 485 (13.2%); 771 (20.9%) and 2311 (62.7%) were rated in categories 3, 4 and 5 respectively.

In all, 604 accessions (making 16.4% of the total accession rated) indicated some potential levels of field resistance to flower thrips. These were scheduled to go in replicated field trials to further assess these potentials.

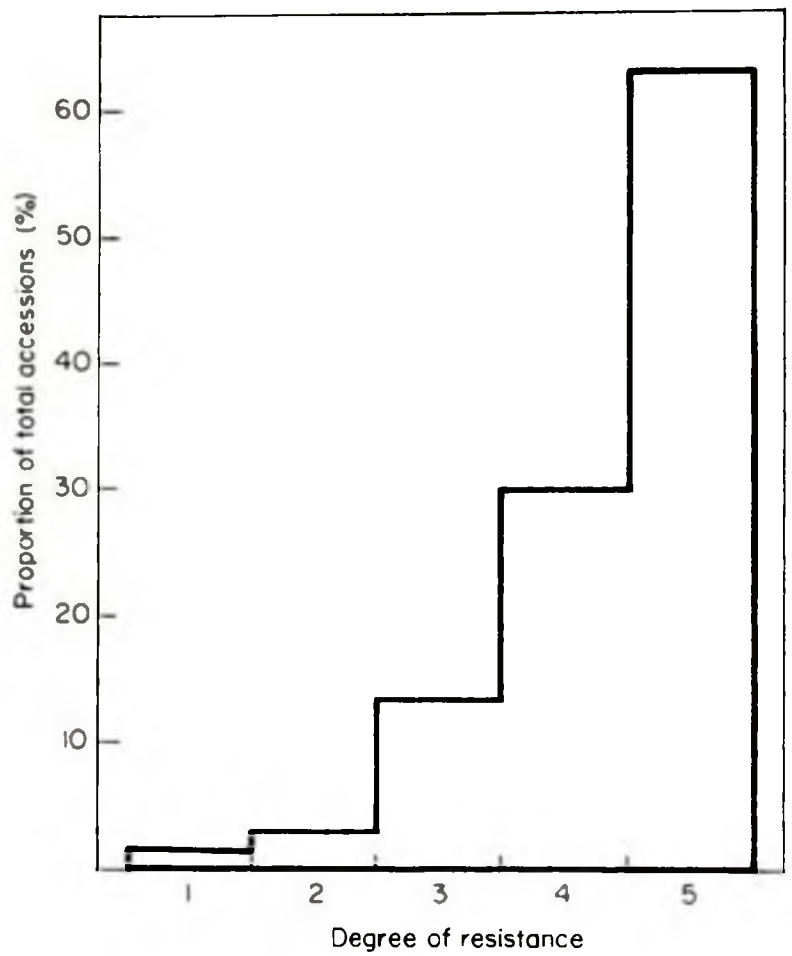

Figure 7.1 Frequency distribution of 3687 cowpea germplasm accessions over a 5-point scale for resistance to flower thrips

Several factors were bound to militate against the reliability of this negative screening trial. However some observations were made in order to ascertain to a reasonable extent, that the trial was measuring resistance to flower thrips. It was necessary to check whether insects other than thrips or diseases caused depression in flower and pod setting. Levels of flower pests, especially Maruca were very low in all four experimental contours. Very few flower samples were found to have been damaged by Maruca and other lepidopterous larvae. In addition there was a large population of hylid frogs that fed on both adult and larvae of Maruca. Meloid beetles which also damage flowers were significantly absent. Disease incidence was rather low in all accessions.

CHAPTER EIGHT

8. SUMMARY

1. The biology of cowpea flower thrips M.sjöstedti was studied and the response of cowpea cultivars to thrips infestation evaluated.

2. Three thrips species, apart from M. sjöstedti, were found to occur on the cowpea crop. However, M. sjöstedti was found to account for more than 90% of the cowpea thrips pests.

3. Using staining techniques, M. sjöstedti was found to oviposit mainly in young flower buds and calyx tube of open flowers.

4. The population build up of thrips was found to be tied closely with the development of floral buds and flowers. As the cowpea crop matured and floral structures became less abundant the thrips population fell.

5. On all cultivars tested, thrips populations became significant around 37 days after planting (DAP).

6. The seasonal abundance of M. sjöstedti was found to be determined largely by weather factors. Heavy rainfall tended to mechanically dislodge thrips from plants. Higher temperatures probably retarded development of thrips.

7. Two population peaks of M. sjöstedti were apparent during the year; one in May and the other in November.

8. The November peak was the highest. It has therefore been suggested that field screening techniques that rely on natural infestation should be undertaken during this period.

9. On evaluating 5 different sampling methods for thrips on cowpea, the use of water traps was found to be most adequate in terms of variability between samples. It has been suggested that the possibility of utilizing the method in future be further pursued.

10. Cylindrincal sticky traps were also found to be promising as regards estimation of thrips populations.

11. Using an artificial infestation method, a screenhouse screening technique was developed to evaluate resistance of cowpeas to flower thrips. It was found that the technique was efficient at separating high susceptibilities from potentially useful materials.

12. In an attempt to measure the influence of number of thrips on the damage severity of cowpea cultivars, a nonsignificant positive correlation was obtained. The computed r^2 value indicated that about 80% of the difference in damage severity could be attributed

to the number of thrips infesting flowers. It has been suggested that future correlation studies should involve whole plant samples.

13 The cowpea cultivar TVx 3236 was found to be moderately resistant to M. sjöstedti. On comparing yields without protection against flower thrips TVx 3236 was most superior. The mechanism of resistance of TVx 3236 however, remains to be worked out.

14. Large variations in thrips numbers were often noted in samples of racemes taken between 37 - 40 DAP. It was apparent that consistent samples involving racemes were obtainable only after 40 DAP.

15. Results of the first phase of a negative field screening trial for cowpea germplasm material indicated that other sources of resistance to flower thrips were apparent in some accessions. It has been suggested that further evaluation should be made in replicated trials.

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APPENDIX 1

KEY TO THE SPECIES OF THRIPS INFESTING LEGUMES IN NIGERIA

(After Okwakpam and Youdeowei, 1980)

1. Apex of abdomen conical, forewings not constricted, with at least one longitudinal vein.....2

   Apex of abdomen tubular, forewings constricted at middle without venation.....*Haplothrips gowdeyi*

2. Inter-ocellar setae large and prominent; forewings with posterior vein. Abdomen without brown and white bands.....3

   Inter-ocellar setae not prominent; forewings without posterior vein; Abdomen with brown and white bands..... *Sericothrips occipitalis*

3. Anterior angular setae half as long as large posterior angulars, hind margins of pronotum with 8 setae between the inner pair of the posterior angulars; anterior vein of fore-wings with a gap

and 2 distal setae; abdominal segment VIII with interrupted comb; body colour pale to blackish brown.....*Megalurothrips sjöstedti*

Anterior angular setae as long as large posterior angulars, hind margin of pronotum with 10 setae between the inner pair of posterior angulars; anterior vein of fore-wing without gap; abdominal segment VIII without comb; body colour brown yellow, head and prothorax much paler than rest of body.....*Frankliniella schultzei*

APPENDIX 2

Chi-Square test for distribution of eggs of *Megalurothrips sjöstedti* in two parts of the cowpea flower.

Flower part	Replication					Totals
	1	2	3	4	5	
Calyx	25(24.8)*	21(20.9)	23(21.7)	29(28.6)	15(17.0)	113
Corolla	7(7.2)	6(6.1)	5(6.3)	8(8.4)	7(5.0)	33
	32	27	28	37	22	

*Numbers in brackets are the expected values.

$$\chi^2 \quad \Sigma \frac{(O - E)^2}{E} \qquad 0.082$$

d.f = 4 and

χ^2 (tab) = 18.47, $P < .001$

APPENDIX 3

Mean monthly rainfall and temperature for 1981/1982 (IITA).

	Rainfall (mm)	Temperature (°C)
September	250.0	25.6
October	145.6	26.7
November	0.0	27.3
December	0.0	28.0
January	1.6	27.2
February	44.6	28.4
March	92.7	28.4
April	87.9	28.1
May	102.5	26.8
June	168.4	25.9
July	137.5	24.3
August	78.2	24.2

APPENDIX 4

Number of thrips per raceme at 7 DAI-1st screenhouse screening.

Cultivar	I	II	III	IV	V	Mean
TVu 76	11.6	45.0	16.8	10.3	15.3	19.8
TVx 3236	2.0	1.2	1.2	1.2	1.8	1.5
Ife Brown	5.1	3.0	5.7	5.8	5.8	5.1
VITA-6	9.0	6.8	5.8	8.0	5.0	6.9
TVu 1509	2.9	2.0	5.3	3.9	2.7	3.4

Analysis of variance (ANOVA)

Source of variation	DF	SS	MS	F
Treatment	4	1053.57	263.39	6.23
Error	20	845.14	42.26	
Total	24	1898.71	79.11	

APPENDIX 5

Number of thrips per flower at 10 DAI. 1st screenhouse screening.

Cultivar	I	II	III	IV	V	Mean
TVu 76	55.0	95.0	69.0	45.5	43.0	61.5
TVu 1509	5.0	8.0	5.0	6.8	8.5	6.7
VITA-6	32.0	20.0	34.0	25.0	20.0	26.2
Ife Brown	31.0	28.0	38.3	30.0	30.0	31.5
TVx 3236	8.0	7.5	8.4	10.3	8.0	8.4

Analysis of variance (ANOVA)

Source of variation	DF	SS	MS	F
Treatment	4	9844.31	2461.08	23.77
Error	20	2070.48	103.52	
Total	24	11914.78		

APPENDIX 6

Number of thrips per raceme at 7 DAI. 2nd screenhouse screening.

Cultivar	I	II	III	IV	V	Mean
TVu 1509	2.1	2.0	4.4	4.2	1.6	2.9
TVu 76	8.4	4.3	7.4	5.4	16.8	8.5
Ife Brown	2.7	8.0	5.0	2.6	2.0	4.1
TVx 3236	2.2	1.9	1.5	4.0	2.1	2.3
VITA-6	3.0	5.0	6.0	2.1	2.2	3.7

Analysis of variance (ANOVA)

Source of variation	DF	SS	MS	F
Treatment	4	118.43	29.61	4.08
Error	20	145.06	7.25	
Total	24	263.49	10.98	

APPENDIX 7

Number of thrips per flower at 10 DAI. 2nd screenhouse screening.

Cultivar	I	II	III	IV	V	Mean
TVu 1509	2.3	3.4	2.0	8.0	2.2	3.6
VITA-6	25.0	39.0	23.0	29.8	26.0	28.6
Ife Brown	31.0	28.0	38.3	20.0	30.0	29.5
TVx 3236	13.6	8.0	8.3	10.3	13.0	10.6
TVu 76	32.0	30.0	34.0	41.0	20.0	31.4

Analysis of variance (ANOVA)

Source of variation	DF	SS	MS	F
Treatment	4	3236.51	809.13	26.24
Error	20	616.80	30.84	
Total	24	3853.31	160.55	

APPENDIX 8

Yield of 4 cowpea cultivars. 2nd season, 1981.

Cultivar	I	II	III	IV	Mean
TVu 1509	676	690	706	732	701
TVx 3236	682	617	650	755	676
Ife Brown	190	189	223	178	195
VITA-6	240	198	220	194	213

Analysis of variance (ANOVA)

Source of variation	DF	SS	MS	F
Block	3	3490.5	1163.5	0.93
Treatment	3	940859.0	313619.67	252.69
Error	9	11173.5	1241.1	
Total	15	955523		

APPENDIX 9

Yield of 4 cowpea cultivars. 1st season, 1982

Cultivar	I	II	III	IV	Mean
TVx 3236	999.0	1141.0	1152.0	661.6	988.4
VITA-5	573.6	558.8	583.4	469.6	546.4
VITA-6	799.5	486.8	323.2	300.5	477.5
VITA-7	619.8	591.6	709.5	545.9	616.7

Analysis of variance (ANOVA)

Source of variation	DF	SS	MS	F
Block	3	149406.95	49802.32	2.37
Treatment	3	623653.99	207884.66	9.91
Error	9	188888.28	20987.59	
Total	15	961949.22		

PLATE 4.1: A water trap mounted in the field