STUDIES ON POPULATION DYNAMICS, SEASONAL INCIDENCE AND CONTROL OF LEGUME BUD THRIPS MEGALUROTHRIPS SJOSTEDTI (TRYBOM) (THYSANOPTERA: THRIPIDAE) IN COWPEA FIELDS IN THE COAST PROVINCE OF KENYA

BY

P.P. NGANGA

A thesis submitted in part fulfilment for the degree of Master of Science (Agricultural Entomology) in the University of Nairobi

1980

DECLARATION BY CANDIDATE

This thesis is my original work and has not been presented for a degree in any other University.

P.P. Nganga

DECLARATION BY SUPERVISOR

This thesis has been submitted for examination with my approval as University Supervisor.

Prof. C.P.M. Khamala

TABLE OF CONTENTS

LIST OF TABLES

TEXT OF FIGURES

Page

SUMMARY

Studies on population dynamics seasonal incidence and control of the legume bud thrips *Megalurothrips sjostedti* Trybom were carried out at the Coast Agricultural Research Station, Mtwapa. Cowpea resistance to thrips attack was also tested using local and exotic varieties. All experiments were randomised block design in plot size 3m x 3m. Thrips population levels were estimated from random samples of 10 flowers per plot in the replicates.

Population levels varied with seasons with significantly more thrips occurring during the long rains season. Rapid thrips population build-up appeared to correspond with the peak flowering period of the cowpea crop. In general, population levels were influenced by cumulative number of flowers in each season. Daily weather changes e.g. rainfall, relative humidity and temperature did not appear to influence thrips population directly.

Varieties VITA 3 and Katumani 1 were the most susceptible. Female thrips occurred in larger numbers compared to males suggesting presence of parthenogenetic reproduction.

All the three insecticides tested, namely, Sevin 85WP, Thiodan 35EC and DDT 25% significantly depressed thrips population with four weekly applications of Thiodan being the most effective.

CHAPTER ONE

1.1 GENERAL INTRODUCTION

The cowpea plant, Vigna unguiculata (L) Walp, has been considered by Sellschop (1962) as one of the most important leguminous crops for human consumption in Africa. It takes a third position to groundnuts Arachis hypogea L. and bambara nuts Voandzea subterranean Thorn. Purseglove (1970) placed it second after the common bean Phaseolus vulgaris L. Cowpea is also important in tropical America, including southern United States of America. In Africa, commercial production of cowpea is found in Nigeria, Dahomey, Niger, Senegal, Sudan, Uganda, Zimbabwe and South Africa (Koehler and Mehta, 1972). West Africa is considered to be the major producer of cowpeas in Africa with a total production exceeding 4.8 million hectares (Stanton, 1974).

Several cowpea varieties are used as vegetable in the tender leave stage. Dry seeds are threshed and used as pulse. It is also canned in California where it has assumed considerable importance as a dry seed for human consumption. It is popular with subsistence farmers in Africa mainly because of its short growing period and its indeterminate growth habit which ensures continuous availability of tender leaves for consumption. According to Ogunmodede and Oyenugu (1970), cowpea is fairly rich in protein and contains the following vitamins; thiamin, niacin, riboflavin, pyridoxine, pantothemic acid, biotin and folic acid. Of importance also is the fact that cowpea performs more favourably in a great diversity of soils and cultural conditions than most other grain legumes (Ligon, 1958).

In Argentina, Paraguay and Venezuela, cowpea is considered less susceptible to pests and diseases than the common bean P. vulgaris (Sellschop, 1962).

Where the paucity of rainfall or lack of irrigation water does not permit production of fine-stemmed and easily cured fodder, cowpea has been used as hay or for grazing (Sellschop, 1962). When used as such, cowpea is unsurpassed as a milk producing feed for sheep and for general improvement of the health of the animals (Saunders, 1935).

According to the Ministry of Agriculture (unpublished report for 1978), there were about 69,00 hectares planted under cowpea in Kenya. About 8,000 were in the Coast Province. The rest were in Eastern (55,00 ha.), Nyanza (4,600 ha.), Western (1,000 ha.), Central (200 ha.) and Rift Valley (200 ha.). Cowpea is also important in other areas of marginal rainfall which are below 1,500m. Previous experiments conducted by Khamala (1976 - Personal Communication) have shown that there is great potential for cowpea production in many areas in Kenya and especially the Coast Province. Almost all the cowpea grown in Kenya is intercropped with maize, sorghum or other crops and monoculture is rare except on very small plots. Cowpea crop takes between two and a half to four months to harvest depending on variety, growth habit, rainfall and local practice. It is intolerant to water logging and must therefore be grown on free draining soils.

Insect attack which occurs at all stages of cowpea crop is one of the most important factors limiting seed yield (Taylor, 1964). The quality of harvestable crop can greatly be limited by insect damage. Insect pests can be so serious in certain parts of Kenya e.g. the Beanfly in Eastern Province that without appropriate control measures, no economic grain legume yields can be realized (Khamala, 1978). Singh (1973) classified cowpea pests into 4 groups according to the plant part attacked:

(1) Leaf eating insects e.g. Ootheca mutabilis (Sahlberg), Leperodes lineata Karsh.

(2) Leaf-sucking insects, e.g. Megalurothrips sjostedti Trybom, Sericothrips occipitalis Hood, Empoasca fascialis Paoli.

(3) Pod-sucking bugs, e.g. Riptortus dentipes Fabricius, Anoplecnemis curvipes Fabricius, Acanthomia sp.

(4) Pod-boring insects, e.g. Maruca testulalis Geyer.

In Kenya, Khamala (1978) reported that some coleopterous and lepidopterous larvae, notably those of the weevil Aperitmetus brunneus (Hustacher), and the black cutworm Agrotis ipsilon Hufnagel feed on the roots of cowpea. Ochieng (1978) added the larvae of the Chrysomelid beetle O. mutabilis to the list of cowpea root feeding insect pests.

Among the leaf-sucking insects, the legume bud thrips Megalurothrips sjostedti is very serious especially during the flowering period. The preponderance of this insect species in cowpea has been reported by Taylor (1965, 1969 and 1974), Okwakpan (1965, 1967), Nyiira (1971), Whitney and Sadik (1972), Koehler and Mehta (1972), Singh (1973), Akingbohungbe (1970) and Agyen-Sampong (1978) among others.

The main objectives of this study were to assess legume bud thrips M. sjostedti population levels and their seasonal incidence, to compare resistance to thrips attack of various cowpea varieties, and to evaluate the effectiveness of a few common insecticides against M. sjostedti in the field.

1.2 LITERATURE REVIEW

The first case of thrips damage to cowpea in East Africa was reported by Michelmore (1954) in Uganda. He observed dwarfing and severe mottling resembling a mosaic due to the presence of a large number of an unidentified species of thrips.

Taylor (1965, 1969 and 1974) and Nyiira (1971) showed that damage to cowpea by legume bud thrips M. sjostedti is characterized by malformation and discoloration of floral parts. Feeding punctures were found on severely attacked stamens, pistils and petals. Akingbohungbe (1970) suggested that such damage to reproductive parts probably caused bud and flower shedding and premature loss of pollen leading to decreased pollination and seedsetting.

Whitney and Sadik (1972) in greenhouse cage tests found that damage caused by M. sjostedti and another thrips, Sericothrips occipitalis Hood, did not affect the number of leaves produced on the cowpea plant. They, however, found that the two thrips species adversely affected plant height, initiation of flowering, number of seeds per plant and seed maturity. They were unable to identify the thrips species causing the particular type of damage.

Akingbohungbe (1970) had reported that plants infested with 10 or more thrips per seedling became severely stunted and gave yield of only 50% or less of uninfested plants. Previous studies by Davidson and Andrewartha (1948a) had estimated that a population density of 40 thrips (Thrips imaginis

Baghall) per flower can cause flower shedding in apples.

Further studies by Whitney and Gilmer (1974) showed that M. sjostedti is a vector of Cowpea Yellow Mosaic Virus (CYMV). CYMV is seedborne and can cause yield reduction of up to 60-100% (Chant, 1960 ; Shoyinka, 1974).

Taylor (1969) reported that infestation on cowpea by M. sjostedti was initiated by immigrant populations from alternative hosts in the immediate preflowering stage. The population peak occurred between 12 and 34 days from onset of flowering and was influenced by flower production, variety and season. He, however, pointed out that the cumulative number of flowers was more important in influencing population trends of M. sjostedti. Taylor (1974) also reported that temperature and rainfall did not have any direct influence on seasonal abundance and population changes in thrips on cowpea. He suggested that since M. sjostedti fed on pollen, its population levels were influenced by pollen abundance.

The biology of M. sjostedti has been studied by Nyiira (1971) and Singh and Allen (1979). The entire life cycle takes 14-18 days under field conditions. Eggs are laid in the buds and nymphs feed and do extensive damage to the flower buds.

Various scientists at the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria have identified thrips resistance in a number of cowpea lines. Some of the lines identified as resistant to thrips are TVU 1509, TVU 7279, TVU 946. Other varieties which have indicated some degree of resistance are Pale green, Jebba pea and TVU 1190. Singh (1977a) reported that varieties VITA 1 and VITA 3 were susceptible to M. sjostedti while VITA 4 and VITA 5 had low susceptibility.

Ingram (1969) in his attempt to control M. sjostedti and Frankliniella dampfi Priesner on P. vulgaris reported that DDT, malathion and lindane reduced populations of both thrips species. He found no increase in yield and thus concluded that these thrips species did not cause any damage to beans. Taylor (1968) showed that insecticides depressed thrips population and that BHC was the most effective. Nyiira (1971) also found that application of insecticides such as fentrothion, carbaryl, lindane and DDT depressed thrips population on cowpea. Further studies by Koehler and Mehta (1972) showed that lindane sprays resulted in increased pod length despite thrips level.

Apart from infesting the cowpea plant, M. sjostedti is known to infest many other alternative host plants. Le Pelley (1959) working in East Africa found M. sjostedti on coffee Coffea arabica L., avocado pear Persia Americana L., Alfalfa Medicago sativa L., bonavista bean Lablab niger Medic., Erythryna spp., Sesbania sp., Vangueria spp., Caesalpinia spp., Tephrosia spp., and Sann-hemp Crotolaria juncea L.

Other authors (e.g. Okwakpan, 1965; Ingram, 1969 and Taylor, 1974) reported M. sjostedti on tomato Lycopercon esculentum Mill., kola nut Cola nitida L., banana Musa sapietum L., Glyricidia spp., sugarcane Saccharum officinarum L., groundnut Arachis hypogea L., soyabean Glycine max (L) Merrill, butterfly pea Centrosema pubescens Benth., pigeon pea Cajanus cajan L., and a number of wild legumes.

Studies of *M. sjostedti* on wild alternative hosts are limited; only Taylor (1974) appears to have looked into population trends of this species on a major alternative host, *Centrosema pubescens*, a wild legume. He observed that there was a constant and continuous presence of *M. sjostedti* on *Centrosema* which flowers intermitently throughout the year. Thrips were caught during every month in 1971 and 1972. Both adults and nymphs were caught indicating that both feeding and breeding took place on the host. Further observations indicated that population trends on *Centrosema* were largely determined by the flowering cycle and maximal numbers of 13-20 thrips per flower were recorded during the main flowering period in October-November.

1.3 GENERAL MATERIALS AND METHODS

The experiments were conducted at the Coast Agricultural Research Station, Mtwapa, which is situated approximately 15 km. north of Mombasa. The altitude is 21m above sea level and the centre coordinates are 03^{o} 56'N and 39^{o} 44'E. The Research Station is a part of a large area of gently undulating coastal plains with well drained, very deep yellowish-brown friable sandy loam or sandy clay loam soils. The soils have been classified as Orthic Ferrasol (FAO/UNESCO), or Typic Eutrustox (USDA soil taxonomy). The pH is approximately 4.2 at 0.30 cm depth.

The experimental plots were situated between pasture/legume trials, a cowpea agronomy trial, a Canavallia ensiformis L. observation plot, a cassava trial and a coconut plantation with undergrowth of grasses, wild legumes and other herbaceous plants. The trials were laid down using randomised block design and were conducted during both the short and long rains season of 1978 and 1979 respectively. Local cowpea varieties used were Katumani 1, Mtwapa 1 and Kakamega 1. Exotic cultivars were ER 1-1, ER 1-2, ER 5, ER 7, VITA 3, VITA 4 and VITA 5 from IITA. A plot was 3m x 3m in all cases. The seeds were planted two per hill at 75cm between rows and 20cm within rows and fertilized with double superphosphate mixed with calcium ammonium nitrate and Murate of potash at a rate of 30:30:30 kg per hectare. Seedlings were thinned to 1 plant per hill when they were 10 days old.

Thiodan 35 EC at a rate of 600gm a.i. in 500 l. of water per hectare was applied 15 and 25 days after planting in all plots to protect the plants from pre-flowering insect pests mainly defoliators.

Nymphs and adults of M. sjostedti were obtained from cowpea fields by making weekly collection of flowers from marginal rows in each experimental plot. Collections were made from 13th December 1978 until 17th January for short rains crop, and from 2nd June until 14th July 1979 for the long rains crop. All plots were randomly sampled by picking 1 flower from every 5th plant in a row until 10 flowers from each plot had been taken. The flowers were immediately preserved in 50% ethyl alcohol contained in glass vials toppered with a close fitting cork.

In the laboratory, the samples were analysed using Southwood's (1966) washing method as adopted by Ota (1968) by using 50% ethanol. The flowers were washed twice before and after dissection to ensure maximum recovery of thrips. Thrips counting was performed under a binocular microscope and sorted into nymphs and adults where necessary.

Weekly temperature, rainfall and relative humidity data were obtained from the climatological records at Kenya Government Meteorological station at Mtwapa 0.5 km away from the plots.

The crop was harvested appropriately as the seeds matured. Yield samples were taken from 15 randomly selecte plants from the centre rows and used to determine the effect of thrips infestation on seed yield.

The variance ratio test was used to determine whether any significant differences between varieties or treatments existed. Significant differences between any two varietal/treatment means were determined using the t-test (Finney, 1971).

CHAPTER TWO

POPULATION DYNAMICS AND SEASONAL INCIDENCE OF MEGALUROTHRIPS SJOSTEDTI IN COWPEA FIELDS IN COAST PROVINCE OF KENYA

2.1 INTRODUCTION

Van Emden (1978) has emphasized the importance of all ecological information from the basic biology of a pest to the full population dynamics of a species or community in pest management programmes. Population fluctuations may be influenced by environmental (density independent) factors as well as intrinsic (density dependent) factors. Abundance of food and living space, for example, may increase survival rate and birth rate in pest populations. When later the amount of food decreases, the pest populations may be drastically reduced due to reduced survival rates and birth rates and increased mortality. Seasonal incidence or occurrence of an insect is a record of its seasonal history. Some insects, for example armyworms may occur at certain times as outbreaks and then disappear completely or remain in very low population levels.

In order to have an effective pest management programme, information on population dynamics and seasonal incidence of a pest species is of great importance. This type of information can be used to determine when and whether an effective pest control programme is necessary. These studies were therefore initiated to provide a clear understanding of M. sjostedti populations in relation to daily and seasonal weather changes (rainfall, temperature and relative humidity) and the phenology (growth cycle) of cowpea.

2.2 MATERIALS AND METHODS

All the ten cowpea varieties mentioned above in section 1.3, namely, Katumani 1, Mtwapa 1, Kakamega 1, ER 1-1, ER 1-2, ER 5, ER 7, VITA 3, VITA 4, and VITA 5 were used in this experiment. The design was randomised block with 10 treatments replicated four times. Data on thrips population as well as data on rainfall, temperature and relative humidity were collected as described earlier. Flowering pattern was obtained in variety Katumani 1 by daily counts on 10 randomly selected cowpea plants in each plot to assess flower density as food source for thrips population at any given time during the seasons. Generation sequences of M. sjostedti were based upon field observations as well as upon the life cycle presented by Singh and Allen (1979).

The crop was harvested appropriately as the mature seeds dried up (see general materials and methods). The results were expressed in kilograms per hectare and used to determine the effect of thrips density on seed yield.

2.3 RESULTS

Results of the population studies are summarised in Tables 1 and II and Figs. 1-13. These tables and Fig. 1 show thrips population trends in all the ten cowpea varieties in both the short and the long rains seasons. Thrips populations rose gradually from the first week up to the third week after the onset of flowering. During the short rains the mean thrips

Table I *M. sjostedti* short rains season population on ten cowpea varieties from mid-December, 1978 to mid-January, 1979

Variety	Mean number of thrips per flower						Average number of thrips per flower	Yield Kg/ha
	Weeks							
	1	2	3	4	5	6		
Mtwapa 1	1.9	3.4	3.6	10.6	11.8	12.2	7.3d	586.9cd
ER 1-2	1.1	3.2	1.2	45.6	36.2	34.4	20.3b	1737.0a
ER 7	4.8	6.1	5.1	12.6	12.2	10.7	8.6d	918.2b
VITA 4	6.2	5.2	10.6	11.6	15.4	16.3	10.9cd	1588.3a
Katumani 1	6.2	8.5	6.2	40.8	58.4	55.9	29.3a	930.4b
VITA 5	2.6	4.5	4.5	10.4	30.4	21.6	12.4c	684.0cd
VITA 3	8.6	8.9	9.1	20.0	58.4	53.8	26.5a	589.6cd
ER 1-1	2.1	4.1	3.7	10.8	36.1	36.2	15.5c	727.6c
ER 1-5	1.4	4.4	4.1	15.4	11.8	10.9	8.0d	1050.9b
Kakamega 1	1.2	4.2	4.0	12.4	17.2	16.7	9.3d	1140.9b
Weekly Mean	1.9	4.0	4.7	18.1	28.8	27.5		
S.E.							2.52	126.3

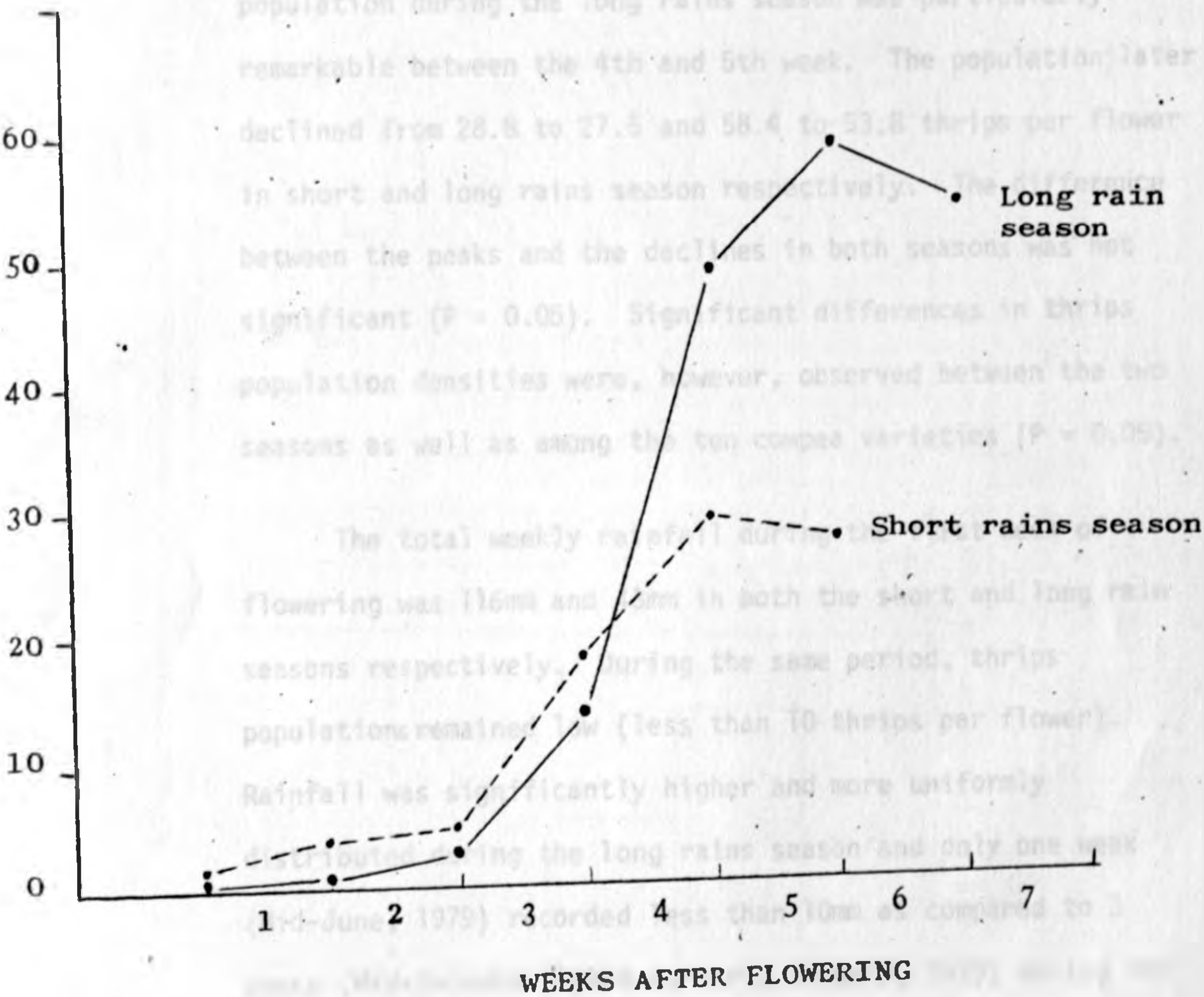
N.B. Numbers followed by same letters (in the same column) are not significantly different from each other (P = 0.05)

Table II *M. sjostedti* long rains season populations on ten cowpea varieties from early June to mid-July, 1979

Variety	Mean number of thrips per flower							Average No. of thrips per flower	Yield Kg/ha
	Weeks								
	1	2	3	4	5	6	7		
Mtwapa 1	0.3	1.0	2.5	6.6	26.6	46.2	35.6	18.4c	973.4bc
ER 1-2	0.4	0.9	2.1	13.7	40.9	49.1	-	17.9c	1419.5a
ER 7	0.4	1.1	1.9	13.3	49.3	56.7	-	20.5bc	1121.8b
VITA 4	0.2	0.4	0.1	10.1	49.5	55.2	55.1	24.4b	1493.1a
Katumani 1	1.0	2.1	4.3	22.5	60.9	72.9	61.9	32.2a	1154.3b
VITA 5	0.5	1.1	2.5	7.7	48.1	55.8	56.1	24.5b	891.6c
VITA 3	0.6	1.2	2.6	22.8	65.4	72.4	62.7	32.4a	1032.6b
ER 1-1	0.5	0.5	1.5	19.2	59.4	66.1	-	24.5b	993.7bc
ER 1-5	0.4	1.1	2.3	9.8	32.1	52.2	52.4	21.5b	1090.9b
Kakamega 1	0.1	0.6	1.6	11.8	43.9	57.6	52.5	24.0b	1354.4b
Weekly Mean	0.4	1.2	2.1	13.8	48.6	58.4	53.8		
S.E.								1.58	62.8

N.B. Numbers followed by the same letters (in the same column) are not significantly different from each other (P = 0.05)

Figure 1. The population trends of M. sjostedti during the short and the long rains seasons.



population rose from 1.9 in the first week to a peak number of 28.8 thrips per flower in the fifth week after the onset of flowering.

There was a similar but more rapid population rise during the long rains season (0.4 to 58.4 thrips per flower in the first week and the 6th week respectively). The rise in thrips population during the long rains season was particularly remarkable between the 4th and 5th week. The population later declined from 28.8 to 27.5 and 58.4 to 53.8 thrips per flower in short and long rains season respectively. The difference between the peaks and the declines in both seasons was not significant (P = 0.05). Significant differences in thrips population densities were, however, observed between the two seasons as well as among the ten cowpea varieties (P = 0.05).

The total weekly rainfall during the first week of flowering was 116mm and 43mm in both the short and long rain seasons respectively. During the same period, thrips populations remained low (less than 10 thrips per flower). Rainfall was significantly higher and more uniformly distributed during the long rains season and only one week (Mid-June, 1979) recorded less than 10mm as compared to 3 weeks (Mid-December, 1978 to early January, 1979) during the short rains season which recorded less than 5mm. Inspite of varying amounts of rainfall from week to week, thrips population rose continuously and later declined without showing any direct response to total weekly rainfall (Figs. 2 and 3). It is, however, evident that the higher rainfall that fell

Figure 2. M. sjostedti population trends on variety Katumani 1 in relation to rainfall, temperature and relative humidity during the short rain season

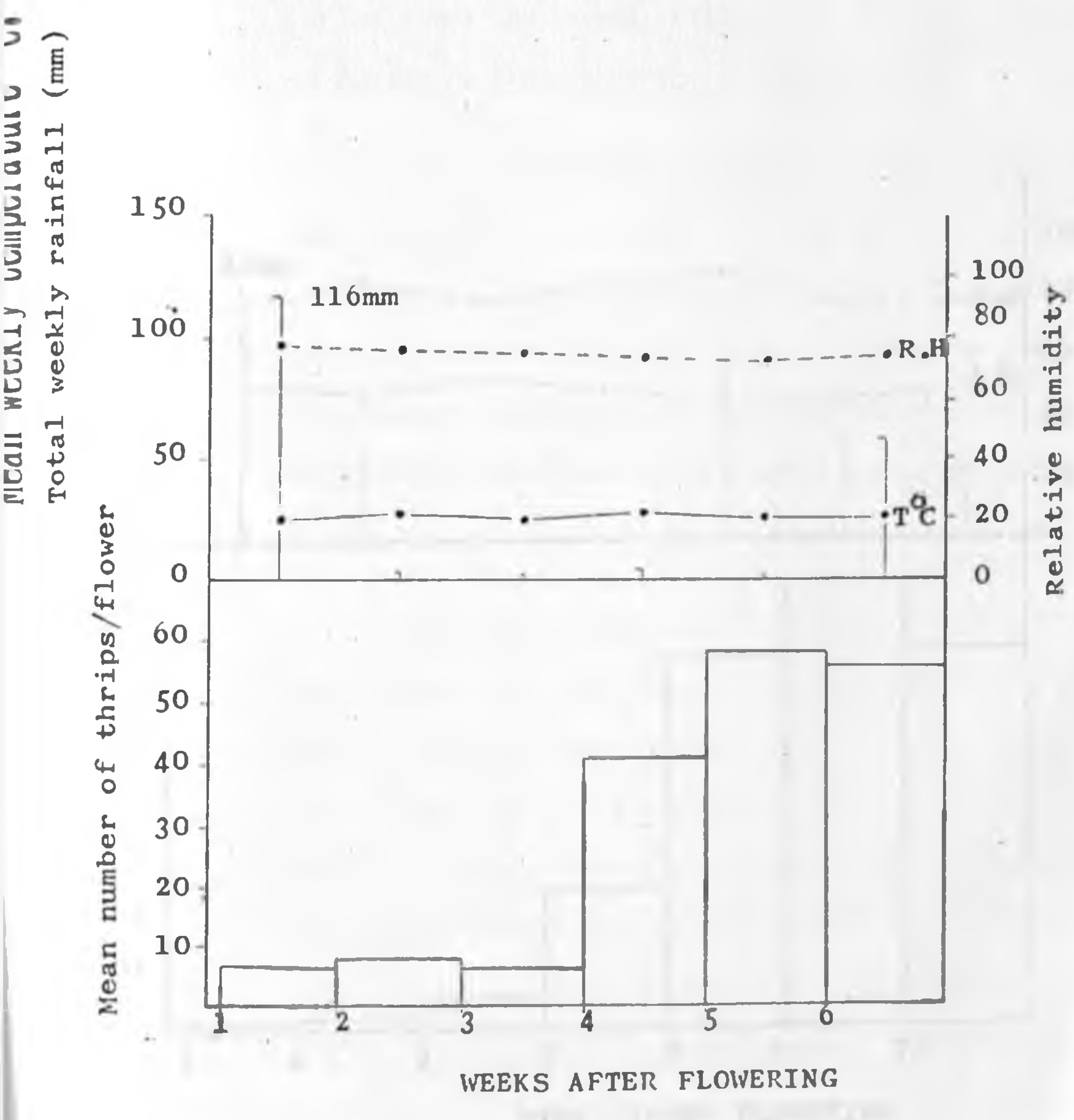
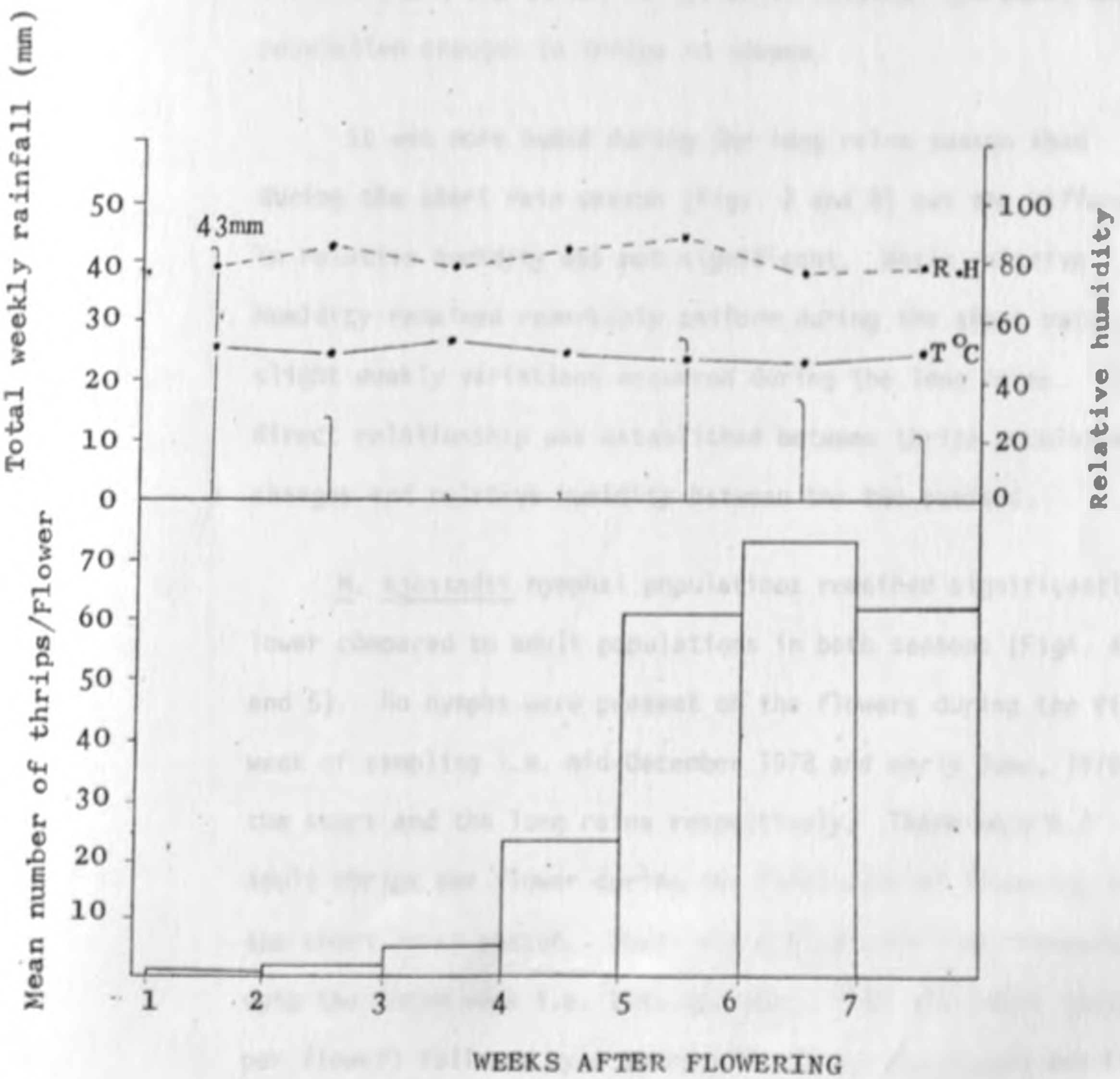


Figure 3. M. sjostedti population trends on variety Katumani 1 in relation to rainfall, temperature and relative humidity during the long rains season



during the long rains indirectly influenced thrips population.

There was little variation between weekly mean temperatures during both seasons (Figs. 2 and 3) and no significant differences were revealed. Daily mean temperatures which were remarkably similar were in the range 20^{0}-31.5^{0}C during the short rains and in the range 20^{0}-29^{0}C during the long rains. It is evident from Figs. 2 and 3 that weekly mean temperatures did not exert any direct influence on seasonal abundance and population changes in thrips on cowpea.

It was more humid during the long rains season than during the short rain season (Figs. 2 and 3) but the difference in relative humidity was not significant. While relative humidity remained remarkably uniform during the short rains, slight weekly variations occurred during the long rains. No direct relationship was established between thrips population changes and relative humidity between the two seasons.

M. sjostedti nymphal populations remained significantly lower compared to adult populations in both seasons (Figs. 4 and 5). No nymphs were present on the flowers during the first week of sampling i.e. mid-December 1978 and early June, 1979 in the short and the long rains respectively. There were 6.2 adult thrips per flower during the first week of flowering in the short rains season. There was a slight decline thereafter upto the third week i.e. late December, 1978 (3.1 adult thrips per flower) followed by a sharp rise during the fourth and fifth week of flowering (early-January, 1979). The nymphal population rose gradually from none to 27.4 (47.4%) thrips per flower in

Figure 4. Population trends of adults and nymphs of M. sjostedti on variety Katumani 1 during the short rains season

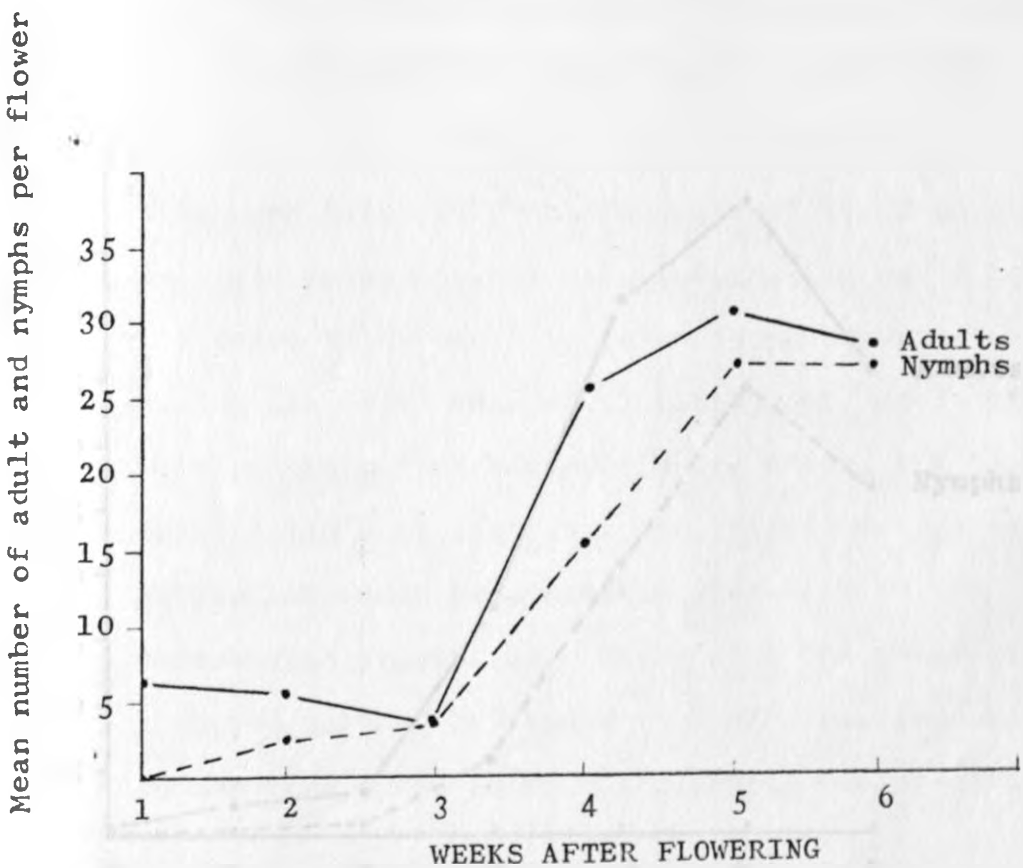
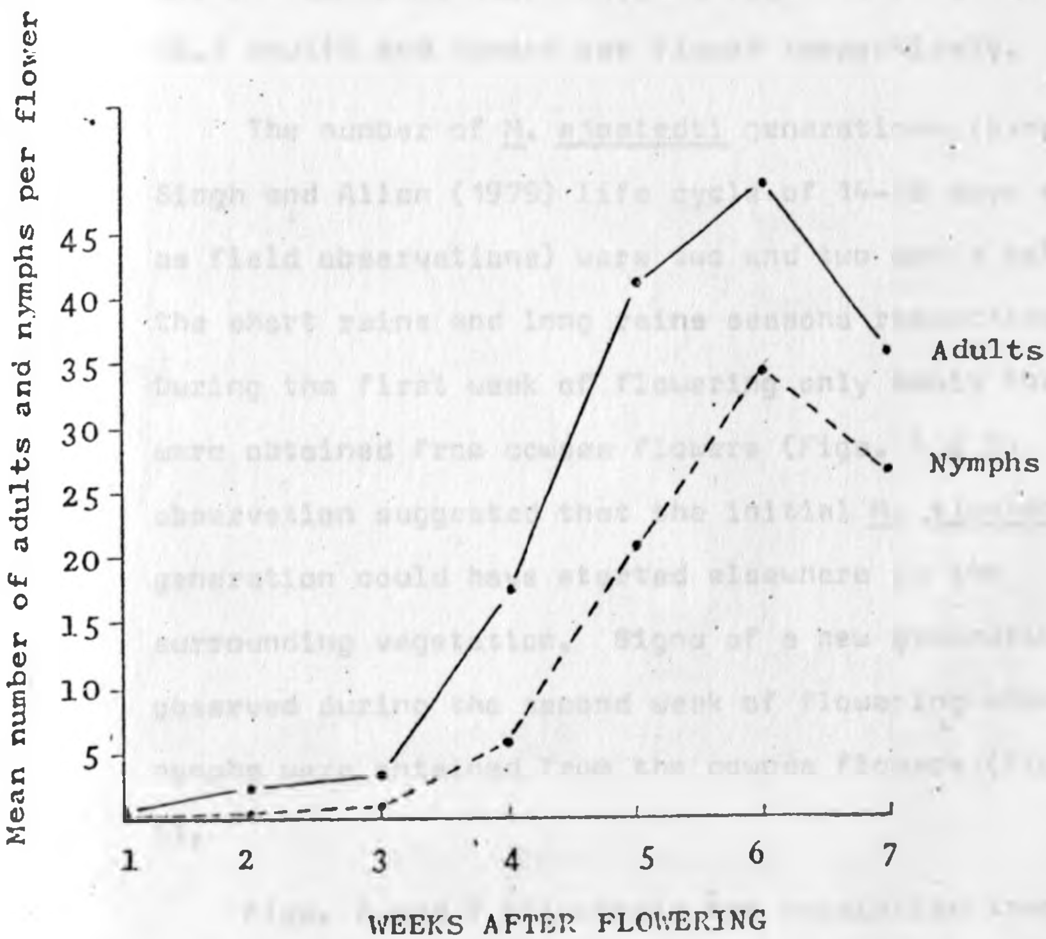


Figure 5. Population trends of adults and nymphs of M. sjostedti on variety Katumani 1 during the long rains season



the fifth week of flowering. After the fifth week, adult thrips population declined but the nymphal population remained more or less constant up to the last (sixth) week of flowering (mid-January, 1979). In the long rains season, there was an initial lag in the build up of adult and nymph populations until the third week (mid-June, 1979) after the onset of flowering. Thereafter, the adult population rose rapidly to 40.7 (64.9%) thrips per flower in the fifth week (late June to early July, 1979). At the end of flowering (mid-July, 1979), there were 35.6 and 26.3 adults and nymphs per flower respectively.

The number of M. sjostedti generations (based on Singh and Allen (1979) life cycle of 14-18 days as well as field observations) were two and two and a half in the short rains and long rains seasons respectively. During the first week of flowering only adult thrips were obtained from cowpea flowers (Figs. 4 & 5). This observation suggested that the initial M. sjostedti generation could have started elsewhere in the surrounding vegetation. Signs of a new generation were observed during the second week of flowering when a few nymphs were obtained from the cowpea flowers (Figs. 4 & 5).

Figs. 6 and 7 illustrate the population trends of adult male and female M. sjostedti in variety Katumani 1. The male to female ratios were 1:2.06 and 1:1.36 in short and long rains seasons respectively.

Figure 6. Population trends of male and female *M. sjostedti* on variety Katumani 1 during the short rains season

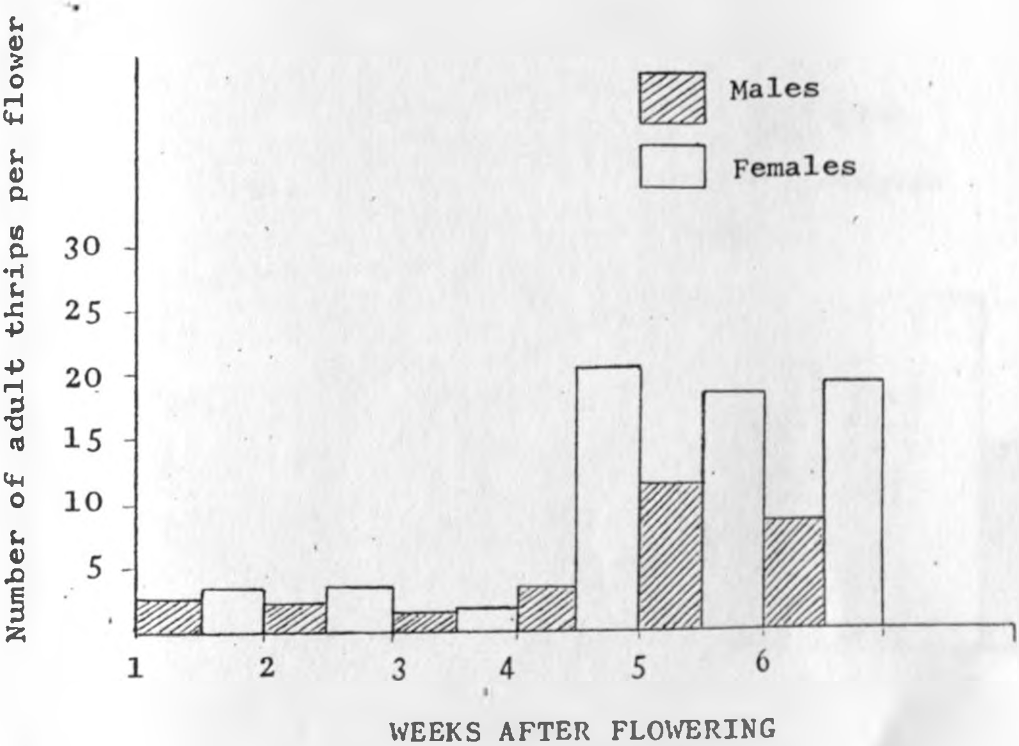
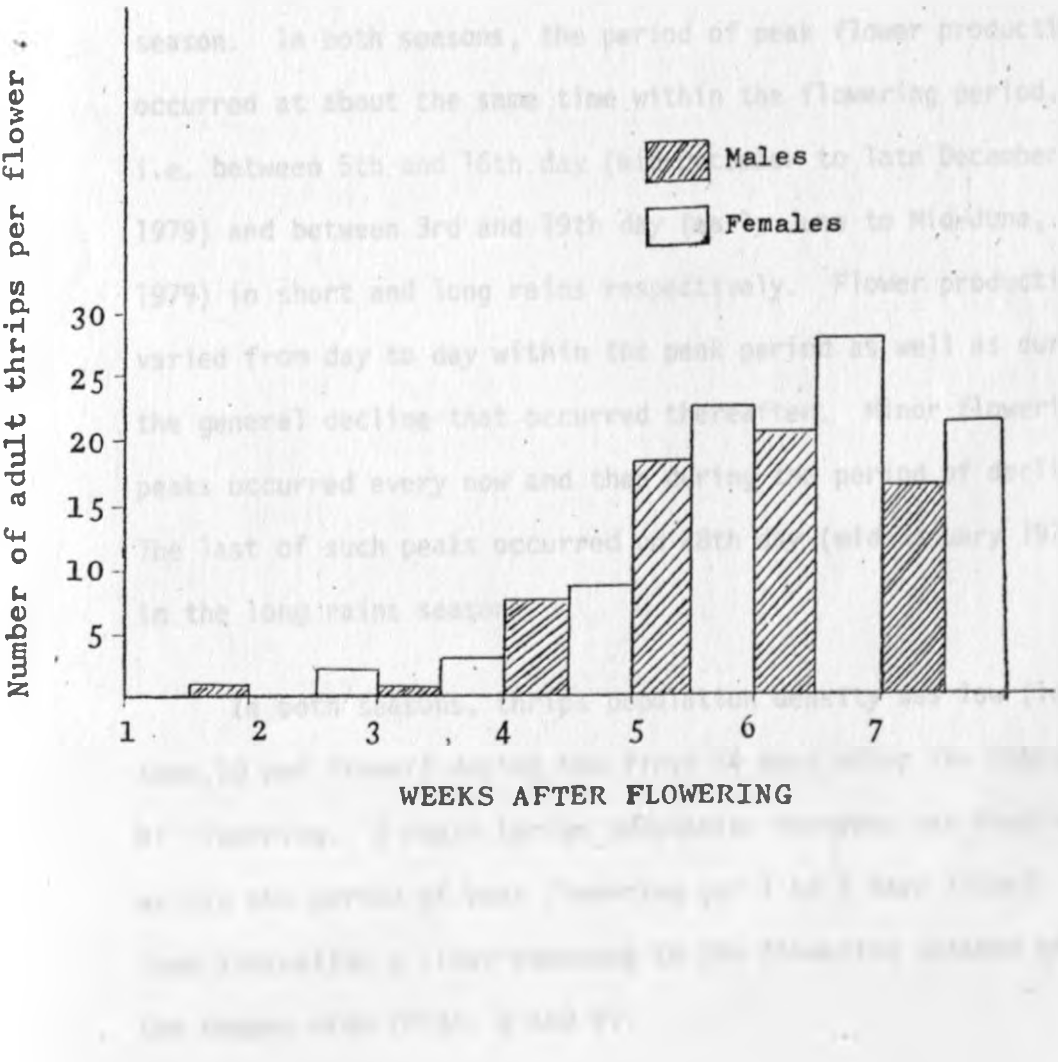


Figure 7. Population trends of male and female *M. sjostedti* on variety Katumani 1 during the long rains season



2.3.1 FLOWER PRODUCTION AND ITS INFLUENCE ON M. SJOSTEDTI POPULATION CHANGES AND DENSITY

Figs. 8, 9, 10 and 11 illustrate the relationship between flowering pattern, cumulative flower production and thrips population changes in variety Katumani 1. The flowering pattern did not differ remarkably between the two seasons. However, the flowering period was remarkably longer in the long rains (about 42 days) than in the short rains (about 35 days). Significantly more flowers per plant per day were also produced during the long rains season (3.95 flowers per plant) as compared to 2.97 flowers per plant recorded in the short rains season. In both seasons, the period of peak flower production occurred at about the same time within the flowering period, i.e. between 5th and 16th day (mid-December to late December, 1979) and between 3rd and 19th day (early June to Mid-June, 1979) in short and long rains respectively. Flower production varied from day to day within the peak period as well as during the general decline that occurred thereafter. Minor flowering peaks occurred every now and then during the period of decline. The last of such peaks occurred on 28th day (mid-January 1979) in the long rains season.

In both seasons, thrips population density was low (less than 10 per flower) during the first 14 days after the onset of flowering. A rapid thrips population increase was observed within the period of peak flowering (or 1 to 2 days after) thus indicating a clear response to the flowering pattern of the cowpea crop (Figs. 8 and 9).

Figure 8. M. sjostedti population trends on variety Katumani 1 in relation to the flowering patern during the short rains season

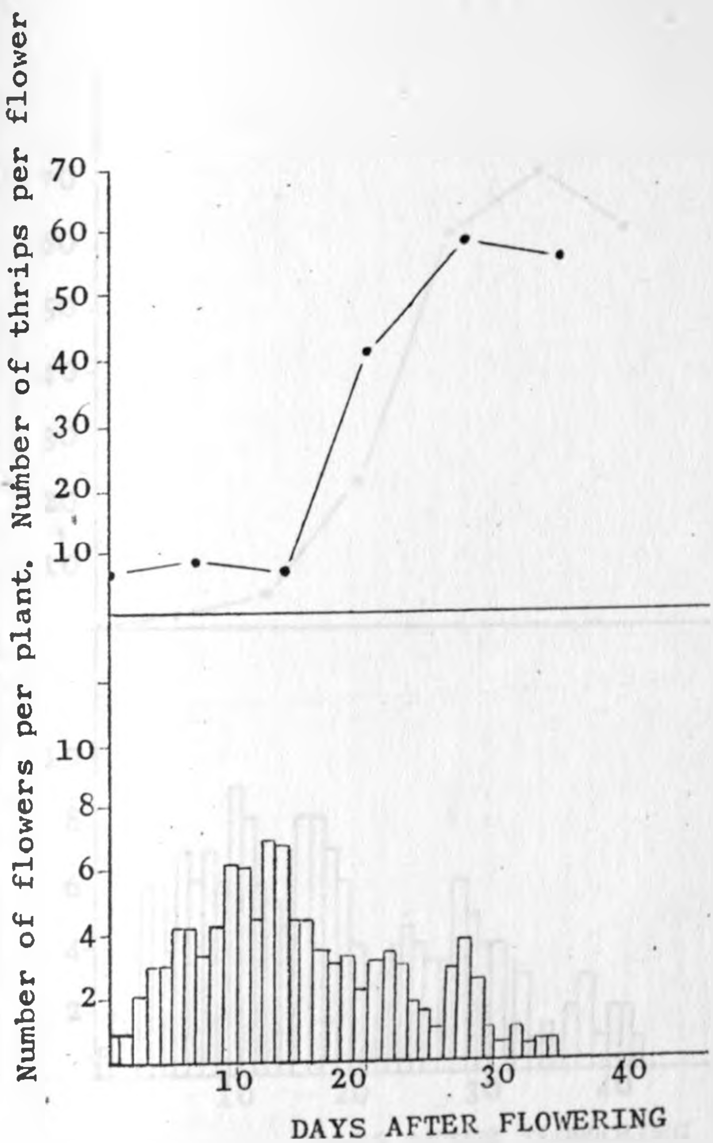


Figure 9. M. sjostedti population trends on variety Katumani 1 in relation to the flowering pattern during the long rains season

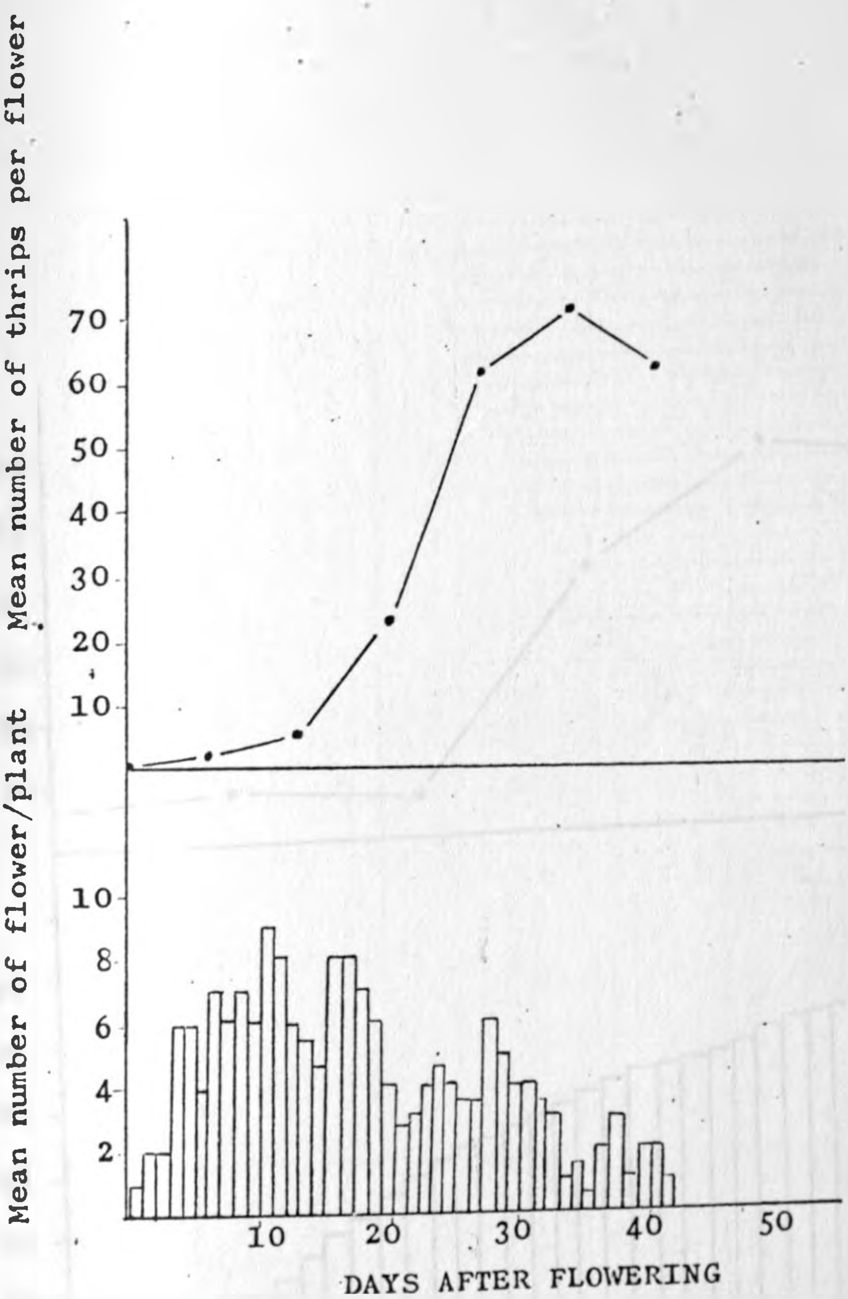
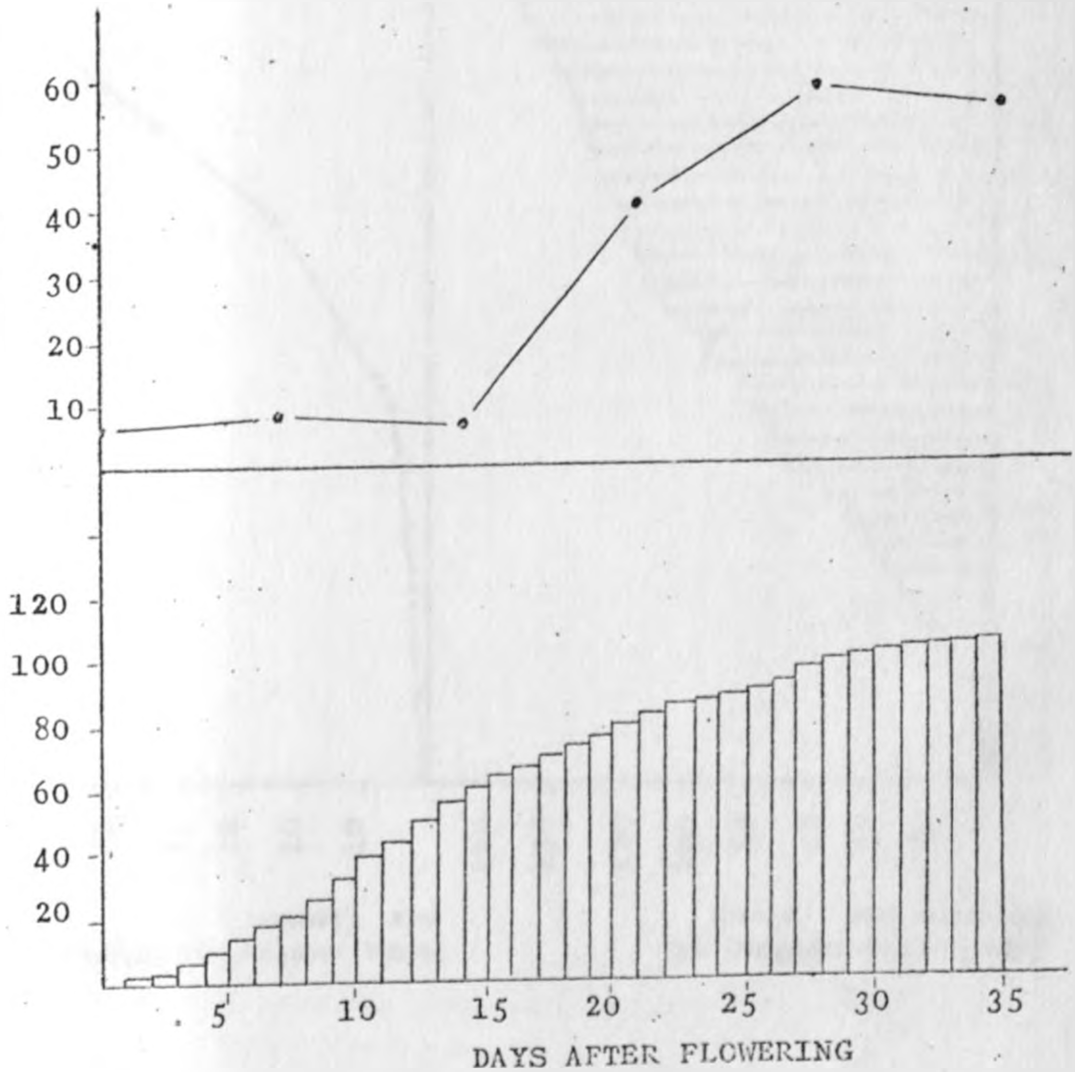


Figure 10 M. sjostedti population trends in variety Katumani 1 in relation to cumulative flower production during the short rains season



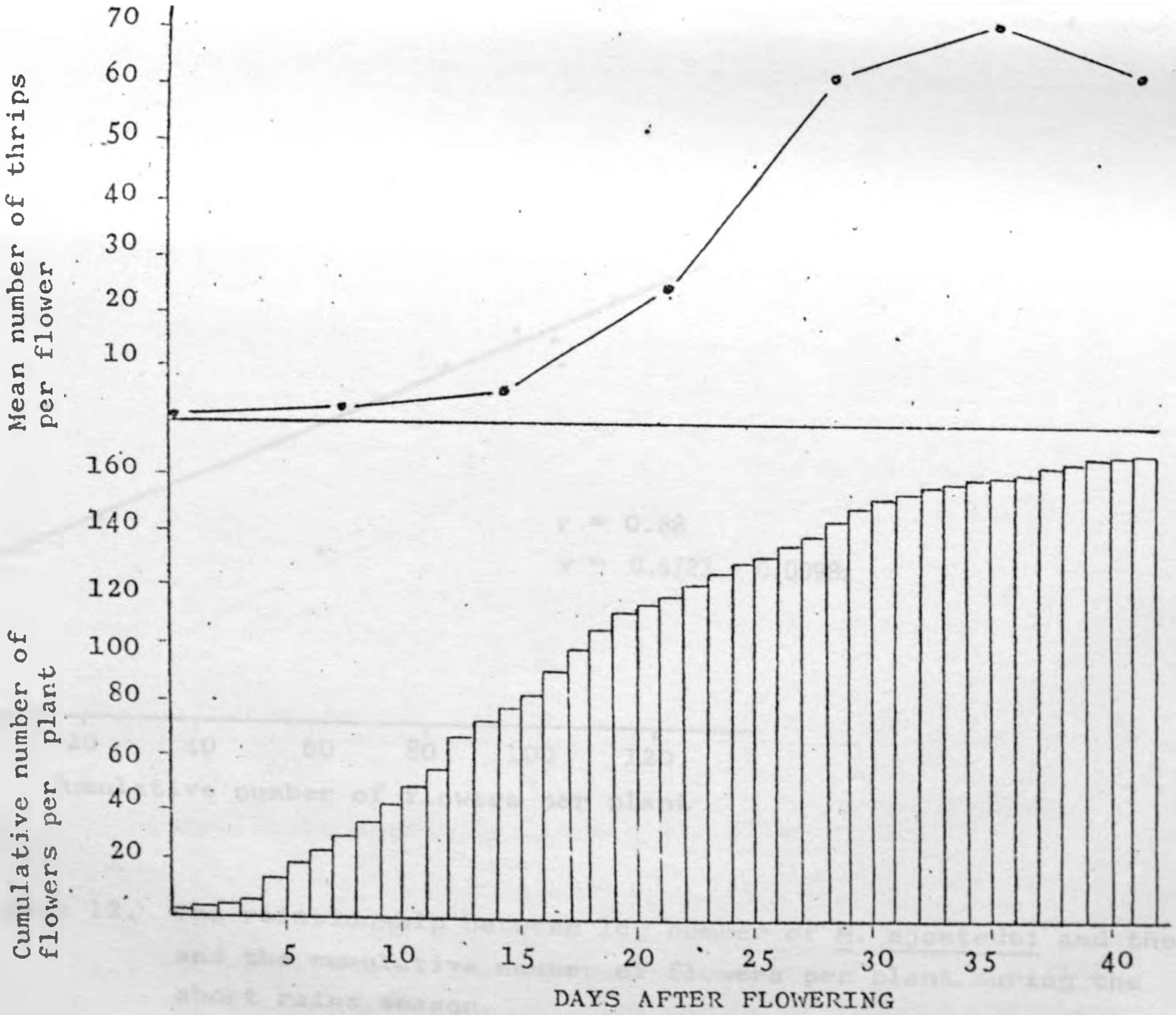


FIGURE 11. M. sjostedti population trends in relation to cumulative flower production on variety Katumani 1 during the Long rains season

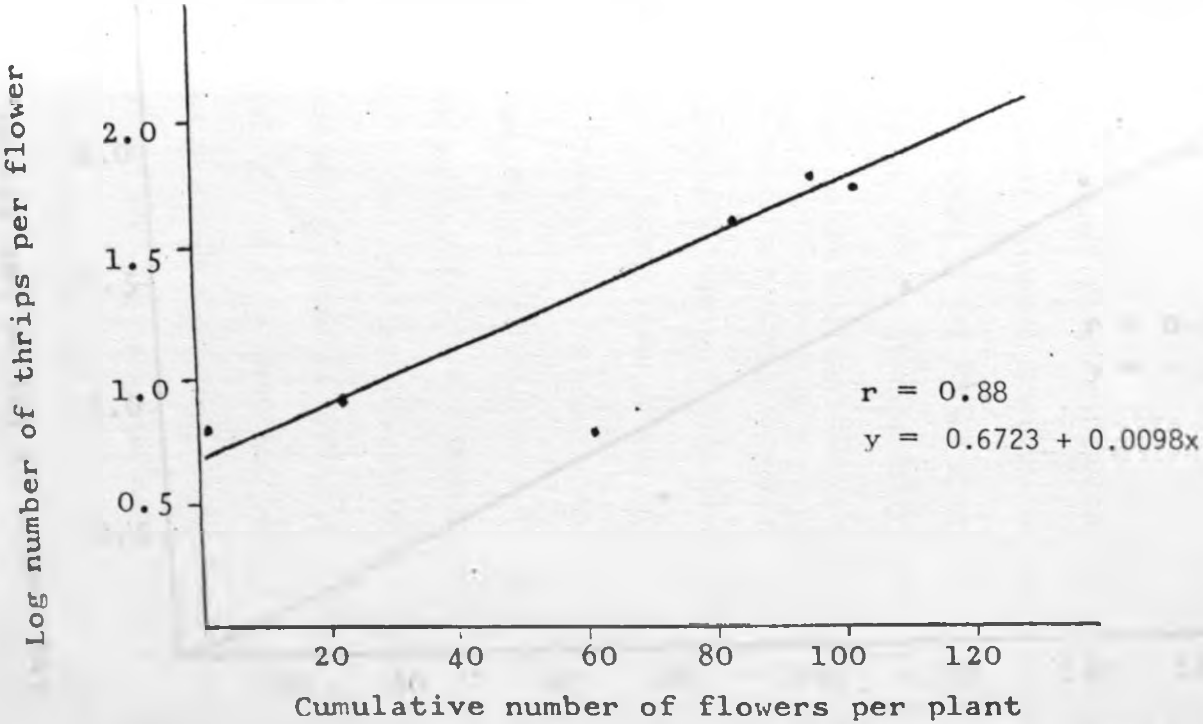


Figure 12. The relationship between log number of M. sjostedti and the and the cumulative number of flowers per plant during the short rains season

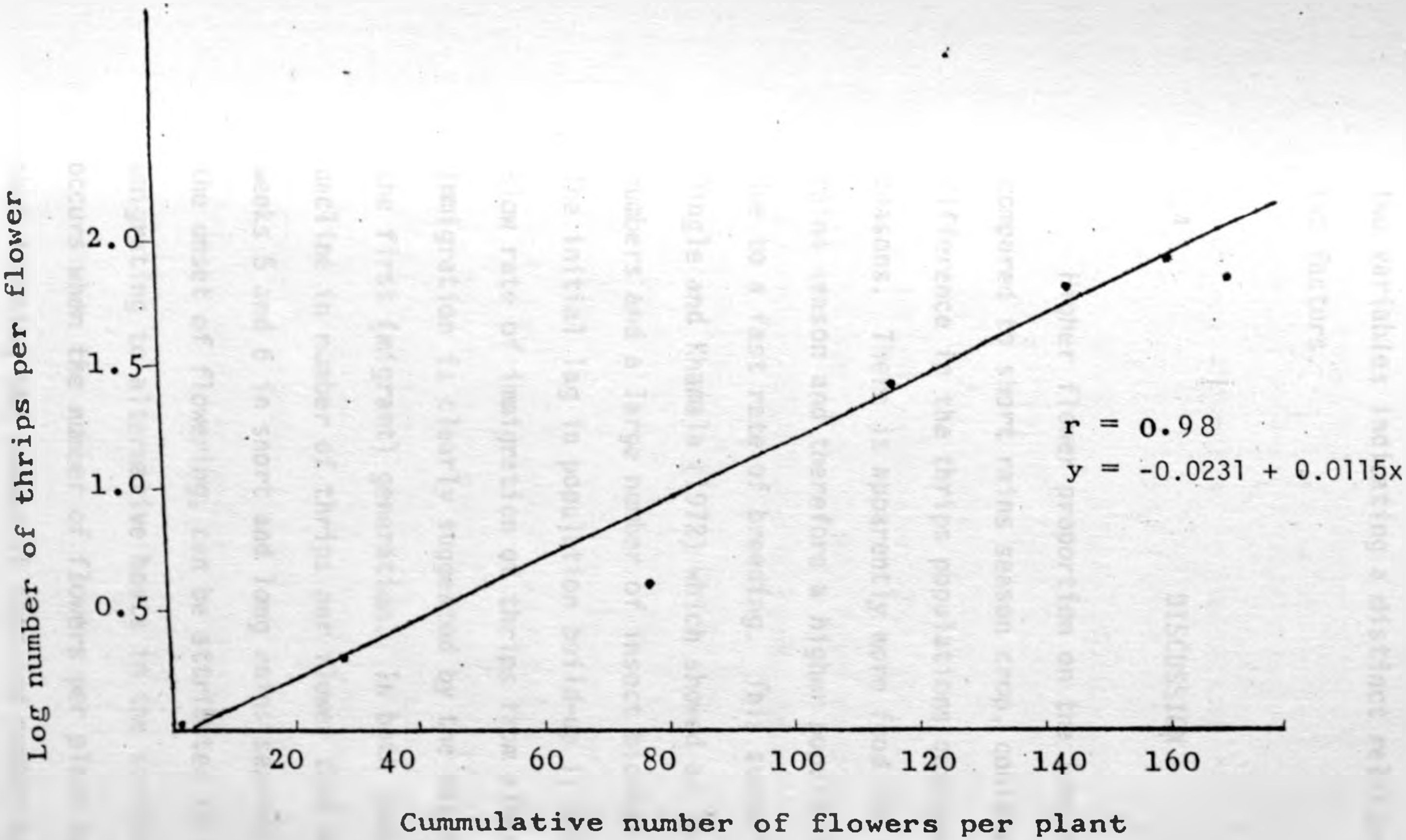


Figure 13. The relationship between the log number of M. sjostedti per flower and the cumulative number of flowers per plant on variety Katumani 1 during the long rains season

In Figs. 12 and 13, the logs of total numbers of thrips per flower have been plotted against the cumulative number of flowers per plant in both the short and long rains season crops. There was a highly significant correlation ($r = 0.88$; $r = 0.98$, in short and long rain seasons respectively) between the two variables indicating a distinct relationship between these two factors.

2.4 DISCUSSION

Higher flower proportion on the long rains season compared to short rains season crop, could account for the difference in the thrips populations observed between the two seasons. There is apparently more food for thrips in the long rains season and therefore a higher population would be expected due to a fast rate of breeding. This supports findings by Dingle and Khamala (1972) which showed an increase in insect numbers and a large number of insect biomass during long rains. The initial lag in population build-up is probably due to a slow rate of immigration of thrips from alternative hosts. Immigration is clearly suggested by the absence of nymphs in the first (migrant) generation. In both cowpea crops, the decline in number of thrips per flower that occurred after weeks 5 and 6 in short and long rains seasons respectively after the onset of flowering, can be attributed to adult thrips emigrating to alternative hosts in the surrounding. This occurs when the number of flowers per plant begins to decline thus limiting the amount of food and number of breeding places available. Throughout the flowering period in both seasons, more adults than nymphs were sampled. This is understandable considering the possible amount of immigration occurring all the time from surrounding alternative hosts. During the period when thrips population was on decline, adult population due to its greater mobility by flight would be expected to decline slightly faster.

Davidson and Andrewartha (1948a, 1948b) suggested that variations in thrips numbers were largely determined by weather directly or indirectly by reference to the duration of the period when breeding places were distributed densely over the area. Further studies by Andrewartha (1961) suggested that weather influenced thrips chance to survive and multiply directly because dry weather during summer increases the likelihood that the pupal stage (in soil) will die from dessication. Cool weather reduces fecundity and retards development. In the present study, weather appeared to play little or no direct part relative to population changes within a given season. It was apparent, however, that broad differences in weather conditions from one season to the other, may play a significant role in determining the total M. sjostedti population between seasons through their influence on the onset and duration of the flowering period. Likewise, temperature through its effect on development may largely influence the number of thrips generations produced each season.

The ratio of male to female in both seasons suggested the presence of parthenogenetic reproduction, thus confirming findings by Lewis (1973), Morrison, (1957), Taylor, (1974), Strassen, (1959) and Imms, (1957).

M. sjostedti sucks sap from stamens, pistils, petals and contents from pollen grains. This food habit would tend to accelerate thrips population growth during peak flowering period. It is at that time when there is abundant food and living space thus increasing survival rates. These findings support those of Taylor (1969, 1974) who found this to be true not only on cowpea but also on major alternative host, Cetrosema pubescens.

The highly significant correlation between log number of thrips per flower and cumulative number of flowers per plant suggests that cumulative number of flowers produced by the cowpea plant could probably be one of the most important factors influencing M. sjostedti population levels on cowpea.

CHAPTER THREE

RESISTANCE OF COWPEA VARIETIES TO *MEGALUROTHRIPS SJOSTEDTI*, THE LEGUME BUD THRIPS

3.1 INTRODUCTION

Some crop varieties have natural mechanisms to resist attack by pests in their ecosystems. This host-plant resistance to insects was first recognised in grapes against grape Phylloxera, *Phylloxera vitifoliae* (Fitch) in Europe in the 1870's. However, the use of insecticide resulted in the retardment of the development of this technique as a means of reducing insect pest populations attacking crops. But development of resistance to insecticides by pests, coupled by exorbitant insecticide costs, have recently renewed and accelerated interest in research on insect resistant crop varieties. In cowpeas, insect resistant varieties have been reported by van Emden (1966), Singh (1974, 1977 , 1978), Singh *et al* (1975), Perrin (1977) and Singh and Taylor (1978).

In these studies, cowpea varieties were tested in the field to compare their resistance to thrips. Resistant varieties would perform relatively better than other varieties under heavy pest pressure.

3.2 MATERIALS AND METHODS

The ten varieties used in the various experiments were grown in the field to compare their resistance to *M. sjostedti*.

The design was randomised block with 10 treatments replicated 4 times.

Data on thrips population levels were collected weekly from each variety as described earlier. Thrips damage to flower bud was assessed by counting the number of damaged flower buds from a weekly random sample of 20 flower buds picked from 10 randomly selected plants in every plot. This was then expressed as a percentage and used as the major criterion for determining resistance. Varieties were rated either as susceptible (over 60% flower bud damage), less susceptible (40-60%), moderately resistant (10-40%) or resistant (under 10%).

3.3 RESULTS

Table III shows that mean numbers of thrips per flower varied from one variety to the other. The lowest mean number of thrips per flower recorded was 7.3 on variety Mtwapa 1 and the highest was 34.2 thrips per flower on VITA 3, (i.e. in short and long rains respectively). Averaged across both seasons, both Katumani 1 and VITA 3 had the highest mean number of thrips per flower (i.e. 30.8 and 29.5 respectively). Similarly averaged, varieties Mtwapa 1 and ER 1-2 had the lowest mean number of thrips per flower (i.e. 12.9 and 10.2 thrips per flower respectively).

The local cowpea varieties Mtwapa 1 and Kakamega 1 had low thrips population levels per flower respectively (Table III). The exotic varieties which showed low thrips levels per flower were ER 7, VITA 4, VITA 5, ER 1-1 and ER 5. All the ER varieties except ER 1-1 had a thrips population of less than 15 thrips per flower (Table III).

Percentage damage to flower buds indicated that varieties Katumani 1 and VITA 3 had the highest damage score of 62.9 and 78.6 respectively (Table III). There was a significant difference between these damage scores at 5% level. Some direct relationship was found between the number of thrips per flower and the percent damage but not in all cases. For example, varieties VITA 3 and Katumani 1 which had large thrips population per flower also incurred high percentage flower damage, thus suggesting direct relationship (Table III).

Varieties ER 1-1 and ER 7 incurred the lowest percent damage to flower buds (Table III). Of the local cowpea varieties tested, only Katumani 1 showed a high percent flowerbud damage i.e. over 60%. Varieties Mtwapa 1 and Kakamega 1 had damage score of under 50%. This was significantly lower than Katumani 1 at 5% level and indicated that the two varieties were more resistant compared to Katumani 1. VITA 4 showed moderate resistance (10-40% flowerbud damage) while VITA 5 showed low susceptibility (40-60% damage). The other varieties showing moderate resistance were ER 7 and ER 1-1. It was difficult to identify the mechanisms of resistance adequately because it was not possible to carry out progeny survival experiments in greenhouse. However, field observations suggested tolerance as one of the resistance mechanisms. Tolerant cultivars supported high insect population without undergoing significant damage. In comparison, susceptible

Table III Mean number of M. sjostedti per flower during the short and long rains and the percent damage to flower buds

Variety	Mean number of thrips per flower			% damage to flower bud		Resistance rating	Yield (Kg.)
	Short rains Season	Long rains Season	Mean	range	Mean		
Mtwapa 1	7.3	18.4	12.9	20-55	46.4c	LS	780.2d
ER 1-2	20.3	17.8	10.2	20-50	40.8c	LS	1578.3a
ER 7	8.6	20.5	14.6	15-40	32.5d	MR	1020.1c
VITA 4	10.9	24.4	17.7	20-50	36.4d	MR	1540.7a
Katumani 1	29.3	32.2	30.8	50-80	62.9b	S	1042.4c
VITA 5	12.4	24.5	18.5	25-60	47.1c	LS	787.8d
VITA 3	26.5	32.4	29.5	60-100	78.6a	S	806.6d
ER 1-1	15.5	24.5	20.0	20-45	35.8d	MR	860.7d
ER 5	8.0	21.5	14.8	15-50	41.4b	LS	1070.9c
Kakamega 1	9.3	20.0	14.7	20-55	40.7c	LS	1247.7bc
S.E.					4.48		93.76

MR = Moderately resistant = 10-40%
LS = Less susceptible = 40-60%
S = Susceptible = Over 60%

N.B. Numbers followed by the same letters (in the same column) are not significantly different from each other (P = 0.05)

cultivars sustained severe damage when attacked by the same size of insect population. For example variety Katumani 1 underwent significantly less flowerbud damage than variety VITA 3 although both the varieties harboured approximately equal thrips population per flower (Table III).

The seed yields varied from one variety to the other. Varieties VITA 4 and ER 1-2 gave the highest yields. The lowest seed yields were obtained from VITA 5 and Mtwapa 1. Field observation revealed that the high yielding cowpea varieties were generally more vigorous during the vegetative phase and had fewer insect problems on their foliage.

3.4 DISCUSSION AND CONCLUSIONS

The data showed that all the ten cowpea varieties differ in their resistance to *M. sjostedti*. Of the exotic varieties, VITA 3 was least resistant. This confirms the findings of Singh (1977a) who also reported that VITA 4 and VITA 5 had low susceptibility. This finding is supported by the present study with regard to VITA 5, but not in the case of VITA 4. It is possible that many unknown factors probably environmental may affect resistance. This was suggested by other workers, namely, van Emden (1966) and Singh (1970) who showed that although resistance is genetically controlled, it is also modified in expression by the environment through various effects on the insect and on plant physiology.

Varieties ER 1-1 and ER 7 which were susceptible in greenhouse tests (Singh, 1977 , 1978; Singh and Allen, 1978) consistently escaped thrips damage in field trials probably due to their early flowering habits and short flowering period. Thrips populations infesting cowpea fields from alternative hosts at early stage remained below economic threshold and did not cause economic injury to the cowpea crop (Singh, 1977). Due to the short flowering period of these ER varieties, the peak period in thrips population is reached when they have already formed their first pods. This influences yields because the first pods are more important in determining the final seed yield in cowpea (Ojohomon, 1968).

The use of thrips resistant cowpea varieties may fall roughly into two categories: (1) as an adjunct to other control measures and (2), as a principal control method.

Resistance as an adjunct to other control measures would involve careful coordination with other control measures on one hand and with crop improvement programme on the other. Insect resistant cultivars combined with minimum insecticide application as a nucleus of an integrated pest-management system, have given much higher yields (Agyen-Sampong, 1976; Assa, 1976; Bindra and Sagar, 1976; Raheja, 1976; Singh, 1976; Taylor, 1976).

Insect resitance as a principal method of pest control would prove especially valuable where the unit value on margin of profit of cowpea is small and the average acreage large (Painter, 1952). It would also be of great value because insecticides would not be necessary. This would be a great step forward for small scale farmers who would not afford insecticides and insecticide application machinery. The progressive farmer would also benefit tremendously because he would no longer be faced with difficulties of transporting water which are common in many parts of Kenya. Reduction of insecticide input also prevents environmental pollution, development of insecticide resistant strains and the threat to parasites and predators. There is no extra cost to the farmer once he obtains a resistant cowpea variety and it is available to him thereafter.

The inadequacy of the data presented here makes it impossible to conclude that yield differences observed between the cowpea varieties were due to resistance or lack of it alone. Other influencing factors, for example, different varietal yield potential are likely to be involved.

CHAPTER FOUR

INSECTICIDE EVALUATION AGAINST *MEGALUROTHRIPS SJOSTEDTI*, A SERIOUS PEST OF COWPEAS IN KENYA

4.1 INTRODUCTION

Evaluation of insecticides against cowpea pests has been undertaken by various workers (Taylor and Ezedinma, 1964; Booker, 1965; Jerath, 1968; Taylor 1968, 1969; Ayoade, 1969, 1974, 1975; Koehler and Mehta, 1972; Mehta and Nyiira, 1973). Variable results have been obtained and several insecticides have been reported as effective against many insect pests of cowpeas including the legume bud thrips *M. sjostedti*. The bulk of these studies have been undertaken in Nigeria. No study on evaluation of insecticides has been undertaken in Kenya. Because *M. sjostedti* is an important pest of cowpea in Kenya, evaluation of at least a few common insecticides would give insight on differential efficacy of these insecticides. The information obtained would be of importance not only to the progressive farmer, but also to the pest control cautious small scale farmer.

4.2 MATERIALS AND METHODS

The three insecticides evaluated were Sevin 85 WP, Thiodan 35 EC and DDT 25%. The design of the experiment was randomised block with 4 replications. Variety VITA 3 was selected for use because it was reported to be susceptible to M. sjostedti attack. The experiment was conducted in both the short and long rains seasons. Four insecticide spray applications were administered from the onset of flowering (about 6 weeks after planting) when M. sjostedti are known to start infesting the cowpea crop.

The sprays were applied at weekly intervals to reduce the high rate of reproduction and population build-up of M. sjostedti. The treatments were as follows:

Treatment 1	Four applications of Sevin at a rate of 1,200 gm a.i. in 500 l. of water per hectare per application.
Treatment 2	Four applications of Thiodan at a rate of 600 gm a.i. in 500 l. of water per hectare per application.
Treatment 3	Four applications of DDT at a rate of 800 gm a.i. in 500 l. of water per hectare per application.
Treatment 4	No spray (Control)

The CP3 Knapsack sprayer was used to spray the crop at 45 p.s.i. Plots were surrounded with polythelene sheet about 1.5m high to minimize drift. The first flower samples to assess thrips population were picked when the crop was about six weeks old. Pod length measurements were determined by obtaining the average length of 100 pods obtained from 15 randomly selected plants from each plot at harvest. Yield samples were taken from 15 randomly selected plants from centre rows and used to determine the effect of thrips infestation on seed yield.

4.3 RESULTS

Results are summarized in Figures 14 and 15 and tables IV and V. Figures 14 and 15 show that all the insecticides depressed thrips populations per flower below the control. For the first 14 days from the first spray application, thrips populations remained equally low in all insecticide treatments. After this period, thrips populations rose gradually. Thrips populations in the control increased steadily and the rate of increase was very high between the third and the fourth week of sampling when the percentage flowering was more than 50%.

In both short and long rains seasons, Thiodan maintained the lowest thrips population level of 4.8 thrips per flower (Table IV). This average population value was significantly lower than that obtained in DDT and Sevin treatments (i.e. 7.4 and 8.1 thrips per flower respectively) whereas the mean thrips population value of 19.9 thrips per flower which was obtained in the control was significantly higher than from individual insecticide treatments. This suggested that while all the insecticides reduced thrips number, Thiodan had the greatest influence.

Table IV also compares and relates thrips population density and seed yield per hectare. Thiodan treatment resulted in significantly higher yield than the other treatments. Seed yield from Sevin and DDT treatments did not differ significantly from each other.

Table IV Mean number of thrips per flower and seed yield per hectare during long and short rain seasons

Treatment	Mean number of thrips per flower			Yield/ha. (kg.)
	Short rains	Long rains	Mean	
Thiodan 35EC	5.2	4.4	4.8c	1060.5a
DDT 25%	8.1	6.7	7.4b	827.1b
Sevin 85WP	8.7	7.4	8.1b	807.1b
Control	22.9	16.9	19.9a	660.3c
S.E.			3.36	82.75

N.B. Numbers followed by the same letter (in the same column) did not differ significantly from each other (P = 0.05)

Figure 14. The effect of insecticide application on M. sjostedti population during the short rains season

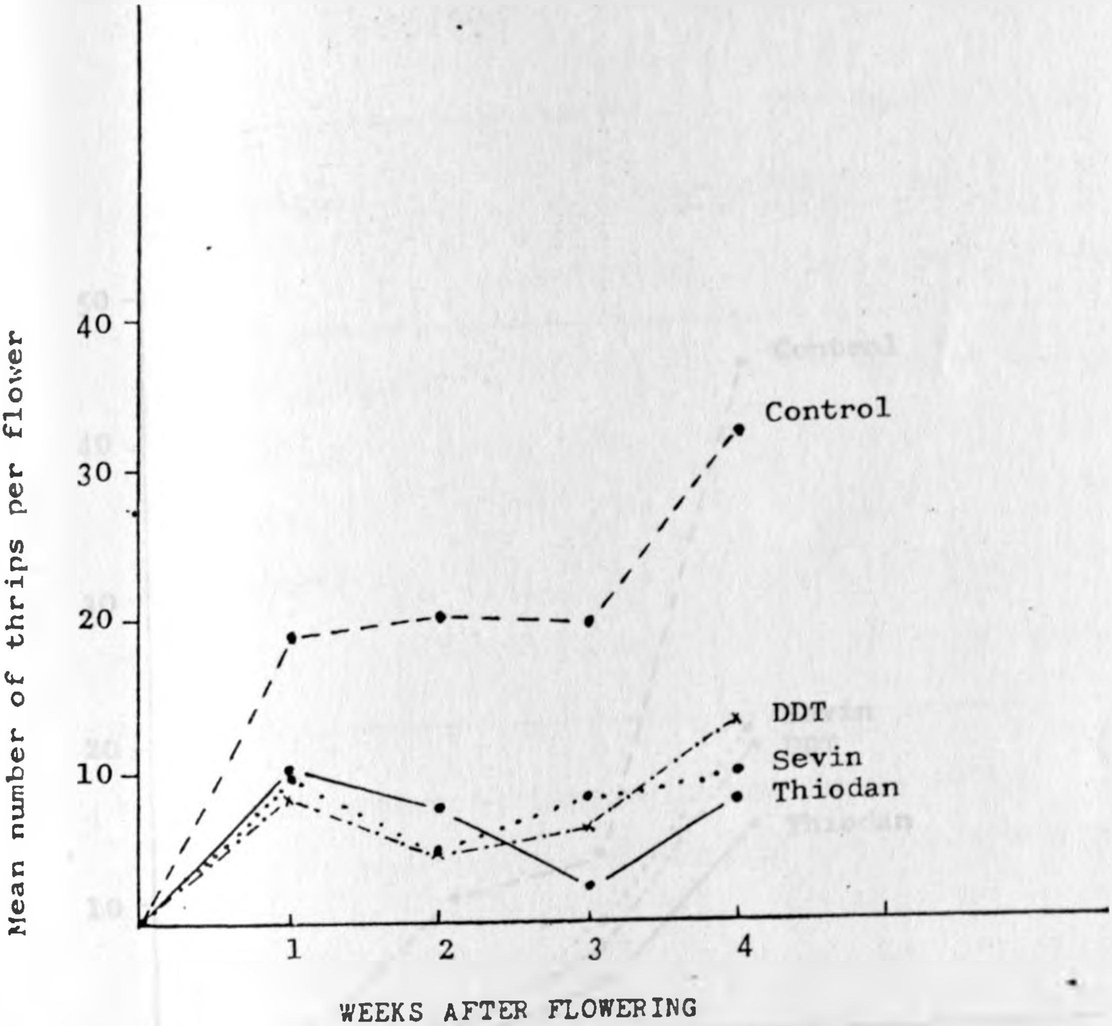


Figure 15. The effect of insecticide application on M. sjostedti population during the long rains season

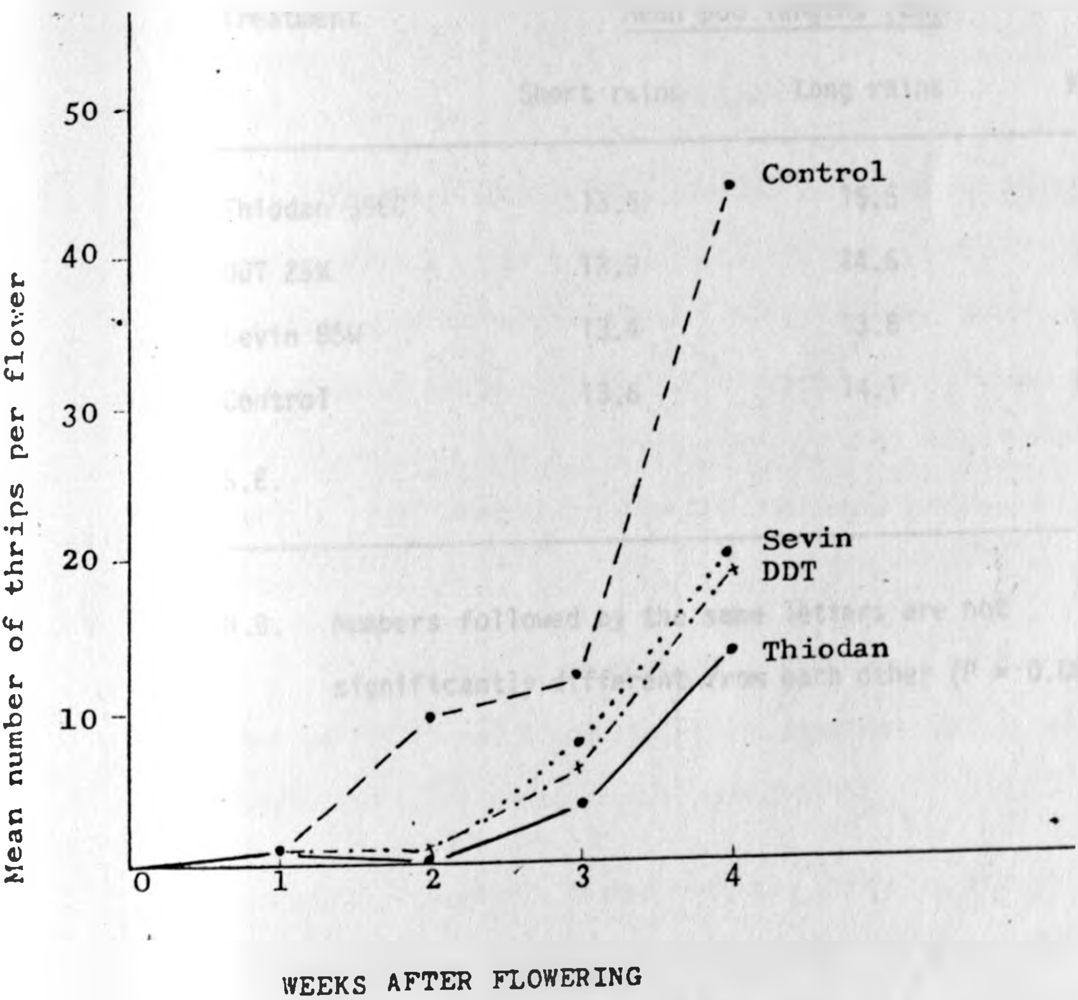


Table V Mean cowpea pod lengths under different insecticidal treatments against Megalurothrips sjostedti in short and long rain seasons

Treatment	Mean pod lengths (cm)		
	Short rains	Long rains	Mean
Thiodan 35EC	13.5	15.5	14.5a
DDT 25%	13.9	14.6	14.3a
Sevin 85W	13.4	13.8	13.6a
Control	13.6	14.1	13.9a
S.E.			0.2

N.B. Numbers followed by the same letters are not significantly different from each other (P = 0.05)

Seed yield from control differed significantly from the insecticide treatments and gave the lowest seed yield per hectare.

Table V shows that there was no significant differences in pod lengths among the four treatments. The mean pod lengths varied from 13.6cm in Sevin treatments to 14.5 in Thiodan treatments.

4.4 DISCUSSION

The importance of insecticides in control of M. sjostedti on cowpea and other grain legumes has been stressed in various countries by Michelmore (1954), Taylor (1968), Nyiira (1971), and Koehler and Mehta (1972). Different insecticides are more effective than others and the commonly used ones include Aldrin, DDT, Dieldrin, gamma BHC, Thiodan, Sevin, Sumithion, etc.

The findings of this study support those of Haq (1961), Nyiira (1971) and Singh (1973) who reported that Thiodan, Sevin and DDT reduced thrips infestation.

The 3 chemicals tested affected thrips in almost a similar manner all being contact/stomach poisons. This is probably the reason why there are only slight differences especially between DDT and Sevin. Because thrips normally feed on superficial epidermal plant cells, stomach poisons on leaf surfaces may not be effective against them.

Persistant contact insecticides such as DDT may be unsatisfactory for controlling young and adult thrips protected in flowers. They may be more useful for destroying stages in the soil. One advantage of Thiodan over Sevin and DDT is that it is non-toxic to bees and other beneficial insects and in that way superior (Bohlen, 1973). When beneficial insects are killed, there is the possibility of an increased number of aphids and virus cases.

In the present investigation, there was increase in seed yield where insecticides were used against thrips on cowpeas. However, the insecticides used are in no way specific to thrips. They could have controlled a multitude of other extremely destructive insects, e.g. the legume pod borer Maruca testulalis, a serious pest of cowpea in the Coast Province. Similarly, insecticides may have controlled other common cowpea pests such as Anoplecnemis curvipes Fabricius, Riptortus dentipes Fabricius, Acanthomia spp. and Nezara viridula L. (Khaemba, 1979 - personal communication).

Koehler and Mehta (1972) reported that cowpea pod length tended to increase as number of thrips decreased and that lindane (gamma BHC) sprays resulted in increased pod length despite thrips level. In the present studies, insecticides did not appear to affect the pod lengths.

Henneberry et al (1961) found that most surface insecticides control thrips effectively for up to three days. This may explain the gradual M. sjostedti population increase despite insecticide applications. This may also be due to the high rate of population turnover and to the numerous alternative hosts which serve as continuous reservoirs for the species.

CHAPTER FIVE

EFFECT OF DIFFERENT INSECTICIDE SPRAYING REGIMES ON *MEGALUROTHRIPS SJOSTEDTI* AND COWPEA YIELD PERFORMANCE

5.1 INTRODUCTION

Work on the effect of different insecticide spraying regimes on cowpea insect pests has been undertaken by various workers (Jerath, 1968; Ojohomon, 1968; Ayoade, 1969, 1974 and 1975; Dina, 1976, 1977). Results obtained were variable but generally, a particular number of insecticide applications gave a better control of a given insect pest leading to a significant increase in yield. Generally, many insecticides are effective for a few days after which there is need for further applications. These extra applications are determined by a number of factors such as the effectiveness of the first application, rate of turnover of the surviving pests, weather, resistance of the pest to the chemical, etc. In the case of thrips, populations may build-up quickly to economic proportions from numerous alternative hosts and high rate of turnover. These investigations were therefore initiated to determine the most appropriate spraying regime against thrips infestation on cowpeas to ensure a high yield.

5.2 MATERIALS AND METHODS

The cowpea variety VITA 3 was used for this experiment which was conducted both during the short and long rains seasons. The experimental design was randomised block with 4 treatments and replicated 4 times.

Thiodan 35 EC at the rate of 600 a.i. in 500 l. of water per hectare per application was used to spray the crop using a CP3 Knapsack sprayer at 45 p.s.i. Precaution to minimize insecticide drift between plots was taken by surrounding the plots with a 1.5m high polythelene sheet.

The tested regimes were as follows:

Regime 1. Four applications at weekly intervals from the onset of flowering.

Regime 2. Five applications at weekly intervals from the onset of flowering.

Regime 3. Six applications at weekly intervals from the onset of flowering.

Regime 4. No insecticide application (control).

Data on thrips population levels were obtained from random samples of 10 flowers picked at weekly intervals from each plot starting at the onset of flowering (6 weeks after planting). Pod length measurements were determined by obtaining the average length of 100 pods obtained from 15 randomly selected plants from each plot at harvest. Seed yield to detect the influence of M. sjostedti on cowpeas was determined as already described above.

5.3 RESULTS

Results are summarized in Tables VI and VII. M. sjostedti population was depressed in all cases to which there was insecticide application (Table VI). Regimes 1, 2 and 3 were more effective than regime 4. This is clearly shown when regimes 1, 2 and 3 are compared to the control regime. The difference between them was significant (P = 0.05). Cowpea seed yield per hectare was highest in regime 3 (1538.7 kg/ha). Generally, regimes 1, 2 and 3 had significant seed yield increase over the control.

Table III revealed that the lengths of individual pods did not differ significantly from each other. The lengths ranged from 17.4 to 18.0 cm in the short rains crop and 15.7 to 16.4 cm in the long rains.

5.4 DISCUSSION

Studies on the spraying regimes for insect control in cowpea fields have been undertaken by several workers. Working in Nigeria, Booker (1965) obtained more than ten-fold increase in seed yield over the estimated national average of 158 lb (71.8 kg.) per 0.4 ha when he applied regime 3 using a mixture of DDT plus gamma BHC starting at the onset of flowering. Ayoade (1974) found that 3 applications of DDT were as effective as regimes 1, 2 and 3 in inducing high yield.

Table VI Effect of insecticide spraying regimes on M. sjostedti population and seed yield performance of cowpea during short and long rains seasons

Regimes	Mean number of thrips per flower			Seed yield per ha. (Kg.)		
	Short rains	Long rains	Mean	Short rains	Long rains	Mean
1. 4 weekly application of Thiodan	21.4	8.2	14.8b	1015.1	1920.9	1468.0ab
2. 5 weekly applications	17.5	8.3	12.9b	971.1	1797.6	1384.4b
3. 6 weekly applications	16.3	10.3	13.3b	1201.1	1876.3	1538.7a
4. No spray (Control)	27.3	37.1	32.2a	899.4	1472.7	1186.1c
S.E.			4.63			76.23

N.B. Numbers followed by the same letters (in the same column) are not significantly different from each other (P = 0.05)

Table VII Mean cowpea pod lengths under different insecticide spraying regimes against M. sjostedti in short and long rain seasons

Regimes	Mean pod length		
	Short rains	Long rains	Mean
1. 4 weekly applications of Thiodan	18.0	16.4	17.2a
2. 5 weekly applications	17.9	16.4	17.2a
3. 6 weekly applications	17.5	16.2	16.9a
4. No spray (Control)	17.4	15.7	16.6a
S.E.			0.12

N.B. Numbers followed by the same letters (in the same column) are not significantly different from each other (P = 0.05)

Jerath (1968) did not find any significant differences in cowpea seed yield among three applications of dieldrin made in the 4th, 5th and 6th; 5th, 6th and 7th; and 6th, 7th and 8th week after crop germination. In the control of thrips, Carson (1964) found 2 to 3 applications of parathion and diazinon satisfactory when applied during the flowering period. Singh and Taylor (1978) working in Nigeria found one spray application with a mixture of monocrotophos, chlorpyrifos ethyl and cynolate at flower-bud formation in cowpeas sufficient for thrips control.

In the present investigation, four applications of insecticide (regime 1) was most successful because there was no significant difference in thrips population as well as in seed yield between this regime and regimes 2 and 3. The seed yield increase obtained from each additional spray decreases as the number of sprays increases (Raheja, 1978). Therefore, the optimum number of applications will be reached when the marginal revenue from the last spray is at least equal but less than the cost of spraying. Assuming that Raheja's arguement is correct, then it may not be economical to have more than 4 weekly spray applications during flowering period for thrips control. There is definitely an upper limit to the number of insecticide applications that is suitable for the control of M. sjostedti above which inefficiency in utilization of chemical control may result.

It would be quite inappropriate to conclude that the increase in seed yield is due to control of M. sjostedti alone as many other destructive insect pests are also controlled.

Nangju (1977) found that four insecticide applications gave higher yield than two applications. He, however, pointed out that other management factors, such as planting date, plant density and fertilizer affect yield.

While controlling M. sjostedti, no chemical control should be undertaken before any signs of flower-bud formation on the crop. This would be uneconomical because no serious thrips damage has been reported before flower-bud formation.

CHAPTER SIX

6.1 GENERAL DISCUSSION

With sufficient information on population trends population dynamics, seasonal incidence and cowpea varietal resistance to M. sjostedti attack, it is possible to develop a chemical control programme that can at least lead towards a reasonable increase in seed yield.

Although simultaneous occurence of many insect pest species damaging various parts of the cowpea crop makes it difficult to estimate accurately the loss in seed yield caused by M. sjostedti, many workers (Taylor, 1965, Agyen Sampong, 1978; Singh, 1976, 1978) feel that it can be extensive. Of importance also is the association between M. sjostedti and Cowpea Yellow Mosaic Virus, which according to Shoyinka (1974), can cause yield reduction of 60-100%. An infective thrips requires only 5-15 minutes feeding to transmit virus to a healthy plant (Razvyakina, 1953; Sakimura, 1960, 1963). Effective control of thrips would definitely aid in reducing CYMV infestation on cowpea.

Lewis (1973) listed 31 toxicants for thrips control. He, however, pointed out that thrips are sometimes difficult to control largely because of the great numbers that infest individual plants and rapid increase of field populations caused by breeding and airborne migrations. Other hinderances to effective thrips control could be attributed to presence of large number of thrips protected between flower petals and the occurrence of overlapping generations.

Various workers (Jones et al, 1934; Lall and Singh, 1968; Wittwer and Hoseman, 1945) have variously associated resistance to thrips attack with such factors as soil types and nitrogen supply. Plants grown under low nitrogen levels were seriously attacked by thrips (Wittwer and Hoseman, 1945). It is important to note that most insect pests have specific food requirements to satisfy. The cowpea varieties tested in the present study varied in resistance to thrips attack because they also differ amongst themselves in many ways, e.g. in yield potential, tolerance to drought, etc. It is possible that the more susceptible varieties had more pollen in their flowers. Taylor (1974) reported that M. sjostedti populations were influenced by pollen abundance. Reproduction in thrips was influenced when they were fed on pollen (Andrewartha, 1935, 1961).

This study revealed that it is possible to reduce thrips infestation on cowpea by use of insecticidal treatments. It may, however, be suggested that a chemical control programme taking into consideration the rate of thrips migration from alternative hosts would be very appropriate. For a species like M. sjostedti with a very wide host range, the probability of large thrips infestation developing on cowpea could be easily predicted by examining thrips populations on alternative hosts. This type of information could be used to decide when and whether insecticide treatments should be necessary.

ACKNOWLEDGEMENTS

I am greatly indebted to Professor C.P.M. Khamala of University of Nairobi whose counsel, guidance and constant supervision made the completion of this work possible.

I am also grateful to those people who gave encouragement and especially to my colleagues at Coast Agricultural Research Station, Mtwapa.

This work was supported by finances from Ministry of Agriculture, Kenya, for which I am extremely thankful.

REFERENCES

Anon (1978). International Institute for Tropical Agriculture Research highlight, Ibadan, Nigeria. 63pp.

Anon (1978). Annual report, Ministry of Agriculture, Kenya. 111 pp.

Agyen-Sampong (1976). Co-ordinated insecticide minimum trials. Yield performance of insect resistant cowpea cultivars from IITA compared with Ghanaian cultivars. Tropical Grain legume Bulletin No. 5:7.

Agyen-Sampong (1978). Progress report on investigation on insect pests of cowpeas in Ghana. Tropical Grain legume Bulletin No. 8:20-23.

Akingbohungbe, E.A. (1970). Thrips and minor pests of cowpeas. Department of Plant Science, Ife University, Nigeria. 17 pp.

Andrewartha, H.G. (1935). On the effect of temperature and food on egg production and length of adult life on Thrips imaginis Bagnall. J. Coun. Scient. and Indust. Res. Aust. 8:281-288.

Andrewartha, H.G. (1961). Introduction to the study of animal populations. Chapman and Hall Ltd. London 283 pp.

Assa, A.E. (1976). Co-ordinated insecticide minimum trials. Yield performance of insect resistant cowpea cultivars from IITA Tropical Grain legume Bulletin No. 5:9.

Ayoade, K.A. (1969). Insecticidal control of the pod borer Maruca testulalis Gey (Lepidoptera : Pyralidae) on Westbred cowpea (Vigna sp.). Bull. Ent. Soc. Nigeria 2: 23-33.

Ayoade, K.A. (1974). Evaluation of DDT schedule for control of pod borer Maruca testulalis Gey infestation on cowpea (Vigna unguiculata) (L) Walp var. Mala. Niger. J. Ent: (1); 9-12.

Ayoade, K.A. (1975). Recent trends on chemical control of insect pest complex of cowpea in Western Nigeria. Proc. of IITA collaborators meeting on Grain legume improvement. pp. 44-51, June 9-12, 1975, IITA. Ibadan, Nigeria.

Bindra, O.S. and Prem Saga (1976). Co-ordinated insecticide minimum trials: Yield performance of insect resistant cowpea cultivars from IITA compared with Indian cultivars. Tropical Grain Legume Bulletin No. 5: 8.

Booker, R.H. (1965). Pests of cowpea and their control in Northern Nigeria. Bull. Ent. Res. 55(4): 663-672.

Bohlen, E. (1973). Crop pests of Tanzania and their control. Verlag Paul Parey (Editor). Berlin and Hamburg. 142 pp.

Carlson, E.C. (1964). Effect of flower thrips on onion seed plants and a study of their control. J. econ. Ent. 57: 735-741.

Chant, S.R. (1960). The effect of infestation with tobacco mosaic virus on the growth rate and yield of cowpea in Nigeria. Emp. J. exp. Agriculture, 28: 114-120.

Davidson, J. and Andrewartha, H.G. (1948a). Annual trends of natural population of Thrips imaginis (Thysanoptera). J. Anim. Eco. 17: 193-199.

Davidson J. and Andrewartha, H.G. (1948b). The influence of rainfall, evaporation and atmospheric temperature on fluctuations of Thrips imaginis (Thysanoptera). J. Anim. Ecol. 17: 200-222.

Dina, S.O. (1976). Effect of insecticidal application at different growth phases on insect damage and yield of cowpea. J. econ. Ent. 69(2): 186-188.

Dina, S.O. (1977). Insecticide testing programme to increase grain yield in cowpea. Tropical Grain legume Bulletin No. 8: 14.

Dingle, H. and Khamala, C.P.M. (1972). Seasonal changes in insect abundance and biomass in an East African grassland with reference to breeding and migration of birds. Ardea 59: 216-221.

Finney, D.J. (1971). An introduction to statistical science in Agriculture. Blackwell scientific publications, 4th edition, Oxford 290 pp.

Haq, A. (1961). A note on broad bean thrips, _T. lefroyi_ Bagnall. Indian J. Ent. 22: 132-133.

Henneberry, T.J., Taylor, E.A. and Smith, F.F. (1961). Foliage and soil treatments for the control of flower thrips in outdoor roses. J. econ. Ent. 54: 233-235.

Imms, A.D. (1957). A general textbook of entomology. 9th edition, London, Methuen. 886 pp.

Ingram, W.R. (1969). Observations on the pest status of Bean flower thrips in Uganda. East African Agricultural and Forestry J. 34(4): 482-484.

Jerath, M.L. (1968). Insecticide control of _Maruca testulalis_ on cowpea in Nigeria. J. econ. Ent. 61(2): 412-416.

Jones, H.A.; Bailey, S.F. and Emsweller, S.L. (1934). Thrips resistance in the onion. Hilgardia 8: 215-232.

Khamala, C.P.M. (1978). Pests of grain legumes and their control in Kenya. In pests of Grain legumes: Ecology and Control. Singh, S.R., van Emden, H.F. and Taylor, T.A. (Editors). Academic Press, 127-134.

Koehler, C.S. and Mehta, P.N. (1972). Relationship of insect control attempts by chemicals to components of yield of cowpea in Uganda. J. Econ. Ent. 65(5): 1421-1427.

Lall, B.S. and Singh, L.M. (1968). Biology and control of thrips in India. J. econ. Ent. 61: 679.

Le Pelley, R.H. (1959). Agricultural Insects of east Africa. East Africa High Commission, Nairobi. 307 pp.

Lewis, T. (1973). Thrips; their ecology and economic importance. Academic press. London and New York. 349 pp.

Ligon, L.L. (1958). Characteristics of cowpea varieties. Bull. B-54. Okla. Agric. Exp. Sta. 47 pp.

Mehta, P.N. and Nyiira, Z.M. (1973). An evaluation of five insecticides for use against pests of cowpea (Vigna unguiculata (L) Walp) with special reference to green pod yield. E. Afric. Agric. and For. J. 39(2): 99-104.

Michelmore, A.P.G. (1954). Cowpea molting and dwarfing. Department of Agriculture, Uganda 137-150.

Morrison, G.P. (1957). A review of British glasshouse Thysanoptera. Trans. r. ent. Soc. London 109: 467-534.

Nangju, D. (1977). Practical management factors in Food legume production. Tropical Grain legume Bulletin No. 8: 51.

Nyiira, Z.N. (1971). The status of insect pests of cowpea (Vigna unguiculata (L) Walp) in Uganda and their control. PANS 17(2): 194-197.

Ochieng, R.S. (1978). Studies on the bionomics of cowpea leaf beetle, Ootheca mutabilis. In pests of Grain legumes: Ecology and control. Singh, S.R.; van Emden, H.F. and Taylor, T.A. (Editors). Academic Press. 187-191.

Ogunmodede and Oyenugu (1970). Vitamin B content of cowpea (V. unguiculata (L.) (Walp). J. Sc. Fd. Agric. 21: 88-91.

Ojohomon, O.O. (1968). Flower, fruit production and abscission in cowpea, Vigna unguiculata (L) walp. J. West Afric. Sc. Ass. 13(2): 227-234.

Okwakpan, B.A. (1965). A preliminary checklist of West African Thysanoptera. Memo. Agric. Dep. Nigeria, No. 65, 10 pp.

Okwakpan, B.A. (1967). Three species of Thrips (Thysanoptera) in cowpea flowers in the dry season at Badeggi, Nigeria. Nigeria ent. Mag. 1(3): 45-46.

Ota, A.K. (1968). Comparison of three methods of extracting the flower thrips from rose flowers. J. econ. Ent. 61: 1754-1755.

Painter, R.H. (1952). Insect resistance in crop plants. Mcmillan, London. 520 pp.

Perrin, R.M. (1977). Screening for resistance in cowpea to Cydia ptychora. Tropical Grain legume Bulletin No. 8 17-19.

Purseglove, J.W. (1970). Tropical crops. Dicotyledons. Longman group limited, London. 719 pp.

Raheja, A.K. (1976). Co-ordinated minimum insecticide trial: Yield performance of insect resistant cowpea cultivars from IITA compared with Nigerian cultivars. Tropical Grain legume Bulletin 5: 5.

Raheja, A.K. (1978). Yield losses from pests and the economics of chemical pest control on cowpea in Northern Nigeria. In Pest of Grain legumes: Ecology and control. Singh, S.R., van Emden, H.F. and Taylor, T.A. (Editors). Academic press. 257-265.

Razvyazkina, G.M. (1953). The importance of tobacco thrips in the development of outbreak of tip chlorosis of Marhorka. Rev. appl. Ent. (a) 42: 146.

Sakimura, K. (1960). The present status of thrips borne virus. In Biological transmission of disease agents. Maramorosch, K. ed. Academic press Newyork-London. 192 pp.

Sakimura, K. (1963). Frankliniella fusca, an additional vector for the tobacco spotted wilt virus, with notes on Thrips tabaci another vector. Phytopathology. 53: 414-415.

Saunders, A.R. (1935). Hay and Fodder grasses and legumes in the Union of South of Africa. Herb. Rev. 3: 128-35.

Sellschop, J.P.F. (1962). Cowpeas, Vigna unguiculata. In Field crop abstracts 15: 259-266.

Shoyinka, S.A. (1974). Status of virus diseases of cowpea in Nigeria. In proceedings of the first IITA Grain legume Improvement workshop, International Institute of tropical Agriculture Ibadan, Nigeria, 1974. 325 pp.

Singh, P. (1970). Host-plant nutrition and composition effects on agricultural pests. Inform. Bull. Belleville Res. Inst. Canada Depart. Agric., 6, 102 pp.

Singh, S.R., (1973). Grain legume Improvement Program. Annual Report. IITA. Ibadan. 47-54.

Singh, S.R. (1974). Entomological Research activities at IITA Grain legume improvement Workshop. 29 Oct. - 2 Nov., 1973. Ibadan, Nigeria. 279-281.

Singh, S.R. (1976). Co-ordinated minimum insecticide trials: Yield performance of insect resistant cowpea cultivars from IITA compared with Nigerian cultivars. Tropical Grain legume Bulletin No. 5: 4.

Singh, S.R. (1977). Cowpea cultivars resistant to pests in world germplasm collection. Tropical Grain legume Bulletin No. 9: 3-7.

Singh, S.R. (1978). Biology of cowpea pests and potential for host resistance. Annual Report. IITA. Ibadan.

Singh, S.R. and Allen, D.J. (1978). Pest, diseases, resistance and protection in Vigna unguiculata (L) Walp. Proc. Int. Legume conference. London. Jul. 23- Aug. 4 1978.

Singh, S.R. and Allen, D.J. (1979). Cowpea pests and diseases: International Institute of Tropical Agriculture, Ibadan, Nigeria. Manual Series No. 2 - 113 p.

Singh, S.R. and Taylor, T.A. (1978). Pests of Grain legumes in Nigeria. In pests of Grain Legumes: Ecology and control. Singh, S.R., van Emden, H.F. and Taylor, T.A. (Editors). Academic press, 99-111.

Singh, S.R.; Williams, R.J.; Rachie, K.O.; Nanju, D.; Wien, H.C. and Luse, R.A. (1975). VITA -3 cowpea (GP-3). Tropical Grain legume Bulletin No. 1: 18-19.

Southwood, T.R.E. (1966). Ecologal methods with reference to the study of Insect populations. Methuen and Co. Ltd., London. 391 pp.

Stanton, W.R. (1974). FAO Production book, Rome 28, 79 pp.

Strassen, R. sur. (1959). Studies on African Thysanoptera. J. Ent. Soc. S. Africa, 22(1): 174-198.

Taylor, T.A. (1964). Field pests of cowpea. Memo. Fed. Dept. Agric. Res. Nigeria, No. 52.

Taylor, T.A. (1965). An attempt at quantitative estimate of major insect damage on cowpeas. Proc. Agric. Soc. Nigeria Vol. 4: 50-53.

Taylor, T.A. (1968). The effect of insecticide application on insect damage and performance of cowpea in Southern Nigeria. Nigerian Agric. Journal 5(1): 29-37.

Taylor, T.A. (1969). On population dynamics and flight activity of Taeniothrips sjostedti (Tryb.) (Thysanoptera: Thripidae) on cowpea. Bull ent. Soc. Nigeria 2: 60-71.

Taylor, T.A. (1974). On the population dynamics of T. sjostedti (Tryb.) (Thysanoptera: Thripidae) on cowpea and an alternative host Centrosema pubescens Benth, in Nigeria. Rev. Zool. Afr. 88(4): 689-702.

Taylor, T.A. and Ezedinma, F.O.C. (1964). Preliminary investigations on field pests of cowpea and methods of control. Niger. Agric. J. 1: 8-11.

Taylor, W.E. (1976). Co-ordinated minimum insecticide trial: Yield performance of insect resistant cowpea cultivars from IITA compared with Sierra Leone cultivars. Tropical Grain Legume Bulletin No. 7.

Whitney, W.K. and Gilmer, R.M. (1974). Insect vectors of cowpea mosaic virus in Nigeria. Annals of appl. Biology 77: 17-21.

Whitney, W.K. and Sadik, S. (1972). Thrips damage to cowpea. Nigerian Society for plant protection occasional publication No. 1: 9.

Wittwer, W.K. and Hoseman, L. (1945). Soil nitrogen and thrips injury on spinach. J. econ. Ent. 38: 615-622.

van Emden, H.F. (1966). Plant resistance to insects induced by environment. Scient. Hort. 18: 91-102.

van Emden, H.G. (1978. Ecological information necessary for pest management in Grain legumes. In Pests of Grain legumes: Ecology and control. Singh, S.R., van Emden, H.F. and Taylor, T.A. (Editors). Academic Press. 287-307.