INSECT PESTS OF COWPEAS *VIGNA UNGUICULATA* (L.) WALP. AND STUDIES ON COWPEA YIELD ASSESSMENT UNDER DIFFERENT CHEMICAL SPRAY REGIMES AND MINIMUM USE OF INSECTICIDES AGAINST THE DOMINANT INSECT PEST SPECIES AT KATUMANI DRYLAND RESEARCH STATION, KENYA

By

FLORENCE R.A. MABONGA

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DECLARATION BY CANDIDATE

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

F.R.A. Mabonga

DECLARATION BY SUPERVISOR

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

Professor Canute P.M. Khamala

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ABSTRACT

Studies to identify major insect pests attacking cowpea, Vigna unguiculata (L.) Walp., in the field and to assess cowpea yields under different chemical control regimes were conducted at Katumani, Kenya during the short and the long rainy seasons of 1978 and 1979 respectively.

From materials collected in unsprayed plots, the cowpea crop was found to be attacked by a total of 43 species of insects which were classified into seven orders: Diptera (1), Coleoptera (10), Heteroptera (15), Homoptera (3), Lepidoptera (8), Orthoptera (4) and Thysanoptera (2). Only a few of these were considered major pests, namely, Acanthomia horrida Germ, Agrotis segetum D and S, Anoplocnemis curvipes F., Aphis craccivora Koch,. Callosobruchus maculatus Fab., Heliothis armigera Hb, Lagria villosa Fab., Maruca testulalis Geyer, Megalurothrips sjostedti Trybom, Nezara viridula L.

Maximum seed yields were obtained from cowpea plots sprayed with gamma BHC insecticide after flowering. There were no significant differences in yields between plots sprayed with insecticide before flowering and those of the untreated plots. Insecticidal treatments applied four times after flowering at 14 days interval, starting at the appearance of first flowers, gave significantly higher yields than spraying

two times after onset of flowering at 45 days apart.

Mean seed yield of the ten varieties of cowpea used differed significantly between treated and untreated cowpea plots. The local varieties KAT 1, KAT 2 and KAK 1 constantly performed well producing higher yields than the exotic varieties except VITA 4.

Aphids which were one of the most important pests of cowpea at Katumani preferred to colonize prostrate varieties to erect ones in growth habit. When gamma BHC insecticide was applied to plots attacked with aphids there was no correlation between insecticide application and cowpea varietal yields.

CHAPTER I

GENERAL INTRODUCTION AND OBJECTIVES, LITERATURE REVIEW AND GENERAL MATERIALS AND METHODS

1.0 GENERAL INTRODUCTION AND OBJECTIVES

Cowpea *Vigna unguiculata* (L) Walp. belongs to the Family Leguminosae and is one of the most important grain legumes of tropical Africa and other tropical countries of the world. In Kenya it is the second important pulse to the common bean *Phaseolus vulgaris* L., being grown on about a total of 109,000 hectares of land (Ministry of Agriculture unpublished Provincial Annual Reports, 1977/78). About 83 percent of the crop is produced in the semi-arid areas of Eastern Province, 15 percent in Coastal Province and the rest in the high rainfall areas of Central, Nyanza and Western Provinces. Like other grain legumes, cowpea is hardly grown as a sole crop but is usually intercropped with sorghum, maize and millet and forms an integral part of the traditional cereal/legume farming system in the main producing areas. It is grown and consumed for its high protein food content value.

Steele (1972) noted that the protein content of cowpea seeds varied from 18 to 26 percent of their weight being within the range of most grain legumes except soya beans which contains as much as 40-50 percent. Thus cowpea like other grain legumes forms an important source of protein in the food diets of a large population in Kenya. This nutritional value of cowpea in terms of high vegetable protein is highly complementary in diets which mostly consist of starchy stables and minimal animal proteins which have become too expensive for the average household (Taylor, 1971; FAO, 1964; Stanton, 1966).

The simplicity of preparing cowpea for consumption makes it an excellent, easily available source of food. In Eastern and Coastal Provinces of Kenya dry seeds are threshed and used as pulses whereas in other parts, particularly, Nyanza and Western Provinces cowpeas are mostly grown for their leaves which are used as vegetables. The dry seeds can be stored quite easily for a long time if protected against attack by the cowpea bruchid Callosobruchus maculatus (F.), and thus are always available for the family. The leaves can also be kept for a long time if they are dried and then pounded.

Increase in the production of grain legumes therefore would offer a partial solution to the shortage of world protein supply. For this reason there has been increasing research effort to improve the seed quality and yielding capacity of grain legumes such as cowpea, common bean and soybean.

Morse (1924) stated that a legume such as cowpea that grows successfully in a wide range of climatic, soil and cultural conditions should be given a high priority for development over other legumes. Its ability to grow well in semi-arid areas makes it the most important grain legume in the dry parts of Kenya and a crop of great potential for the future.

Although the potential of cowpea is fully realised in Kenya, very little research has been conducted to improve seed quality and yielding capacity. Consequently, dry seed yields are as low as 200 kg/ha (information from Ministry of Agriculture).

It is widely recognised that one of the major constraints in cowpea production in Africa is the high incidences of insect pest and disease attacks which cause heavy losses. Taylor (1964a) showed that all stages of cowpea production were subject to damage and losses due to insect pests leading not only to substantial reduction in yield but reduced quality. What is eventually obtained by the farmer is far below the potential of the crop. Khamala (1978) stated that high yields of cowpea in Kenya like in other African countries were largely hindered by insect pest damage and suggested that applying control methods described by Taylor and Ezednima (1964) and Booker (1965a) could lead to yield increases.

Apart from a few observations and reports from farmers and agricultural extension workers very little is known about insect pests of cowpea in Kenya(Khamala 1978). There is practically no precise information on cowpea insect pest complex: distribution and occurences in time and space; their intensity and potential destructiveness. There is no data on effective chemical control methods. Information is also lacking on alternative control measures such as biological and varietal resistance and on toxicology of insecticides both in the field and stored products.

This research was therefore initiated to investigate the pest complex of cowpea and their control with the following objectives:

1. To determine the major cowpea insect pests in Kenya.
2. To assess cowpea yields under different insect chemical control regimes, and
3. To determine the minimum insecticidal use for control of the dominant cowpea insect pests.

1.10 LITERATURE REVIEW

A wide variety of insect pests known to attack various stages of the cowpea Vigna unguiculata, and their control have been studied in many parts of the world. The most comprehensive studies of the pests of the cowpea, their control and economic importance in Africa have been carried out in West Africa by Taylor(19[illegible], 1964a, 1964b, 1965a, 1965b, 1967, 1968a, 1969a, 1969b, 1971, 1974, 1978), Taylor and Ezednima (1964), Booker (1963, 1965a, 1965b, 1967). Appert (1964), Ayoade (1969), Jerath (1968), Van Halleren (1971), Singh (1975a, 1975b), Raheja (1976a, 1976b), Anyen-Sampong (1977) and Haque (1977). Studies of the economic importance and control of the major pests of cowpeas in East Africa were conducted by Thomas (1968), Bolden (1969), Nyiira (1971), Koehler and Mehta (1970, 1972), Mehta and Nyiira (1973), Kayumbo (1975, 1977, 1978). These workers have reported occurrence of insect pests on field cowpeas and demonstrated the effectiveness of their control by applying various insecticides. However, in recent years, the problems caused by chemical control measures in subsistence agriculture have prompted further studies on the biology and ecology of some of the most important cowpea insect pests in Africa with a view of controlling them by integrated pest management techniques involving cultural, biological and chemical methods.

Working in Nigeria, Taylor (1964a) reported 42 insect species attacking leaves of the cowpea, 9 species feeding on flowers and 18 species as pod pests. A total of 43 insect species were recorded feeding on cowpeas at Morogoro, Tanzania (Kayumbo, 1978). These were 14 Coleoptera, 5 Lepidoptera, 19 Hemiptera, 3 Diptera and 2 Thysanoptera. Le Pelley (1959) listed some of the pests of cowpeas in Uganda. However, the most comprehensive list from Uganda, is that compiled by Mehta and Nyiira (1973). These two workers recorded a total of 38 insect species on cowpeas which included 10 Lepidoptera, 14 Hemiptera, 9 Coleoptera, 3 Orthoptera and 2 Thysanoptera. Eight of the Lepidoptera species fed on leaves, 2 on flowers and 3 on pods. All the Coleoptera and Orthoptera were leaf feeders while the thrips fed on flowers.

These workers showed that leaf-eating insect species were of economic importance in that they destroyed the quality of cowpea leaves and rendered them inedible. They also reduced the photosynthetic surface of the leaves and hence their radiation intake. Such a reduction interfered with the recoverable seed yield of the cowpea crop. The species which fed on flowers reduced the number of pods formed through flowers drop (Booker, 1965a), while those species which attacked pods destroyed formed seeds thus reducing the commercial yield and rendered some seeds unusable due to reduced quality and vitality.

Booker (1965a) conveniently divided the major pests of cowpea into two groups, namely, pre-flowering and post-flowering insect pests. Taylor (1971) suggested that in view of the fact that many of the injurious species overlapped in time and in relation to the phenology of the crop, the pests could be classified into four major groups:

a) Root-feeding species

b) Leaf and stem-feeding species

c) Flower-feeding species

d) Pod and seed-feeding species

Very little is known of insects that infest roots of cowpea. In Kenya, their attack on roots was sporadic and Khamala (1978) considered them of less economic importance.

Previous workers found that leaf- and stem-feeding pests constituted the largest group among insects attacking cultivated grain legumes in tropical Africa. Although most cowpea varieties have been shown to exhibit a high degree of tolerant resistance against leaf- and stem-feeding group of insects (Booker, 1965a), Coleoptera and Lepidoptera species in this group caused notable damage leading to economic importance (Singh and Taylor 1978). In particular, Ootheca mutabilis Sahl. was reported as the outstanding foliage-feeding beetle infesting cowpea seedlings in Nigeria (Booker, 1965a; Singh, 1977; Singh and Taylor, 1978; Taylor, 1971). This beetle extensively defoliated young cowpea plants and also transmitted the cowpea yellow mosaic virus (CYMV) (Bock, 1971; Chant,1959; Taylor, 1964b; Whitney and Gilmer, 1974). This species was also reported from Ghana and Tanzania where it occurred in devastating populations on field cowpea plants (Anyen-Sampong, 1977; Kayumbo, 1978). The biology of O.mutabilis has been studied in detail by Ochieng (1977). He found that the whole life cycle took 51-100 days in the early season at

$25^{o}C$ to $35^{o}C$, and 148-176 days in the late season at the same temperature. Lagria caprina (Thomas) and L. villosa Fab. are the other two beetles which were reported as minor pests feeding on cowpea leaves (Anyen-Sampong, 1977; Singh, 1977).

The leaf-eating lepidopterous larvae such as Spodoptera littoralis (Boisd.), Diacrisia lutescens Walk, Euproctis sp. and Ameacta flavizonata Hmp., were reported by Booker (1965b) as minor pests of cowpea in Nigeria. Delassus (1970) reported the occurrence of Spodoptera littoralis, S. exigna Hb., S. exempta Wlk., and Amsacta moloneyi BRC, on cowpea in Senegal. Anyen-Sampong (1977) in Ghana listed S. littoralis, Plusia signata (F.) and Anticarsia irrorata F. as cowpea foliage feeders. Cutworms, Agrotis spp., were reported in Uganda as the most serious lepidopterous larvae of cowpea seedlings (Nyiira, 1978).

Two homoptera species, the leaf-hopper Empoasca dolichi Poali and the aphid Aphis craccivora Koch have been reported by several workers as pests of cowpea foliage. Taylor (1964a & 1964b) worked in Nigeria and incriminated E. dolichi as a minor pest of cowpea during the seedling stage. However, recent investigations by Singh (1977) indicated that large numbers of this pest were capable of causing serious economic damage to certain cowpea varieties. Aphis craccivora was reported to be a major pest of cowpea in Asia by Sarup et al (1960) and a minor pest in Africa (Booker, 1965b; Mehta and Nyiira, 1973; Singh, 1977, Anyen-Sampong, 1977). However, recent observations by Singh (personal communication) indicated that heavy aphid infestations on field cowpea were more frequent and widespread and caused economic damage in Africa.

Alcidodes lecogrammus Erichs is a stem girdler beetle of cowpea plants. Both adults and larvae caused damage (Booker, 1965a; Raheja, 1975; Nyiira, 1978) but was not a serious pest.

Flower-feeding species have been shown to be responsible for the greatest economic damage to cowpeas. In Nigeria, Booker (1965a) recorded and estimated damage caused by Maruca testulalis Geyer. Taylor (1971) grouped the flower-feeding species into two: the lepidopterous flower-feeders and the other sucking insect pests. He also confirmed the role of M. testulalis as the most important pest on flowers and recorded up to 30 per cent damage to pods. Koehler and Mehta (1972) in Uganda, and Dalassus (1970) in Senegal, separately showed that M. testulalis caused deformation and loss of flowers becoming the most serious pest of cowpea in these countries. Nyiira (1971) confirmed the status of M. testulalis in Uganda. He estimated 50-60 per cent damage to flowers and 60 per cent damage to green pods by this pest. It fed on leaves, stems, flowers and pods. The biology of this pest has been extensively studied by several workers from different countries (Akinfenwa, 1975; Djamin, 1961; Taylor, 1976 & 1978). They found that eggs were laid on flowers and flower buds. Early instars infested the pods after feeding on flowers and flower buds initially.

Other flower-feeding lepidopterous larvae reported by Taylor (1971) and Booker (1965b) in Nigeria included the lycaenids Euchrysops malathara Boisd, Virachola antalus Hopff and Cupido ciccus Gdt.

Previous studies revealed that thrips represent the second category of important flower-feeders. The cowpea flower thrip Megalurothrips sjostedti (=Taeniothrips sjostedti) Trybom. and Sericothrips occipitalis Hood were shown by Taylor (1965b) to cause distortion and malformation of flowers in cowpea and, populations as high as 100 thrips per flower resulted in flower shedding. Ingram (1969) investigated the biology, the pest status and control measures of M. sjostedti in Uganda which he also recorded on soybeans, groundnuts and Crotalalria juncea (L.). Koehler and Mehta (1972), working in Uganda, confirmed the presence of M.sjostedti and S. occipitalis on cowpea plants causing similar damage as that reported by Taylor in addition to plant dwarfing. Whitney and Sadik (1972) worked in Nigeria and found M. sjostedti and S. occipitalis damaging cowpea foliage and flowers. They recorded up to 50 per cent reduction in seed yield of attacked plants. S. occipitalis is described mainly as a leaf-feeder and a serious pest of cowpea only under green-house conditions (Taylor, 1969a). Singh (1977) established that M. sjostedti was basically a floral pest whereas S. occipitalis was a foliage pest. Observations made at the International Institute for Tropical Agriculture (IITA) confirmed that S. occipitalis was a serious pest in warm greenhouses especially under drought stress conditions (Singh, 1977). It was further discovered that it was a pest of cowpea seedlings in the field on off-season crop grown under irrigation (Singh, 1977). M. sjostedti was found by Anyen-Sampong (1977) to be a leaf-sucking pest of cowpea in Ghana.

Hemipterous sucking bugs and lepidopterous larvae have been shown to be the most important insect pests attacking the pod stage of the cowpea field crop. The incriminated species belong to three coreid genera, namely, Anoplocnemis, Acanthomia and Mirperus; one Alydid of the genus Riptortus; and two pentatomid genera, Nezara and Aspavia (Booker 1965a, Taylor 1971 and Singh 1977). The bugs attacked the pods as soon as they were formed resulting in their premature shrivelling and drying. Pods which were attacked late became spindly-shaped and partially seed filled. The losses ranged from total pod loss to nil seed formation where crop protection practices were not carried out during the post-flowering phase (Anyen-Sampong, 1977; Singh, 1977).

Booker (1965a) was concerned with yield losses and recorded up to 89 per cent through damage to cowpea pods by Acanthomia brevirostris Stal., A. horrida Germ, Anoplocnemis curvipes (F.) and Mirperus jaculus Thumb in Northern Nigeria. Working in Southern Nigeria, Taylor (1971), found A. horrida, A. curvipes, R. dentipes and Mirperus torridus Westw., the most important hemipteran pests responsible for up to 60 per cent losses by attacking pods. Nyiira (1971) also found that in Uganda up to 23 per cent of the seeds produced were shrivelled or partially developed due to damage by pod-sucking bugs. Materu(1970) conducted experiements on beans and pigeon peas to study the nature and amount of damage caused by Acanthomia tomentosicollis Stal. and A. horrida in Arusha, Tanzania. The bugs caused reduction of weight, number and quality of seeds. The largest loss was due to seed damage reducing quality which, even at a low bug density, was considerable. Anyen-Sampog (1977) listed R. tenuicornis Dall., Cletus fuscenscena Walk., Anoplocnemis spp., A. tomentosicollis and Clavigralla sp. as being responsible for peremature drying and shrivelling of the pods and young cowpea seeds in Ghana. Kayumbo (1978) reported the occurrence of A. horrida, A. tomentosicollis, Riptortus spp. and Nezara viridula (L.) in large numbers during cowpea green-pod stage in Tanzania.

Materu (1968) studied in detail the biology of A. tomentosicollis and A. horrida. He compared the duration of life cycles of these two bugs and established that at 25°C A. tomentosicolis took a shorter period than A.horrida to develop on these crops. Ochieng (1977) was concerned with the detailed biology of Anoplocnemis curvipes and showed that at fluctuating greenhouse temperatures between 25° and 32°C in Nigeria egg duration averaged 11 days and the remaining period of the total life cycle varied between 58 and 67 days.

The African bollworm, Heliothis armigera Hb. and the cowpea flower moth, Maruca testulalis were the important lepidopterous pests of cowpea associated with pod damage in Uganda and Tanzania (Nyiira,1971 and Kayumbo, 1978). The larvae of H. armigera attacked and bored into green pods becoming sporadically serious. It was also reported to be a serious pest of cowpea in the southern parts of Africa especially in Botswana and Malawi (Roome, 1971). The biology of this pest was reviewed by Singh and Van Emden (1979) who reported life cycle duration of between 31 to 68 days depending on host plant and climatic conditions.

The oriental fruit moth, Cydia ptychora (=Laspeyresia ptychora) Meyer was found by Nyiira (1971) attacking ripe and dry cowpea pods in the field and caused about 18-20 per cent damage. The biology of this moth was first described by Taylor (1965a). He found that the total life cycle duration took between 18 and 24 days at 25.5 to $30^{\circ}C$.

The cowpea bruchid weevil, Callosobruchus maculatus (F.), a serious pest of cowpea in storage, initially infested the seeds while still in the field and multiplied rapidly under storage conditions. (Caswell, 1970). Losses in Nigeria during storage caused by this pest were estimated by Caswell to be well over 1.6 million dollars per year.

Most of the existing literature on cowpea pest control concerns chemical treatments and there is very little on natural enemies and cultural practices. Experimentation on chemical control of field cowpea pests was first undertaken in Nigeria by Taylor and Ezednima (1964) who found that dieldrin, lindane (gamma BHC) and aldrin were economic and promising insecticides. Also working in Nigeria, Booker (1965a) reported a substantial increase in cowpea dry seed yield and a threshing percentage as high as 75 per cent when insecticides such as DDT + gamma BHC and carbaryl were applied during the post-flowering growth period. Further work in Nigeria by Taylor (1968a) demonstrated that 0.25 lbs gamma BHC in 35 gallons of water applied to one acre planted with cowpeas gave good control as did dieldrin or mixture of DDT + gamma BHC.

Taylor (1968b) was mainly concerned with biological control of cowpea pests using the micro-organism Bacillus thuringesis var. thuringesis Berliner on M. testulalis larvae and concluded that more work on this aspect was still required. Investigations on the use of insecticides against Maruca testulalis was resumed in Nigeria by Jerath (1968), Ayoade (1969) and Dina (1973) who each separately confirmed earlier reports that dieldrin and DDT sprays were effective and increased cowpea seed yields significantly.

Working in Uganda, Koehler and Mehta (1972) discussed the use of DDT, diazinon, dimethoate, lindane and fenitrothion against the major pests of the cowpea crop. They found that DDT 25 per cent emulsifiable concentrate applied at 1 lb active material in 30-100 gallons of water per acre, commencing at the immediate flowering stage, was satisfactory from the standpoint of economy, insect control, availability and hazards to personnel applying the chemical. They showed that 4-5 spray applications were optimum.

Mehta and Nyiira (1973) continued their investigations into the chemical control of cowpea pests and recommended five chemicals, namely, carbaryl, malathion, fenitrothion, dimethoate and lindane. It was recommended that weekly applications of fenitrothion at 1.12 lb active ingredient in 45-50 gallons of water per acre starting at the immediate pre-flowering stage, improved green pod yield and quality. It mainly suppressed the amount of green-pod damage caused by Maruca and considerably reduced the number of damaged seeds by over 60 per cent. It was further recommended that lindane and carbaryl, applied weekly from the immediate pre-flowering period, would perform fairly satisfactorily, improving the green-pod yield and reducing the number of seeds damaged by Maruca by 30-35 per cent.

The pollution potential and other side effects of the commonly used chemicals against cowpea insect pests, such as DDT, lindane, dieldrin, diazinon and fenitrothion, prompted entomologists to shift emphasis to investigations into the utilization of integrated pest-management strategies (Taylor, 1969b; IITA 1973 Annual Report). Ayoade (1969 and 1974) demonstrated that three applications at 5 days interval at the onset of cowpea flowering was enough for effective pod-borer control. Similar findings were reported at IITA by Singh (1975a and 1975b). Taylor (1968a) showed that eight applications of gamma BHC at 5 days interval commencing at the immediate cowpea pre-flowering stage gave effective control of the major pests. Taylor (1970) later commended that the real answer and the strategy for pest control on grain legumes in future should be based on a fundamental understanding of the crop/pest complex relationship.

A number of workers have reported on the natural enemies of cowpea pests with a view of rendering them more effective as a means of regulating pest numbers. Booker (1965b) listed parasites of Maruca testulalis, Melanagromyza vignalis Spencer, Callosobruchus maculatus Fab. and Piezotrachelus varius Wagner collected from cowpea fields. He further recorded species of Syrphidae (Diptera) and Coccinellidae (Coleoptera) as predators of Aphis craccivora Koch. Materu (1971) studying the bionomics of Acanthomia spp., found two parasites of these pests, namely Hadronotus gridus Nixon (Hymenoptera, Scelionidae) parasitizing eggs of A. tomentosicollis, and Mornomyia argentifrons Walker (Diptera, Tachnidae, Phasiini) parasitizing adults of A. horrida. Aina (1972) reported Rhinocoris bicolor F. (Reduviidae, Heteroptera) as attacking adults of A. horrida in the field. Ochieng (1977) identified two natural enemies of O. mutabilis, namely, Monomorium sp. (Hymenoptera, Formicidae), a predator of the eggs, and Rhinocoris bicolor, a predator of the adult beetle. He also listed several enemies of Anoplocnemis curvipes which included Gryon charon Nixon (Hymenoptera, Scelionidae), Protelenomus anoplocnemidis (Ghesquiere) (Hymenoptera, Scelionidae), and Ooenycyrtus sp. nr. telenomicida

Vassillor (Hymenoptera, Encyrtidae) which were found parasitizing the eggs.

Very little intensive research has been conducted in Kenya to improve grain legume seed quality and yielding capacity through a thorough understanding of the biology and ecology of their insect pest complexes. Published research work in the realm of pest management of cowpea in Kenya is practically non-existent. To develop and utilize effective pest management procedures, information is needed on crop yield reduction relative to pest density (Hillhouse and Pitre, 1974). Therefore a study of insect species associated with cowpea in Kenya would be a useful initial step in providing a firm basis for establishing crop pest protection programmes.

1.20 GENERAL MATERIALS AND METHODS

Before starting the actual experiments it was necessary to arrange for and secure enough land, and to obtain the required cowpea seed varieties for the experiments. This section describes the locality, materials and methodologies common to all experiments for insect collection and for evaluating their damage to cowpeas by yield assessment. The methods dealing with specific experiments will be described in the appropriate chapters.

Location:

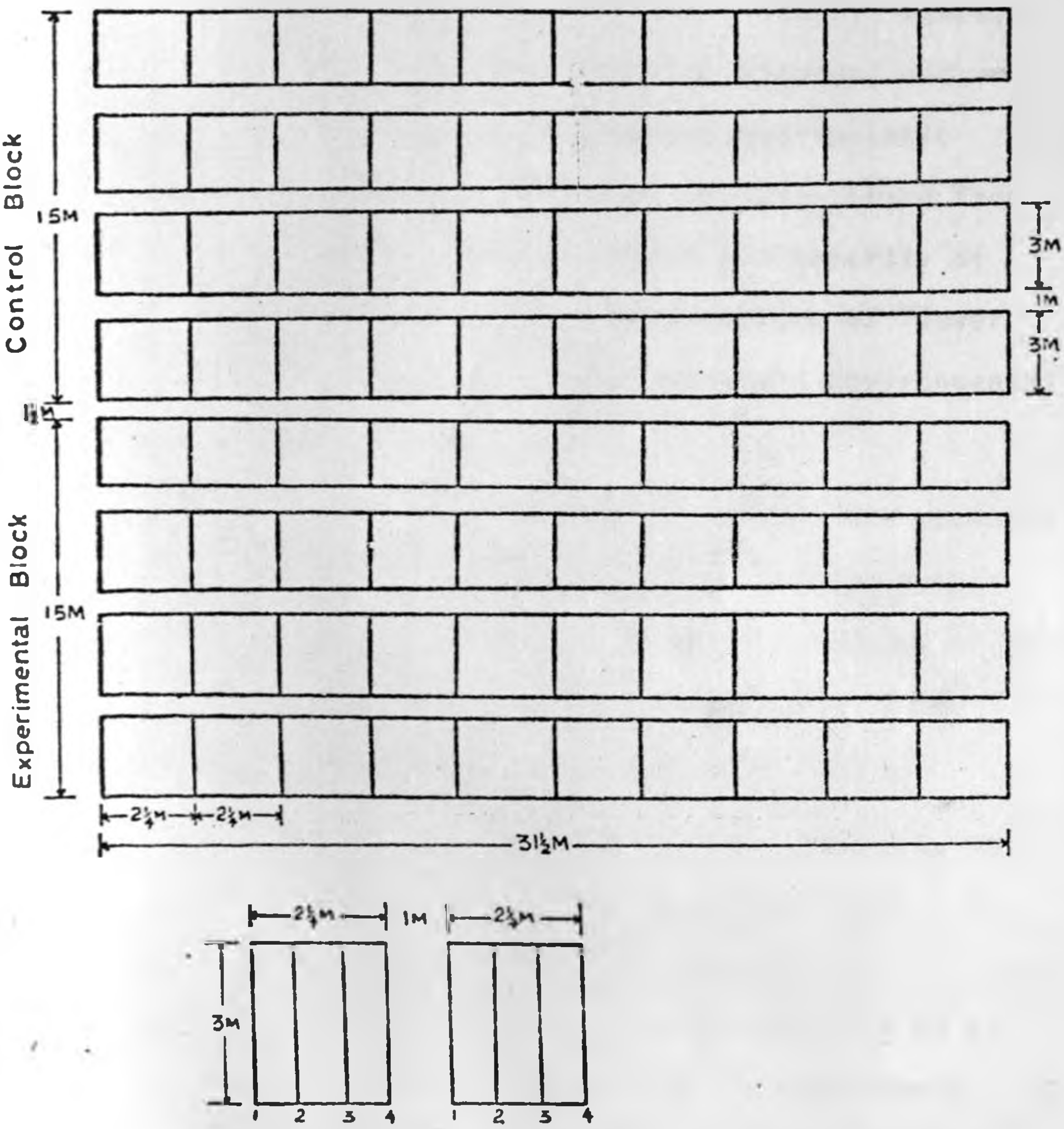
These experiments were conducted at Katumani Dryland Agricultural Research Station of the Ministry of Agriculture, located in the semi-arid area of Eastern Province of Kenya. In recent years, research in agricultural productivity of the semi-arid areas in Kenya has been intensified. The cowpea crop, with its capacity for low water demand, is among the many crops under test at the Katumani Dryland Agricultural Research Station with a view to increasing its production. Therefore this area was the most suitable for the experiments. The station is situated 10 km south of Machakos town, Machakos District; centre coordinates $1^{o}35'S$ and $37^{o}14'E$. It is 1575 m above sea-level and has an average annual rainfall of 718 mm over a period of 14 years. The long rains often occur between March and June, while the short rains are sporadic and unpredictable but may fall between October and December. Dorminant soils are well drained, deep, dark reddish brown friable sandy clay (Kenya soil survey, 1977). The soil reaction is slightly acid but increases to moderately alkaline. Common crops in the District and at the research station include maize, beans, pigeon peas, sorghum, millet and cowpeas. Cowpea is commonly intercropped with maize or sorghum.

Materials:

The experimental cowpea seeds were obtained from the Faculty of Agriculture of the University of Nairobi which had built up a large stock of both exotic and local varieties. Seven of the ten varieties used in these experiments were exotic initially obtained from the International Institute for Tropical Agriculture (IITA). These were VITA 3, VITA 4, VITA 5, ER 1-1, ER 1-2, ER 5 and ER 7. The local varieties were KATUMANI 1 (KAT 1), KAT 2 and KAKAMEGA 1 (KAK 1). Basically each experiment consisted of four replicated plots (Blocks) of 31½ m by 15 m each. Each plot was divided into ten subplots (Figure 1). Each subplot was randomly planted with any of the selected ten varieties of cowpea in four rows with 16 plants per row. Two seeds were planted per hole and then thinned to one plant after emergence. The spacing between rows was 75 cm and between plants 20 cm. The outer rows of each subplots acted as guard-rows and a space of 1 m was kept between the sub-plots. The subplots were clearly pegged and labelled. A spacing of 1 m was kept between the plots (replicates). Triple superphosphate fertilizer at the rate of 60 kg per hectare was applied to the soil at planting time.

The experiments were conducted during two rainy seasons, namely, the short rainy season of 1978 and the long rainy season of 1979. In 1978, planting was carried out at the onset of the rains on 6th November. It was necessary to gap-plant these plots following a severe cutworm attack on the young plants of the first planting. Gapping was carried out on 4th December. In 1979, the long rainy season delayed and planting was done on 18th April when it started raining.

Figure 1 Field Layout of Experimental plots and subplots



Sub-plot 1 Sub-plot 2

Evaluation of Damage to cowpea plants by various insect pests:

The main types of damage was easily recognised in the field or by dissecting flowers and pods in the laboratory. An attempt was made to obtain quantitative estimates of major pest damage on cowpea stems, leaves, flowers and pods in the field and after harvest, and to indicate the magnitude of the losses attributable to this and other causes. This type of data varied from season to season because the incidence and severity of insect attack was not constant. Other causes of flower and pod losses occurred due to also variable environmental factors.

It was difficult to establish or assess the economic importance of the different leaf-feeding species either because of the sporadic nature of attack or because of the ability of the plants to withstand considerable leaf-damage without showing any depression in seed yield.

Leaf-eating beetles and leaf-feeding lepidopteran larvae varied tremendously in importance from season to season and were therefore generally regarded as occasional (minor) pests; they were considered to be of minor importance. However, damage due to these pests was evaluated by counting the number of plants damaged by each of the insects.

With the commencement of flowering during the eighth week, evaluation of damage by flower-feeding insect species was carried out by taking a random sample of 10 flowers from guard rows from each subplot once a week. Systematic sampling was achieved as follows: leaving the extreme outer plants, one at each end, every third plant in the two guard rows of each subplot was tagged. This made a total of five plants in each guard row. Sampling was taken from these tagged plants by picking any two flowers or pods. The flowers were washed twice in 50 per cent alcohol before and after dissection of flowers to ensure maximum insect recovery. Counts of all the insects present were made under a binocular microscope. They were mainly thrips and lepidopterous larvae which were later identified. Observation on flower damage was terminated when the first pods began to dry out. Although some flowering continued until and after harvesting, these were ignored since earlier observations by Taylor (1965b) had shown that these late flowers in general fail to produce pods.

Weekly records of damage to pods were made from the eleventh week, a final record of pod damage being taken at harvest when all pods on the plants, including the shrivelled ones, were harvested. Only conspicuous external damage to pods for example, due to bollworms, could be recorded in the field, but damage to seeds by sucking bugs was estimated after harvest when pods were dissected and seeds counted and weighed. The total yield of dry undamaged seeds per subplot was also taken. All the results were analysed statistically for variability and significance between the different treatments and plots.

Insect Collection Methods:

As revealed by the literature review, many insect pests occur in cowpea fields some of them on plant surfaces and others within plant tissues and in soil. Therefore to be able to provide a comprehensive species list of the common insect pests of field cowpea crop, several methods had to be used to obtain the insects. Less agile lepidopterous larvae, aphids and beetles were hand-picked. Cutworms were recovered by removing soil with a hand shovel around the freshly severed seedling stems and searching. Flowers, stems, pods and seeds were taken to the laboratory and dissected to recover insects living in their tissues. For more agile insect pests such as bugs, leafhoppers, grasshoppers and adult moths and butterflies, a sweep-net was used. A standard 38 cm wide sweep-net was used to collect insect foliage feeders on cowpea as well as their predators. Sampling using a sweep-net was started two weeks after planting and continued through harvest time. Samples were taken once every week between 10.00 a.m. and 4.00 p.m. Sweeps were made across every alternative row in every sub-plot (modified sweep-net method of Hillhouse and Pitre, 1974). One hundred sweeps were taken in each plot.

Some common insect species were easily identified in the field using text books by Bohlen (1973) and Hill (1975). Other insects were identified by comparison with identified insect material at the National Museum, Nairobi, and material kept at Zoology Department, Nairobi Unviersity

Chiromo, and at the National Agricultural Laboratories of the Ministry of Agriculture, Kabete. A few insects whose identity was difficult to determine by using these records were sent to the Commonwealth Institute of Entomology, London, where they were identified. Identified species were labelled and preserved for future use in identifying other specimens.

Initial identification of some immature stages, especially larvae, proved difficult; therefore it was necessary to rear them to adults. During each sampling visit such larval forms were collected and brought back to the laboratory for rearing. In the laboratory, the various larvae were fed on cowpea leaves. Each larva and a fresh shoot of cowpea plant were placed in a clean glass jar whose top was covered by a cloth net. They were left in the laboratory under room temperature. The food was changed every 24 hours and the pupae were left in the jar to develop into adults which were then identified.

To evaluate cowpea yield under different chemical spray regimes, and to determine minimum use of chemicals for control of the dominant cowpea crop insect pests, Gammalin 20 per cent emulsifiable concentrate insecticide was used at the rate of 1000 gm a.i. per 600 litres of water per ha per application. Gammalin is the trade name of lindane or gamma BHC. This insecticide was selected because of its popularity with the farmers for its effectiveness against many sucking and biting insects such as bugs, thrips, leafhoppers, beetles and their larvae.

grasshoppers and cutworms. Cooper begler CP_3 knapsack sprayer was used to apply the insecticide.

Cowpea seed yield assessments for these experiments was carried out by picking all pods from plants in the two central rows in each subplot. After hand-shelling, all the seeds were weighed to calculate seed yield in kg/ha.

CHAPTER 2

INSECT PESTS OF FIELD COWPEA CROP IN KENYA

2.0 INTRODUCTION

Results of a survey of insect pests of field cowpea crop conducted at Katumani Dryland Agricultural Research Station are presented in this section. The principal objective of this survey was to classify the pests found in cowpea fields. The insects were classified into taxa, pest status, plant region attacked and seasonal abudance. A secondary objective was to give detailed taxonomic descriptions of the common and most serious pests to assist in their accurate identification and hence facilitate future studies of the behaviour and bionomics of individual species.

2.10 MATERIALS AND METHODS

The suvey was conducted on early-planted fields in both the short 1978/1979 (October-January) and the long 1979 (April-June) rainy seasons. The fields were half ha plots each planted to the Katumani (KAT 1) cowpea variety and were untreated with respect to insecticides in each season. The fields were regularly weeded and therefore considered clean with respect to weeds at each collection date. The field location during the short rainy season was bordered by pigeon pea fields and rolling hills on three sides and a river on the remaining side. Whereas the field location during the long rainy season was surrounded by maize fields on two sides, insecticide treated cowpea field on the third and untreated plot of pigeon peas on the fourth side.

Sampling of the cowpea fields commenced two weeks after planting and thereafter once weekly in both the seasons through harvest. To ensure a comprehensive collection of pests including species inhabiting inside plant tissues, two sampling techniques were adopted. Hand-picking was applied to stem-, pod-, and flower-borers and for the less agile crickets, ground beetles, aphids, and leaf- and stem-feeding caterpillars. A sample of ten stems, flower-buds, flowers and pods each were picked at random and dissected to recover the insects inside them. This provided the number of insect pests species that were stem, flower or pod-feeders and their frequency in each plant part attacked (see also general methods above).

A second method was a 100 sweep-net sample size using a standard 38 cm diameter sweep-net. Most samples were collected between 10 a.m. and 4.00 p.m. This method mainly collected flying grasshoppers, leaf-hoppers, adult bugs, moths, butterflies and foliage feeding beetles. These samples provided information on the relative abundance of species collected during the short and the long rainy seasons during 1978 and 1979 respectively. It also provided information on the seasonal abundance of selected species in the same periods of study.

Plant material and insects collected were transported in plastic bags to the laboratory where specimens were prepared for identification and counting. Identification was restricted to species actually observed in the field damaging the cowpea plant and excluded predators and pollinators. Adults, larval Lepidoptera and nymphal Orthoptera and Heteroptera were easily identified using available keys and by comparing with specimens at the National Museum, Nairobi. Difficult immature stages, especially the Diptera, were allowed to develop to adulthood in the laboratory as described earlier in general materials and methods to facilitate accurate identification.

Classification into 'major' and 'minor' pests was based on observations on the incidence, abundance and the degree of importance of the damage caused by these pests in the field. Major pests paused problem to the growing of cowpeas, e.g. cutworms, seriously affected the amount of yield, and seek-sucking bugs affected the quality. Minor pests were those insects which certainly harmed the cowpea plants, but their damage was not serious as it neither interfered with plant growth nor amount and quality of yield.

2.20 RESULTS

2.21 List of Field cowpea Insect Pests, Plant Part Attacked and their Pest Status at Katumani Dryland Agricultural Research Station.

A total of 43 insect pest species were found and identified from all collections made in cowpea fields at the Katumani Dryland Agricultural Research Station during the short and long rainy seasons in 1978 and 1979 respectively. Table 1 shows that taxonomically, these species were classifiable into seven orders, namely: Diptera (1), Coleoptera (10), Heteroptera (15). Homoptera (3) Lepidoptera (8), Orthoptera (4) and Tysanoptera (2). The greatest number of species were collected using the sweep-net and a few were hand-picked.

The species which were collected had been observed feeding on different parts of cowpea in the field (Table 1). The beanfly Ophiomyia phaseoli was found feeding in and damaging cowpea stems. Only two stems in the entire field were found damaged by this fly and therefore its status was that of minor pest.

Most of the beetles collected from the cowpea field were observed feeding on foliage with the exception of Callosobruchus maculatus which fed on dried seeds and the flower beetles Coryna kersteni and Mylabris amplectens which were found feeding on flowers. Callosobruchus maculatus was a major pest though its damage in the field was negligible. However it is known to be a major pest in storage. The two flower feeders did not cause any noticeable damage to flowers. Of the beetle foliage feeders, Lagria villosa topped the list in numbers. It mainly fed on leaves and high populations could result into serious damage especially at the seedling stage.

Table 1. A list of Field Cowpea Insect Pests, Plant Part Attacked and their Pest Status at Katumani Dryland Agricultural Research Station.

Order and Family	Scientific name	Common name	Plant part attacked	Pest status
DIPTERA				
Agromyzidae	Ophiomyia phaseoli Tryon.	Bean fly	Foliage	Minor
COLEOPTERA				
Bruchidae	Callosobruchus maculatus Fab.	Cowpea seed beetle	Seed	Major
Coccinaliidae	Epilachna carina F.	Epilachna Ladybird	Foliage	Minor
Curculionidae	Alcidodes leucogrammus Erichs.	Stripped bean weevil	"	"
	Nematocerus sp.	Shiny cereal weevil	"	"
	Systates pollinosus Gerst.	Sytates weevil	"	"

Table 1 Continued..

Order and Family	Scientific name
COLEOPTERA	
Galerucidae	*Luperodes quaternus* Fairm.
Lagriidae	*Lagria villosa* Fab.
Meloidae	*Coryna kersteni* Gerst.
	Mylabris amplectens Gerst.
Tenebrionidae	*Gonocephalum simplex* Fab.
HETEROPTERA	
Coreidae	*Acanthomia horrida* (Germar)
	Acanthomia tomentosicollis Stal.

Common name	Plant part attacked	pest status
-	Foliage	Minor
-	"	Major
Pollen beetle	Flowers	Minor
" "	"	"
Dusty brown beetle	Foliage	"
Spiny brown coreid bug	Pods	Major
"	"	Minor

Table 1 Continued..

Order and Family	Scientific name	Common name	Plant part attacked	Pest status
HETEROPTERA				
Coreidae	Anoplocnemis curvipes F.	Giant Coreid bug	Pods	Major
	Cletus fuscescens Wlk.	Coreid bug	Green pods	Minor
	Leptoglossus membranaceus Fab.	Leaf-footed coreid bug	" "	"
Alydidae	Riptortus dentipes F.	Alydid bug	Pods	"
Lygaeidae	Lygaeus pandurus Scop.	-	Foliage	"
Miridae	Lygus apicalis Fieb.	-	"	"
Pentatomidae	Acrosternum acutum Dallas.	Green shield bug	Pods	"
	Agonoscelis pubescens Thumb.	Cluster bug	"	"
	Aspavia albidomaculata Stal.	-	"	"
	Nezara viridula L.	Green stink bug	"	Major

Table 1 Continued..

Order and Family.	Scientific name
HETEROPTERA	
Pentatomidae	Piezodorus pallescens Germar.
Pyrrhocoridae	Dysdercus cardinalis Gerst.
	Dysdercus fasciatus Sign.
Aphididae	Aphis craccivora Koch
Cicadelliae	Empoasca dolichi Paoli
	Empoasca fabae (Harris)

Common name	Plant part attacked	Pest status
-	Pods	Minor
Cotton stainer bug	Foliage, Pods	"
Barred cotton stainer bug	"	"
Cowpea or groundnut aphid	Foliage, Flowers, Green pods	Major
Leafhopper	Leaves	Minor
Potato leafhopper	Leaves	"

Table 1 Continued..

Order and Family	Scientific name
LEPIDOPTERA	
Arctiidae	Spilosoma investigatorum (Karsch.)
Noctuidae	Agrotis ipsilon Hfn.
	Agrotis segetum D & S
	Heliothis armigera Hb.
	Plusia orichalcea Fab.
	Spodeptera exigna Hb.
Pyralidae	Maruca testulalis Geyer
Tortricidae	Laspeyresia ptychora Meyr

Common name	Plant part attacked	Pest status
Stinging caterpillar	Foliage	Minor
Dark sword grass cutworms	"	"
Cutworms	"	Major
African bollworm	Flowers, pods, seeds	"
-	Foliage, Flowers	Minor
Lesser Armyworm	Foliage	"
Legume pod-borer	Flowers, pods, seeds	Major
-	Pods, seeds	Minor

Table 1 Continued...

Order and Family	Scientific name
ORTHOPTERA	
Acrididae	Acrotylus patruelis H.S.
	Zonocarus elagans Thumb.
Gryllidae	Gryllotalpa africana P. de D.
	Gryllus bimaculutus de Geer
THYSANOPTERA	
Thripidae	Megalurothrips sjostedti (Trybom)
	Sericonthrips sp.

Common name	Plant part attacked	Pest status
Short-horned Grasshopper	Leaves	Minor
Elegant Grasshopper	"	"
African Mole Cricket	Stems & Leaves (Seedlings)	"
Two spotted Cricket	"	"
Flower thrips or Legume bud thrips	Flowers	Major
Thrips	"	Minor

Other beetle foliage feeders included Alcidodes leucogrammus which fed on cowpea stems, Epilachna carina, Gonocephalus simplex, Luperodes vaternus, Nematocarus sp. and Sytates pollinosus which were all minor pests.

With the exception of Lygaeus pondurus and Lygus apicalis which fed on leaves, all the other bugs namely, Acanthomia horrida, A. tomentosicollis, Acrosternum acutum, Agonoscelis pubescens, Anoplocnemis curvipes, Aspavia Albidomaculata, Cletus fuscescens, Dysdercus cardinalis, Dysdercus fasciatus, Leptoglossus membranaceus, Nezara viridula., Piezodorus pallescens and Riptortus dentipes, fed exclusively on green pods. In this group, only three bugs namely, Acanthomia horrida, Anoplocnemis curvipes and Nezara viridula qualified to be classified as major pests. The rest were minor pests since their damage to pods was hardly noticeable.

Aphis craccivora was collected mainly from leaves, stems, flowers and green pods on which it caused severe damage through its sucking of juice from these plant parts affecting the amount and quality of seed yield. It was therefore classified as a major pest.

The Lepidoptera species were more generalized in their feeding as shown in Table 1. Five of the species: the two Agrotis spp., Plusia orichalcea Spilosoma investigotorum, and Spodoptera exigna fed on foliage; while the pod borers Heliothis armigera and Maruca testulalis caused considerable damage to pods and seeds. Of the foliage feeders, cutworms Agrotis sp. were the most serious, and in the 1978 short rainy season were responsible for over 75% crop loss when they cut down most of the seedlings in the plots. The two pod borers were also serious pests. Although Laspeyresia ptychora was also observed feeding on pods, it did not cause much damage and therefore was considered a minor pest. The other Lepidoptera foliage feeders did not cause any noticeable damage and were therefore considered minor pests.

Four Orthoptera species, namely, Acrotylus patruelis, Gryllotalpa africana, Gryllus bimaculutus and Zonocarus elagans, were observed feeding on cowpea leaves at the seedling stage. The seedlings did not show any major injury afterwards due to this feeding activity and, accordingly these species were classified as minor pests.

The two thrip species, Megalurothrips sjostedti and Sericothrips sp. were collected from flowers where they were feeding. The dominant species in terms of numbers was Megalurothrips sjostedti whose feeding on stamens, pistils and petals caused flower shedding and probably premature loss of pollen thus earning it the status of major pest.

2.22 Brief Descriptions of the Common Field Cowpea Insect Pests at Katumani Dryland Agricultural Research Station

Fifteen species of the 43 insect species collected were commonest and major pests and, therefore are described here briefly to assist in their identity for future studies of their behaviour and bionomics.

1. Acanthomia horrida (Shiny Brown Coreid bug) Plate 1.

Adults are small, light brown sluggish bugs, about 10 mm long. Two conspicuous spines occur on the thorax. They fed on sap, principally from developing pods and seeds. Attacked pods shrivelled and dried prematurely. Seeds inside pods that had been sucked by bugs showed dimpling on seed coats and on drying became brown and shrivelled with wrinkled coats. This bug occured in large numbers in the field particularly in the short rainy season. Materu (1970) demonstrated that an average of 6.2 bugs per plant not only lowered seed germination but also reduced seed yield. A similar report by Hill (1975) mentioned infestation rate of two bugs per plant lowering seed weight by 40-60%.

2. Acanthomia tomentosicollis (Spiny brown bug)

Adults are small reddish-brown bugs, about 8 mm long. The two spines on the thorax are not as conspicuous as they are in A. horrida. These bugs also fed on sap from developing pods and seeds causing characteristic damage to pods and seeds. Only few species of this bug were present in a few samples. Thus, although this species was a minor pest in these studies, it is described here to facilitate identification from its close relative A. horrida

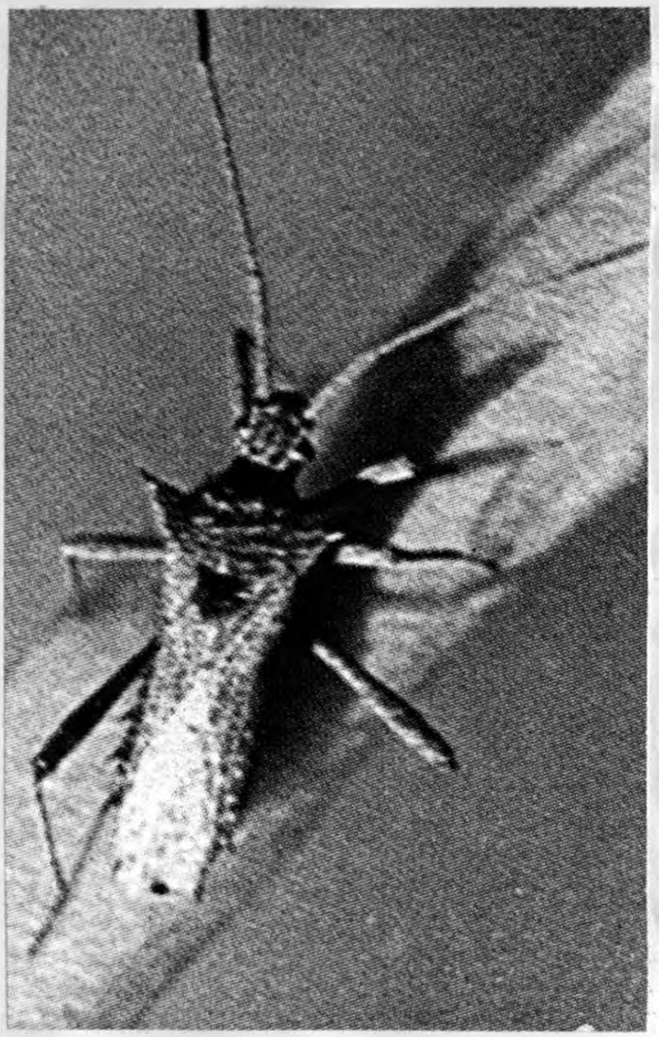


Plate 1

Adult Spiny Brown Coreid bug *Acanthomia horrida* showing characteristic pronounced thoracic spines

(Source : Bohlen (1973) , p. 33)

3. Agrotis ipsilon (Dark sword grass cutworms)

Adults are fairly large, dark-grey bodied with a wing-span of about 45 mm. The caterpillars are large, hairless, brownish-grey, about 30 mm long. These caterpillars, like Agrotis segetum, also fed on seedlings causing typical damage as described for the latter. The two species were found together in the same plot, but segetum was the predominant one.

4. Agrotis segetum (Cutworm) Plate 2a and 2b

Caterpillars of the genus Agrotis are called 'cutworms' because of their feeding habit to cut off seedlings near ground level. Mature caterpillars are large, hairless, grey to blackish in colour about 45 mm long. They have faint dark lines along the body sides. Adults are fairly large, nocturnal moths with a wing span of about 35 mm, grey body, grey forewings with dark brownish-black markings. The hind wings are almost white basally but with a dark terminal fringe.

Cutworms fed on seedlings by cutting the stems at ground level. The young larvae fed on leaves and later the mature larvae migrated to the ground where they hid in the soil near the seedlings and at night, they appeared on the soil surface and attacked the seedlings. Cutworms were found by searching in the ground within the vicinity of the cut seedlings. On the average to every two cut seedlings one cutworm was recovered.

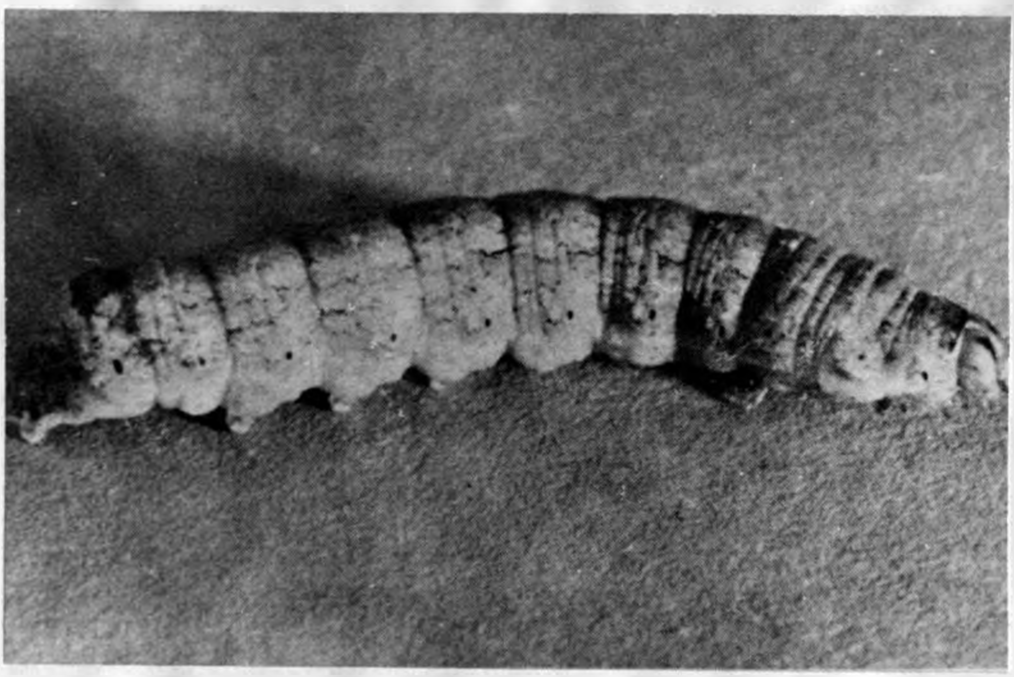
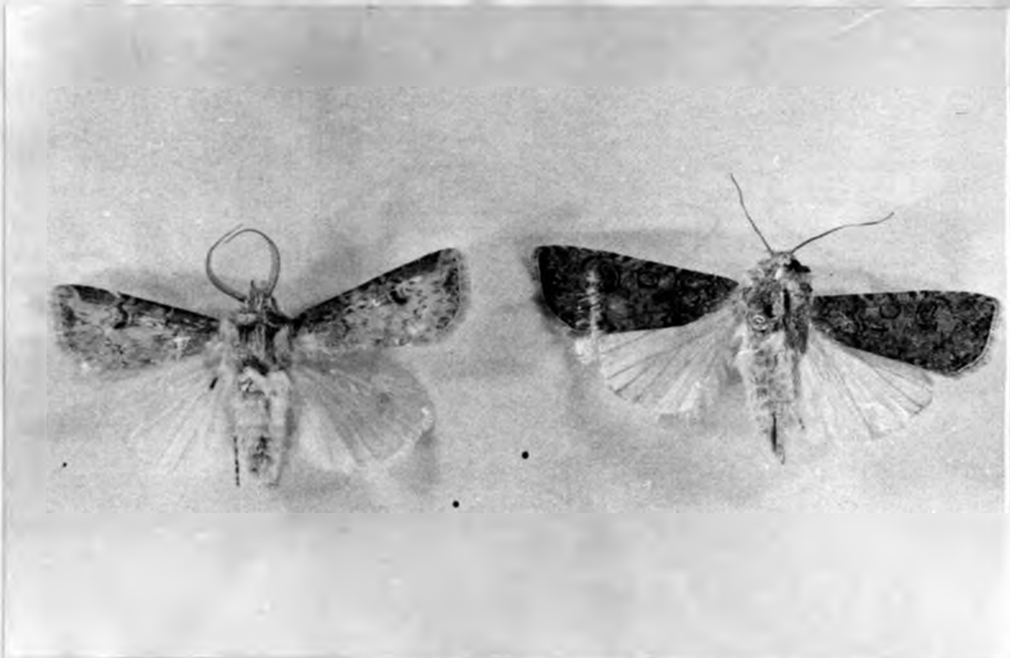


Plate 2a

Mature Larva of cutworm *Agrotis segetum*



MALE FEMALE

Plate 2b

Male and Female Adults of cutworm A. segetum

5. Alcidodes leucogrammus (Stripped bean weevil)

Adults are small reddish-brown to dark brown weevils about 8 mm long. Each forewing is marked by three white stripes. A fully grown grub (larva) is about 10 mm long, legless, c-shaped, and white in colour.

Both, larvae and adults caused damage to the plant. The grubs developed inside the stems causing cancerous swellings by their feeding activities. Severely attacked plants stopped growing, withered and died. The adults fed mainly on the leaves, causing roundish holes in the leaf blades. This stripped bean weevil, though reported as a minor pest during the present studies, has been reported by Booker (1965a) to cause stunted growth and reduction in yield when present in large numbers. About three stems were found attacked by the grubs.

6. Anoplocnemis curvipes (Giant Coreid bug) Plate 3

Adults are black fairly large bugs, about 30 mm long. They are strong fliers; when disturbed they usually flew to nearby trees or bushes. Male and female were easily distinguished by the shape of the hindlegs which in males are abnormally broad, strongly curved bearing a large spine on inner margin. Adult bugs fed on sap from green pods and developing seeds. The attacked pods shrivelled and dried prematurely. Majority of seeds from affected pods did not germinate. The bugs' numbers in the samples was generally low.

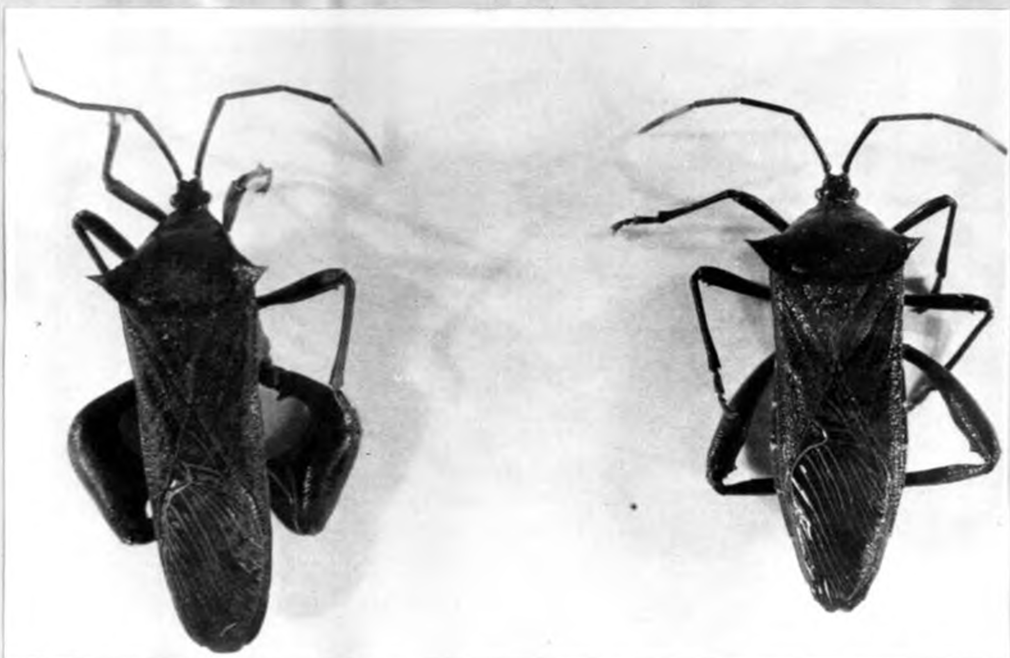


Plate 3

Male and Female Adults of Giant Coreid bug <u>Anoplocnemis curvipes</u>

7. <u>Aphis craccivora</u> (Groundnut or Cowpea aphid)
Figures 2a, 2b, 2c, Plates 4, 5a, 5b, 5c

Adults are small, wingless, shiny-black pear-shaped insects, about 2 mm long. Winged adult forms (Figure 2b) were only produced when there was over-crowding. This adult type enables the aphids to migrate and colonize fresh food plants (Borror and DeLong, 1970). They possess a pair of cornicles at the posterior end of the abdomen. Both adults and nymphs lived in colonies on different parts of the cowpea plant sucking the sap from young shoots (plate 4), flower buds and young pods (Plate 5b). When young plants were attacked they died; older plants were stunted in growth, displayed curled pods (plate 5c) and their fruit-set was reduced. This led to reduction in yield.

8. <u>Callosobruchus maculatus</u> (Cowpea seed beetle or Cowpea Bruchid) Figure 3a and 3b

Adults are small brownish beetles about 3 mm long. The head is produced anteriorly into a short broad snout. and the posterior part of the abdomen is not covered by the elytra and is distinctly spotted. Distinctive sexual dimorphism is shown in the antennae (Fig. 3b). The larva is scarabaei-form.

These insects cause serious damage in stored cowpea seeds when not protected with an insecticide, and is considered one of the most important cowpea pest during storage. The initial infestation occurs in the field and multiplies rapidly after harvest in storage. A number of

Figure 2a Wingless Adult of Groundnut aphid *Aphis craccivora*

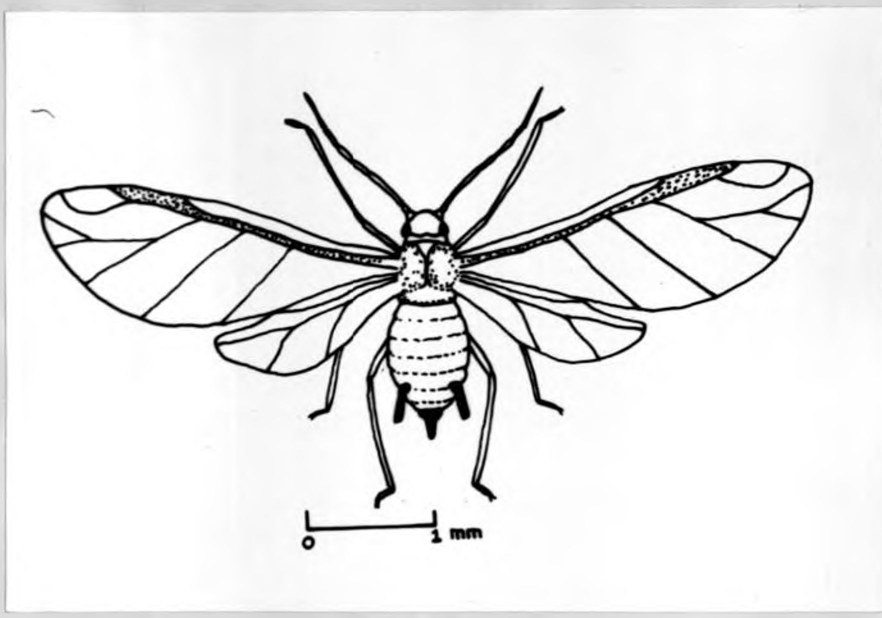


Figure 2b Winged Adult of Groundnut aphid Aphis craccivora

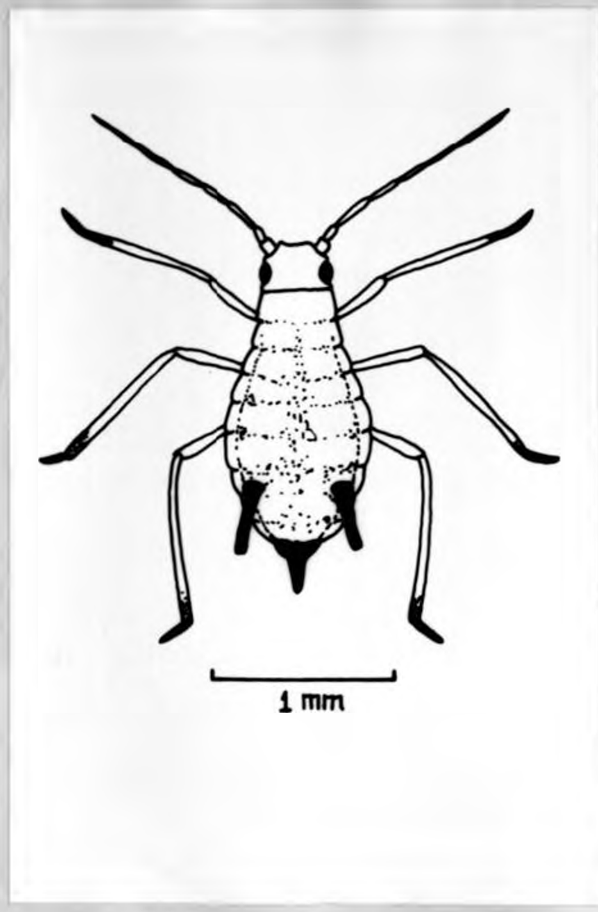


Figure 2c Showing drawing of Nymph Groundnut aphid
<u>Aphis</u> <u>craccivora</u>

Plate 4

Groundnut Aphid Aphis craccivora on cowpea young shoots in the field at Katumani

Plate 5a

Straight cowpea pods before attack by the Groundnut Aphid *Aphis craccivora* in the field at Katumani

Plate 5b

Cowpea pods at initial stage of attack by the Groundnut Aphid *Aphis craccivora*

Plate 5c

Second stage of attack of cowpea pods by Groundnut Aphid *Aphis craccivora*

Pods curve in severe attack

Figure 3a Drawing of Adult Callosobruchus maculatus

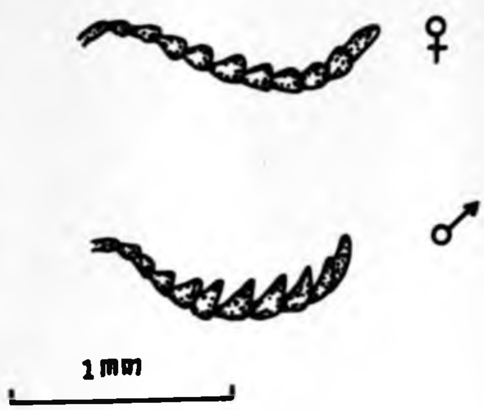


Figure 3b Antennae of Callosobruchus maculatus showing sexual dimorphism

adult bruchids were found in samples collected when pods had started drying. A month later, the stored seeds were found infested with large bruchid populations. The damage to cowpea seed is due entirely to larval feeding inside the seed. Studies indicate 100 per cent infestation by cowpea weevil after three to five months storage (Singh, 1978).

9. *Heliothis armigera* (African bollworm) Plate 6a & 6b

The adult moth is a brown, sometimes grey, nucturnal moth with a wingspan of about 38 mm. It has a prominent kidney shaped patch near the middle of the forewing. The larva is the pest. It is a stout caterpillar of viriable colour but often greenish or brownish. When fully grown it measures about 40 mm long and has characteristic longitudinal markings on each side of the body consisting of a pale white band, an almost black band followed by another light band.

Young caterpillars fed on cowpea flowers and small pods. Older caterpillars burrowed into large pods and fed on the developing seeds. Several young pods and developing seeds in the pods were consumed. The caterpillars often fed with their head inside the pod, but with the posterior part of the body outside, thus being easily visible. Main damage was caused when the caterpillars ate the seeds by penetrating the pods. They also bored into flower buds hollowing them out. The larvae

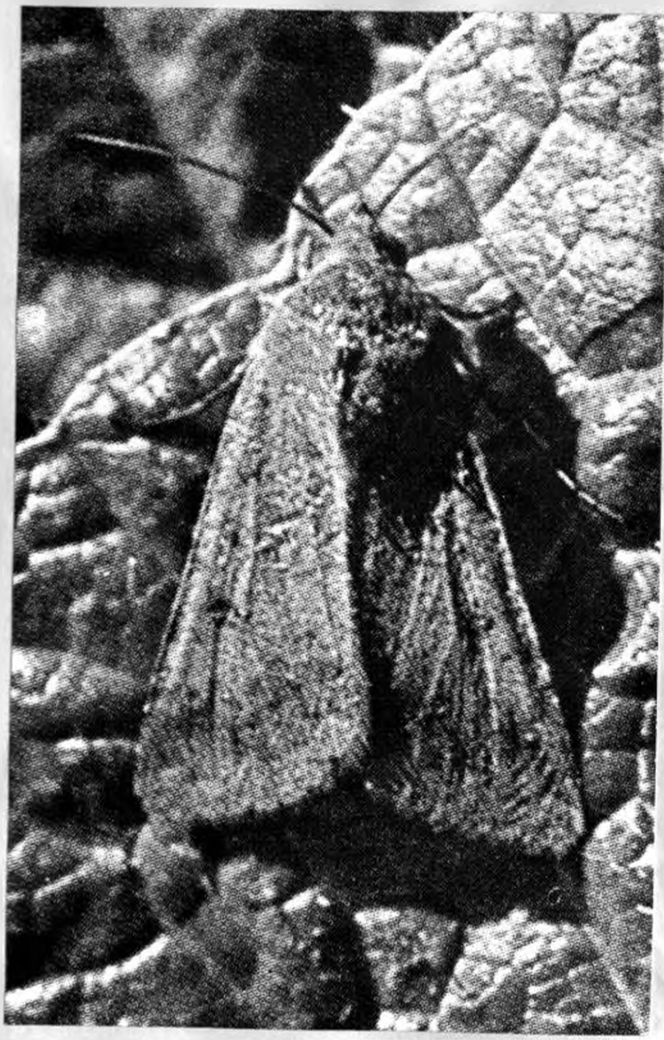


Plate 6a

Adult African bollworm *Heliothis armigera* at rest (Source: Bohlen (1973). p. 41).

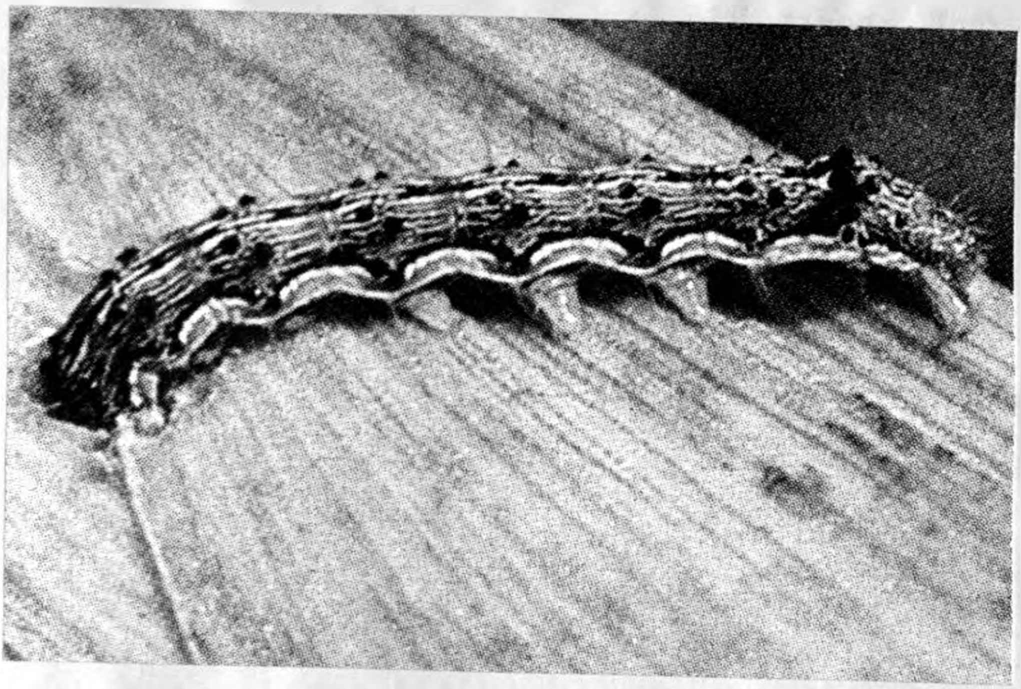


Plate 6b

Mature Larva of African bollworm Heliothis armigera

(Source; Bohelen (1973) p. 41)

moved from one pod to another thus multiplying their damaging activities. Infested flowers and young pods dropped prematurely. Up to 14.5 percent damage to pods was attributed to Heliothis armigera.

10. Lagria villosa - Plate 7

Adults are large beetles about 14 mm long, dark-brown or purplish in colour with a metalic tinge. They fed on leaves at all stages and caused characteristic holes in the leaves. The beetle was observed in the field soon after germination and remained on the crop through harvest. A considerable number of these beetles were present in each sample. Larger population numbers than those observed could form an outbreak which would cause serious damage unless control measures are taken.

11. Maruca testulalis (Legume pod borer) Plate 8a and 8b

The legume pod borer larva is yellowish-white, greenish-white or reddish-white. It has characteristic irregular brownish-black dorsal, lateral and ventral spots. The mature caterpillar is about 16 mm long. Young larvae develop in flower buds and flowers. Older larvae penetrate and enter pods where they live and feed. Pupation takes place in a silken cocoon in the soil. Adult moths are light-brown with whitish markings on forewings and have nocturnal habits. The wingspan is about 20 mm. At rest the moth has its wings folded so as to form a right angle with the surface on which it is resting. When disturbed

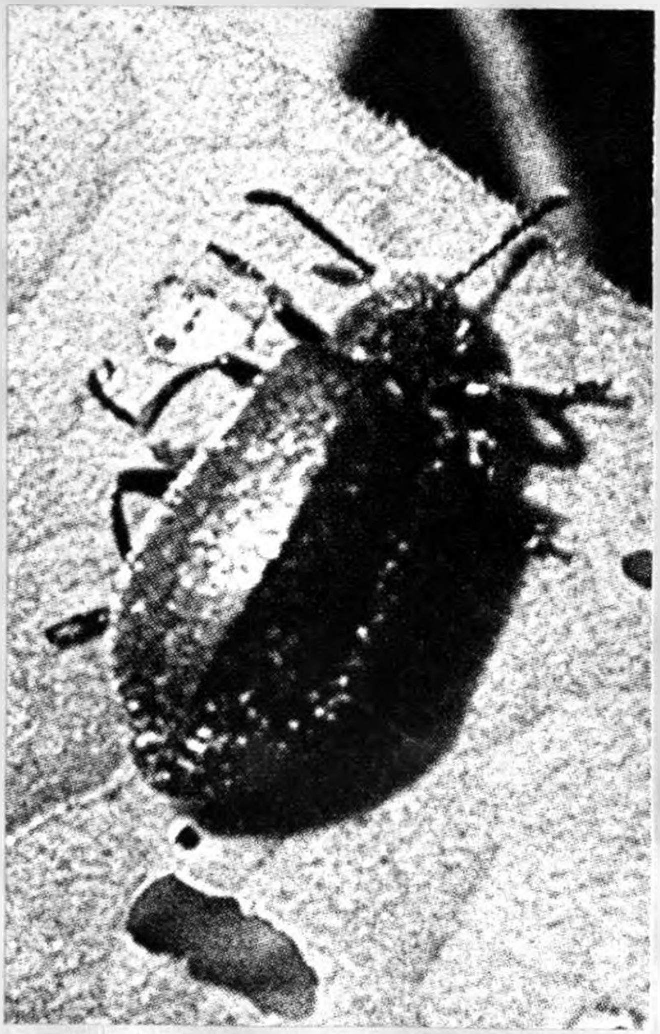


Plate 7

Adult beetle of Lagria villosa
(Source: Bohlen (1973), p. 43)

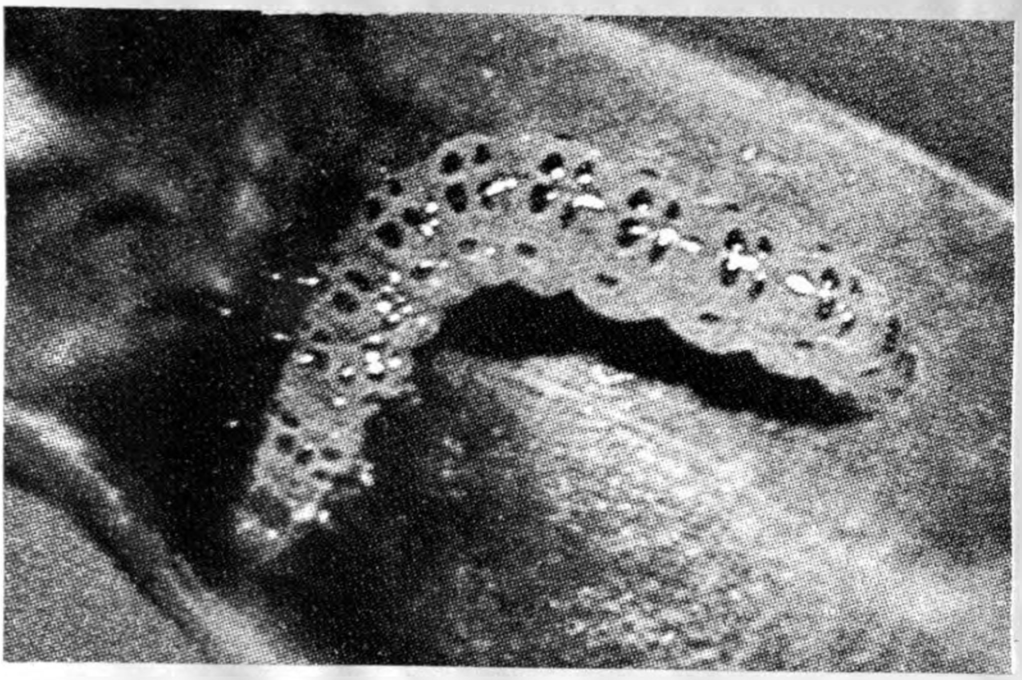


Plate 8a

Showing mature larva of Legume pod borer Maruca testulalis

(Source: Bohlen (1973(, p. 30)

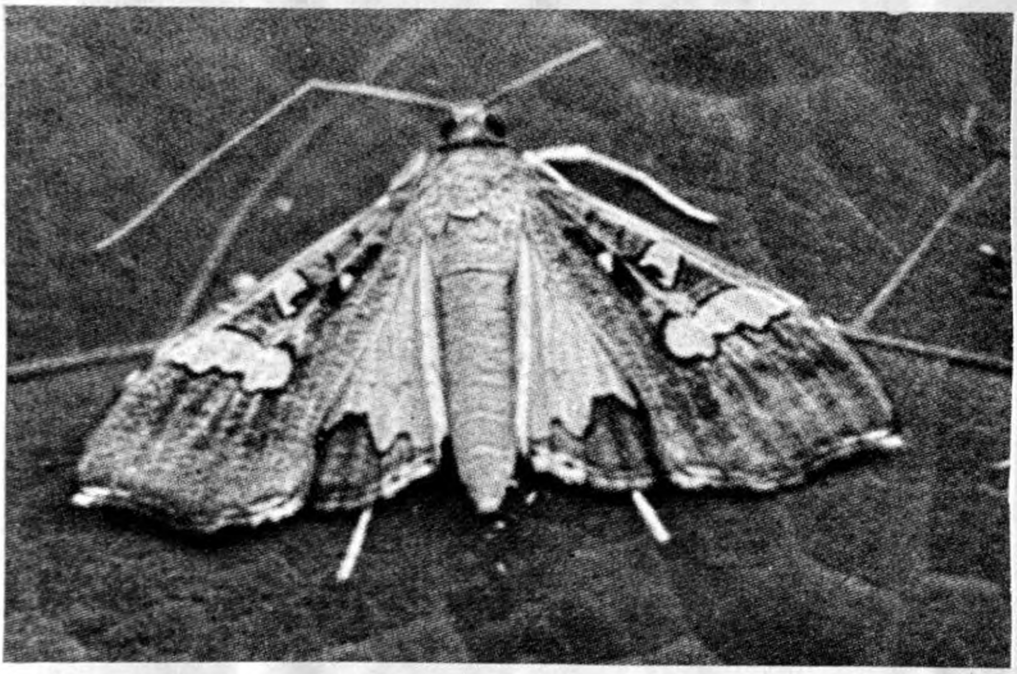


Plate 8b

Showing characteristic wing markings on Legume pod borer *Maruca testulalis*

(Source:ohlen (1973), p. 30)

Figure 4a Drawing of adult flower thrip Megalurothrips sjostedti

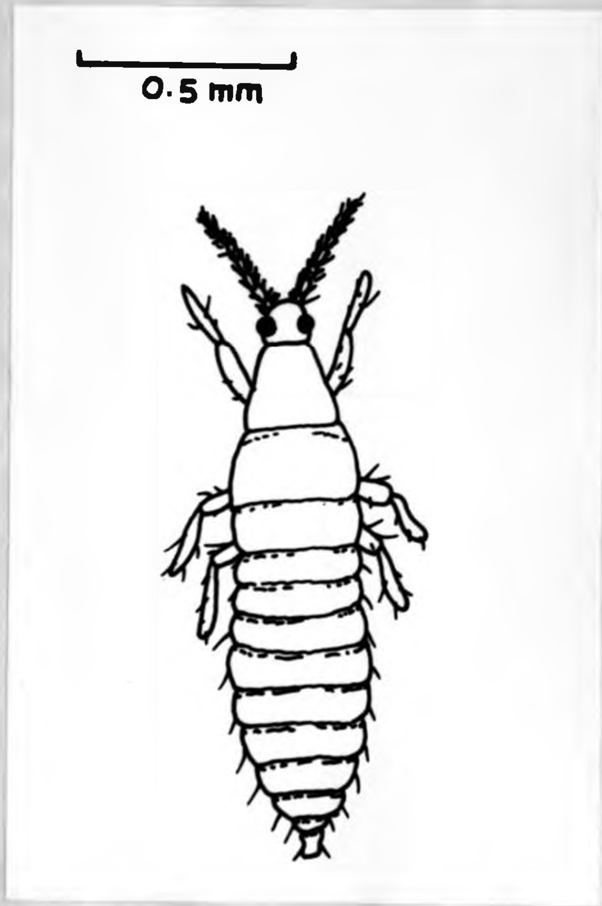


Figure 4b Drawing of Nymph of the Flower thrip
Megalurothrips sjostedti

they fly with characteristic up-and-down movements and quickly dive for shelter in the cowpea crop where they remain hiding for the rest of the day. Adult moths were hardly ever seen on the crop after 8 a.m. and sweeps with nets yielded very few of them.

Flower buds and pods are eaten by developing caterpillars causing serious damage to seed yields through flower abortion and direct feecing inside the pods. Yellow frass at the entry points to pods and flowers was characteristic of the presence of infestation by this pest. Occasionally leaves and pods were spun together and caterpillars fed within the web. Attacked pods were malformed as they could not grow straight because of the webbing. It was observed that whenever pods touched each other, this point of contact was invariably found to have been used by Maruca for infestation. Thus cowpea varieties with up-right straight pods were less attacked. Conversely, varieties with pods held together at a narrow angle on the peduncle suffered heavier infestation rates. Pod damage amounting to 17.0 percent was attributed to this pest in the present study.

12. Megalurothrips sjostedti (Flower thrips or Legume bud thrips. Figures 4a and 4b

Adults are minute shiny black slender-bodied insects about 1 mm long with two pairs of fringe wings. They were found easily in cowpea flowers where they fed by puncturing stamens, pistils and petals. An average of

3.2 and a maximum of 13 thrips per flower at the peak of flowering were recorded. No thrips were recovered from flower buds.

Thrips feeding injuries were characterised by the distortion, malformation and discoloration of floral parts. Studies indicate poor fruit formation by attacked flowers (Bohlen, 1973), and injuries to floral parts, particularly anthers and filaments, may lead to premature loss of pollen and decrease in both pollination and seed set (Taylor, 1965a). Singh (1977), stated that heavily infested plants did not produce any flowers and the damage to flower buds was more serious than that to open flowers, anthers and filaments. Akingbohungbe (1970) suggested that such damage to reproductive parts probably caused bud and flower shedding or abortion.

13. Nezara viridula (Green Stink bug) Plate 9 & 10

Adults are large green shield bugs, about 15 x 8 mm. They fed on sap principally from developing pods and seeds and also from the softer foliage parts of the cowpea plant. When undeveloped seeds were attacked, pods frequently aborted. Studies indicate an average of one stink bug per one third of metre row reduces yields by 10 percent (Singh and Taylor, 1978). A few stink bugs were present in each sample. Large numbers of stink bugs occurred in cowpea fields just before flowering when mating took place until plant maturity.

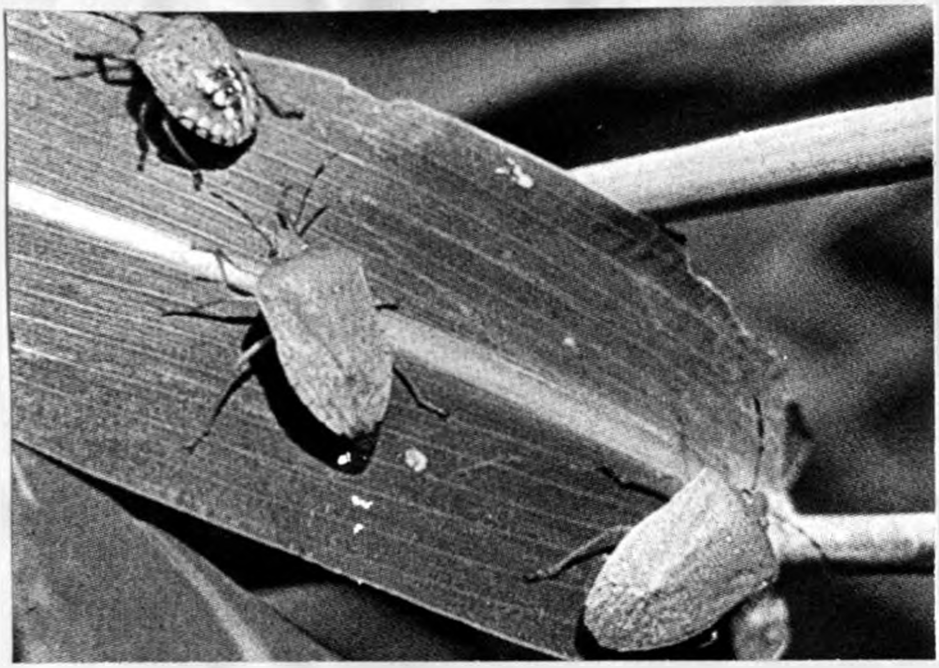


Plate 9

Nymph and Adult of Green stink bug *Nezara viridula*
(Source: Bohlen (1973), p.39)

Plate 10

Showing Green stink bug *Nezara viridula* mating on cowpea crop in the field at Katumani

14. Ophiomyia phaseoli (Beanfly)

Adults are tiny black flies about 2 mm long. The larvae (maggots) are the pests. They are white, about 3 mm long when fully-grown. They lived and fed by mining the inside of stems eventually settling at the base near the ground causing characteristic swellings. Their feeding activities caused swelling with numerous cracks in the stems. Attacked seedlings withered and died. Those that grew to maturity were easily blown down by wind. Pupation took place in the cracks of the swollen stem bases. Severe damage was more pronounced in seedlings. Older plants suffered less damage. The maggots mined through the leaf blades and petioles to the nodes before entering the stem to mine downward towards the ground. Infected nodes became necrotic and swollen, and then cracked causing withering. Seriously infested plants became stunted and at maturity produced poor seed yields in quantity and quality. Although very few seedlings and older plants were found infested in the present investigations, O. phaseoli is potentially a serious pest of cowpeas in Kenya since its attack on Phaseolus vulgaris (French beans) in the same area caused 100% loss (Khamala 1978).

15. Sericothrips sp. (Thrips)

Adults look like Megalurothrips sjostedti but they are much darker. Very few of these thrips were found in flowers living together with Megalurothrips sjostedti. An average of 0.1 thrips was found per flower. Since the number of these thrips was so small compared with that of Megalurothrips sjostedti, their damage was considered negligible.

2.23 Relative Abundance of Common Major Cowpea Insect Pest species during 1978 and 1979 short and long rainy seasons respectively.

There was a small positive correlation of relative abundance of species occurring in the short rainy season in 1978 with relative abundance of the same species in 1979 during the long rainy season ($P = 0.44$) (Table 2). Nine of the species, namely, Acanthomia horrida, Anoplocnemis curvipes, Aphis craccivora, Callosobruchus maculatus, Helio this armigera, Lagria villosa, Maruca testulalis, Megalurothrips sjostedti and Nezara viridula, occupied nearly the same positions in the two seasons. Only Agrotis segetum was far from being in perfect agreement in the two seasons.

Although populations did not seem to be of equal size in both seasons, the fluctuations did not greatly affect the relative abundance of most species with respect to others, with the exception of Agrotis segetum which was totally absent in the long rainy season of 1979 though it had ranked number 1 in the short rainy season of 1978. This suggests that there was stability in the occurrence of most species as they occurred at about the same relative frequency (Table 2).

Table 2 Relative Abundance of some of the common major cowpea Insect pests at Katumani Dryland Agricultural Research Station during the 1978 and 1979 short and long rainy seasons respectively

Species (arranged alphabetically)	Relative Abundance (Ranked*) 1978 (Short rainy season)	1979 (long rainy season)	Total
Acanthomia horrida	6	5	24
Agrotis segetum	1	10	153
Anoplocnemis curvipes	7	6	18
Aphis craccivora	2	1	157
Callosobruchus maculatus	10	9	4
Heliothis armigera	9	8	7
Lagria villosa	4	3	86
Maruca testulalis	8	7	12
Megalurothrips sjostedti	3	2	123
Nezara viridula	5	4	48

*Used Spearman's rank correlation P = 0.44

The species were ranked according to their total numbers as shown by samples in each season. Ranks 1 and 10 represent greatest and least (or absent) abundance respectively.

Aphis craccivora, Lagria villosa, Megalurothrips sjostedti and Nezara viridula occurred repeatedly in cowpea fields and, in some cases, at rather predictable levels with respect to one another. Conversely, there was a conspicuous scarcity of certain species such as adult Callosobruchus maculatus, Heliothis armigera and Maruca testulalis as revealed by the sampling methods. The numbers of Acanthomia horrida, Agrotis segetum, Anoplocnemis curvipes and Maruca testulalis collected in short rainy season contrasted sharply with the long rainy season collection. Whereas they were relatively common in the short rains samples, they were very rare in the long rains samples.

2.24 Seasonal Abundance of some of the Common major cowpea insect pest species at Katumani during short (1978) and long (1979) rainy seasons

The seasonal abundance of cowpea insect pest species during the short and long rainy seasons revealed by random sampling of stems, flowers and pods, and by sweep-net method are shown in tables 3A and 3B respectively. Aphis craccivora was picked in large numbers in December and January and in April and May in both the short and long rainy seasons respectively. The next most common species, Lagria villosa, occurred in abundance uniformly within the fields with only slight peaks indicated in December and March. The other common insects were Nezara viridula, Megalurothrips sjostedti and Acanthomia

Table 3A Seasonal Abundance of the common major cowpea insect pest species at Katumani during Short (1978) and Long (1979) rainy seasons as shown by random stem, flower and pod sampling

Year (Season)	Short Rains 1978)				Long Rains (1979)				
Species	November (Pre-flowering)	December	January (Post-flowering)	February	March (Pre-flowering)	April	May (Post-flowering)	June	July
Acanthomia horrida	0	0	1	0	0	0	1	0	0
Agrotis segetum	153	0	0	0	0	0	0	0	0
Anoplocnemis curvipes	0	0	0	1	0	0	0	0	1
Aphis craccivora	12	28	20	2	15	25	26	19	9
Callosobruchus maculatus	0	0	0	0	0	0	0	0	0
Heliothis armigera	0	0	1	3	0	0	0	0	0
Lagria villosa	10	16	6	5	11	7	8	4	1
Maruca testulalis	0	0	2	4	0	0	o	2	0
Megalurothrips sjostedti	0	0	41	17	0	0	49	12	1
Nezara viridula	0	4	9	7	0	1	1	5	2

Table 3B Seasonal Abundance of the common major cowpea insect pest species at Katumani during the Short (1978) and Long (1979) rainy seasons as shown by sweep-net sampling

Year (Season)	Short Rains (1978)				Long Rains (1979)				
Species	November (Pre-flowering)	December	January (Post-flowering)	February	March (Pre-flowering)	April	May (Post-flowering)	June	July
Acanthomia horrida	0	0	9	8	0	0	1	3	1
Agrotis segetum	0	0	0	0	0	0	0	0	0
Anoplocnemis curvipes	0	0	5	8	0	0	2	1	0
Aphis craccivora	0	0	1	0	0	0	0	0	0
Callosobruchus maculatus	0	0	0	3	0	0	0	1	0
Heliothis armigera	0	1	0	0	1	1	0	0	0
Lagria villosa	4	3	3	2	2	2	1	1	0
Maruca testulalis	0	1	1	1	0	0	0	1	0
Megalurothrips sjostedti	0	0	1	0	0	0	1	1	0
Nezara viridula	0	2	6	3	0	1	4	2	1

horrida, in that order, whose peaks were evident as shown in tables 3A and 3B. However, it also was most obvious that seasonal abundance of the species studied varied within a field location to the extent that a generalized configuration of abundance could not easily be made.

The plants growth phase divided into pre-flowering and post-flowering, influenced the abudance of the species studied. Clearly, from tables 3A and 3B, some species were only sampled during one of the phases, that is, either during pre-flowering or post-flowering phase. For example, Agrotis segetum was collected only in the pre-flowering phase in the short rainy season of 1978, while Acanthomia horrida, Anoplocnemis curvipes, Callosobruchus maculatus and Megalurothrips sjostedti were present in samples collected only during the post-flowering phase. Although Heliothis armigera, Maruca testulalis and Nezera viridula, were common to both pre- and post-flowering phases, all were more abundant in post-flowering than in pre-flowering samples. Lagria villosa was fairly evenly distributed in the two phases with a slight peak in pre-flowering phase. Aphis craccivora was also evenly sampled in both pre- and post-flowering phases.

Tables 3A and 3B clearly show that for the study of seasonal abundance of insect pests, sampling techniques must be carefully chosen based on a sound knowledge of the behaviour and ecology of the species to be sampled. Aphis craccivora which was sampled in large numbers in December, January, April, May and June by random hand-picking, was hardly present in the sweep-net samples. Similarly Acanthomia horrida and Anoplocnemis curvipes which had fairly considerable numbers in sweep-net samples of January, February, May and June were hardly present in the randomly hand-picked samples taken in the same month.

2.30 DISCUSSION

These investigations have demonstrated that field cowpea in Kenya is liable to attack by a large variety of insect pest species. When the studies began very little was known about insect pest complexes of cowpeas in Kenya. Without knowledge of pest complexes it would be impossible to construct effective pest management systems for cowpea insects. The 43 species identified in these investigations were very similar in composition to the cowpea insect complexes identified in other East African countries, particularly Tanzania by Kayumbo (1978) and Uganda by Mehta and Nyiira (1973).

More interesting still, the Kenya cowpea insect pest complex has similarity to those studies in West Africa, especially Nigeria by Taylor (1964a). The main difference between East and West African complexes is that the latter appears to contain more species than the former. Perhaps this difference in species numbers could be accounted for by the long research tradition on cowpea pests in West Africa than East Africa. The climatic diversity between the two regions could be another contributary factor. The hot humid tropical climate that characterize West Africa is likely to produce a higher species diversity than East Africa.

Some individual species occuring in different places tended to have different pest status. For example, while Laspeyresia ptychora was reported to be a serious major pest of cowpeas in Uganda and West Africa, in Kenya it occurred in very small sporadic numbers and its damage was hardly noticeable. This probably reflects the presence in Kenya of unknown unfavourable environmental factors which inhibit its outbreak. Conversely, some species like Maruca testulalis were equally destructive major pests in Kenya as reported in Tanzania, Uganda and Nigeria.

No new species to science were discovered. Therefore, it only sufficed in these investigations to briefly describe the most distinguished characterisitics of the species classified as major cowpea pests in the cowpea complex in order to facilitate identity for future research and for elucidating control measures aimed at target species.

The importance of data on relative abundance of species was to reveal rare and common pest species within the cowpea complex during the short and long rainy seasons. This knowledge could assist a farmer in knowing whether there are numerous enough individuals of a given pest species in his plot at a particular time or season to eat much or little of his crop. Ten of the identified and classified species as major pests in Kenya were common relative to each other (Table 2). Since sampling both during the short and long rainy seasons was conducted when the food for the pests in the form of the cowpea plant was in abundance, this probably explains why the fluctuation did not greatly affect the relative abundance of most species with respect to each other. Another factor that could have influenced the size of the relative abundance of species was the efficiency of the sampling methods used. The fact that this did not appear to have had any influence, confirms the consistency and reliability of the methods.

The influence of seasons on abundance of cowpea pests in Kenya is probably best elucidated in a statement by Andrewartha and Birch (1961) who stated that, ".... it is characteristic of populations whose numbers are determined largely by weather, that they should fluctuate more or less in step with the seasons". In keeping with this statement, the long rainy season would be expected to provide a long favourable period for insect reproduction and hence more abundant insect populations than the short rainy season. To the contrary, in the present investigations, the limited available data appeared to indicate that the short rainy season had a greater insect abundance in cowpea fields than the long rains. This may partly be explained by the fact that 1979 was rather an unusual year in that the long rainy season had less monthly rainfall compared to the preceeding short rainy season of 1978. Monthly mean rainfall reading from the meteorological station at Katumani in 1979 for March, April, May and June were 84.5, 147.9, 63.5 and 10.0 mm respectively as compared to 36.4, 164.0 and 88.1 mm. each for October, November and December in 1978. Clearly, except for the month of October, the preceeding 1978 short rainy season was favourable in terms of rainfall as a factor influencing insect life than the following long rainy season of 1979. However, other unknown environmental factors may have also contributed to the observed data, and therefore, further research covering several seasons is required for conclusive explanations of these differences to be drawn.

CHAPTER 3

DETERMINATION BY SEED YIELD ASSESSMENT OF THE MOST SUITABLE PERIOD TO APPLY INSECTICIDES ON SOLE CROP COWPEA FOR EFFECTIVE PROTECTION AGAINST INJURIOUS INSECT PESTS

3.0 INTRODUCTION

A common feature of cowpea production in Kenya is low yield (200 kg/ha) or sometimes total crop failure. Consequently, total output in the country is much lower than the demand, and cowpea production tends to be uneconomic. Although experiments have not yet been conducted to accurately assess the losses due to insect pests, it is most likely that this is one of the chief causes of low production.

Research elsewhere has shown that sole crop cowpea is very vulnerable to insect pests and losses in yield can be as high and even over 90% (Raheja, 1976a) unless it is protected by chemical spraying. However, some damage done by insects at certain cowpea plant growth stages may be below the economic injury level. This is because most cowpea varieties are capable of recovering fully even from moderate to heavy insect damage and give high seed yields.

Experiments conducted in Nigeria to assess the losses caused by insects to cowpea have shown that cowpea plants normally recover from heavy foliage damage to give high yields (Raheja, 1976a). Since chemicals are extremely expensive, it would be advantageous to farmers if they know the most critical time when to apply insecticides to effectively reduce insect injury and at the same time avoid suffering unnecessary losses through chemical inputs.

In Nigeria, the most suitable chemical spray regime for sole crop cowpea is spraying at weekly intervals from flowering period. This was as a result of the finding by Raheja (1976a) that any damage done by insects during the pre-flowering stage was below economic injury level.

The present investigations were initiated to determine whether under Kenyan conditions there would be a different spraying regime from that practiced in Nigeria. This report gives results of experiments conducted at Katumani Dryland Agricultural Research Station during the short and long rainy seasons of 1978 and 1979 respectively, to determine the most suitable or critical times during the growth stage of cowpea plants, to apply chemicals so as to give effective protection against insect damage. Ten different cowpea varieties were used to test whether such a timing would be specific to a given variety or whether it would be generally applicable to any cowpea variety.

3.10 MATERIALS AND METHODS

In addition to the materials and methods stated in the general methods (Chapter 1), this experiment consisted of three blocks, A, B and C, each with four replicates in a randomised block design (Figure 5). Each replicate was made up of ten subplots of 3 by 2½m each planted to any of the selected ten varieties of cowpea (Figure 1). The varieties were 3 local ones (KAT 1, KAT 2 and KAK 1) and 7 exotic varieties (VITA 3, VITA 4, VITA 5, ER 1-1, ER 1-2, ER 5 and ER 7).

The subplots were separated from each other by a gap of 1 m and the blocks by 1½ m. Weeding was done whenever it was necessary. Each of the three blocks received a different chemical spraying treatment as follows:

Block A: Applied insecticide before flowering (Treatment A).

Block B: Applied insecticide from flowering through pod formation (Treatment B).

Block C: Untreated.

Gammalin 20 percent was used as described in Chapter 1.

This experiment was conducted during the short rainy season of 1978 and the long rainy season of 1979. Table 4 gives the dates of planting, insecticide application and first harvest. Harvesting of the plots of the short rainy season extended over a period of two weeks because of the two plantings as already stated and also due to the variability in pod ripening among the varieties. The short rainy season crop received only

Figure 5 Field layout of Plots for the Determination by Seed Yield Assessment of the Most Suitable Period to Apply Insecticides on Sole Crop Cowpea for Effective Protection Against Injurious Insect Pests

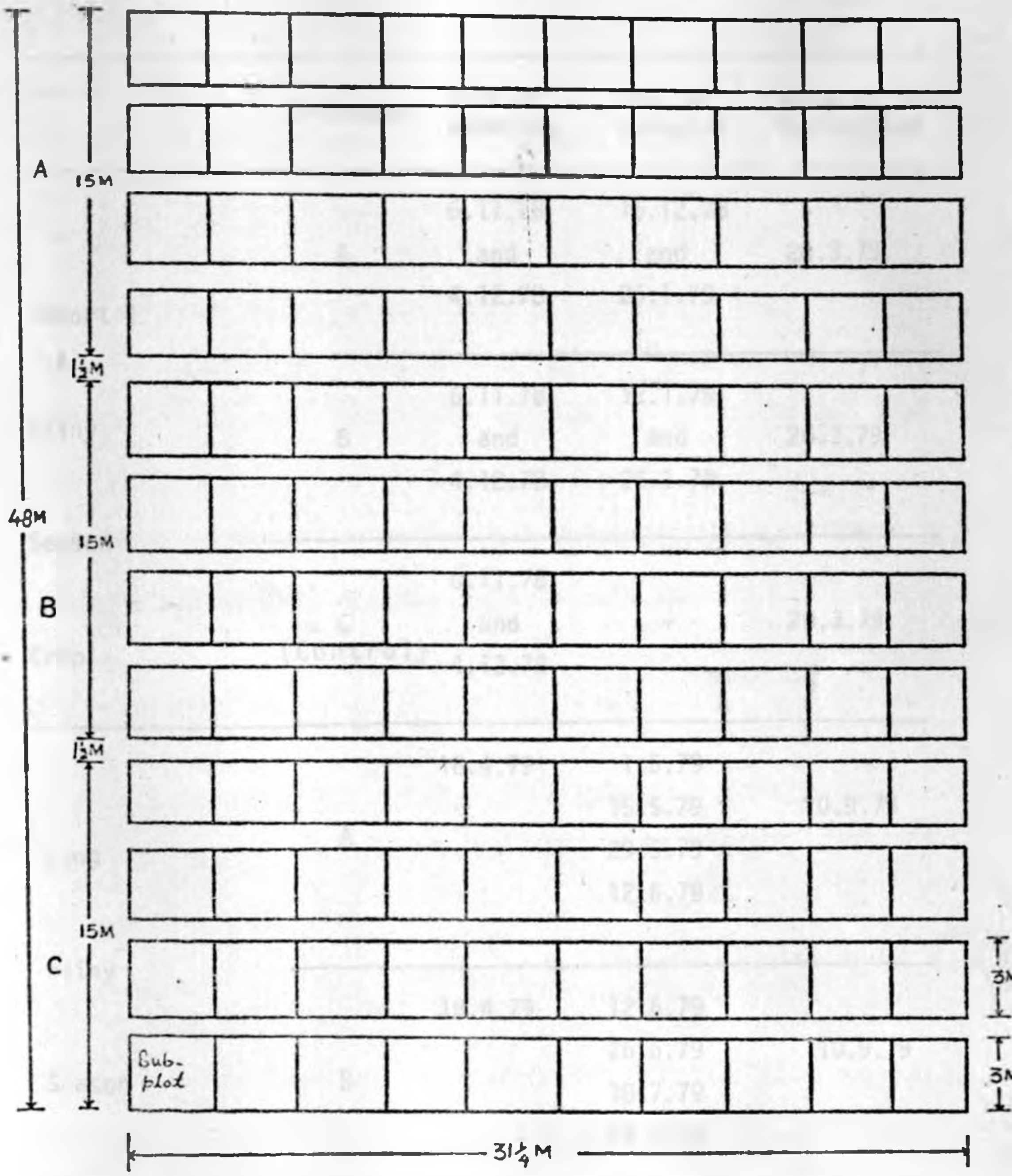


Table 4 Dates of planting, insecticide application and first harvest of cowpea at Katumani, Kenya, 1978/79

	Treatment	Date of planting	Date of spraying	Date of 1st harvesting
Short rainy Season Crop	A	6.11.78 and 4.12.78	15.12.78 and 26.1.79	20.3.79
	B	6.11.78 and 4.12.78	12.1.79 and 26.2.79	20.3.79
	C (Control)	6.11.78 and 4.12.78	-	20.3.79
Long rainy Season Crop	A	18.4.79	1.5.79 15.5.79 29.5.79 12.6.79	10.9.79
	B	18.4.79	12.6.79 26.6.79 10.7.79 24.7.79	10.9.79
	C (Control)	18.4.79	-	10.9.79

two applications of insecticide per treatment. For treatment A (Block A) first insecticide application was made as soon as 50% of the seeds had germinated which was 11 days after planting (D.A.P.), and at the first flower appearance, 59 days after planting. Insecticide treatment to Block B was at first flower appearance and at 50 per cent podding, 84 days after planting. The long rainy season crop received four insecticide applicationsper treatment (A & B) at 14 days intervals as follows: treatment A (Block A) insecticide was applied at 13, 27, 41 and 55 days after planting; whereas treatment B insecticide applications were made at 55, 69, 83 and 97 days after planting. In summary, the regimes of insecticide applications were as follows:

During short rains	Regime 1:	Twice, at germination and at 1st flower appearance (= Pre-flowering)
	Regime 2:	Twice, at onset of podding and at 50% podding (= Post-flowering)
During long rains	Regime 3:	Fortnightly, beginning at germination to the 55th D.A.P. (= Pre-flowering)
	Regime 4:	Fortnightly, beginning from the 55th D.A.P. to the 97 D.A.P. (or harvest) (= Post-flowering)

In order to reduce wind drift of the insecticides from sprayed to unsprayed plots the spraying was done between 7 and 9 a.m. when it was calm with no signs of rain within the next six hours.

Different cowpea varieties planted at the same time flower and pod at various times. Therefore, timing for insecticide application was standardized by selecting days taken to first flower appearance, 50 per cent flowering, first pod appearance, and 50 percent podding for each variety in all the three blocks (A, B and C).

Performance of each treatment was evaluated on the basis of each final yield.

3.11 Seed Yield Assessment

Before assessing seed yields experiments were conducted to determine whether or not insecticide treatments would affect flower patterns and pod formation. Harvest for each of the crops was started as soon as most of the pods had dried. Yield data were obtained from the two control rows of each subplot. All pods from the two central rows of each subplot were hand-shelled after which all the seeds were weighed to calculate seed yield in kg/ha. All the results were analysed statistically.

3.20 RESULTS AND DISCUSSION

3.21 Effect of spraying on flower and pod production

Table 5 shows that spraying with gamma BHC did not alter the time taken to commence flowering nor did it affect flower formation and pod production (Fig.6 and 7). This tallies with the findings of Taylor (1968a) while working in Southern Nigeria. Therefore, seed

Figure 6 Effect of insecticide applications on flowering patterns and flower production in ten varieties of cowpea

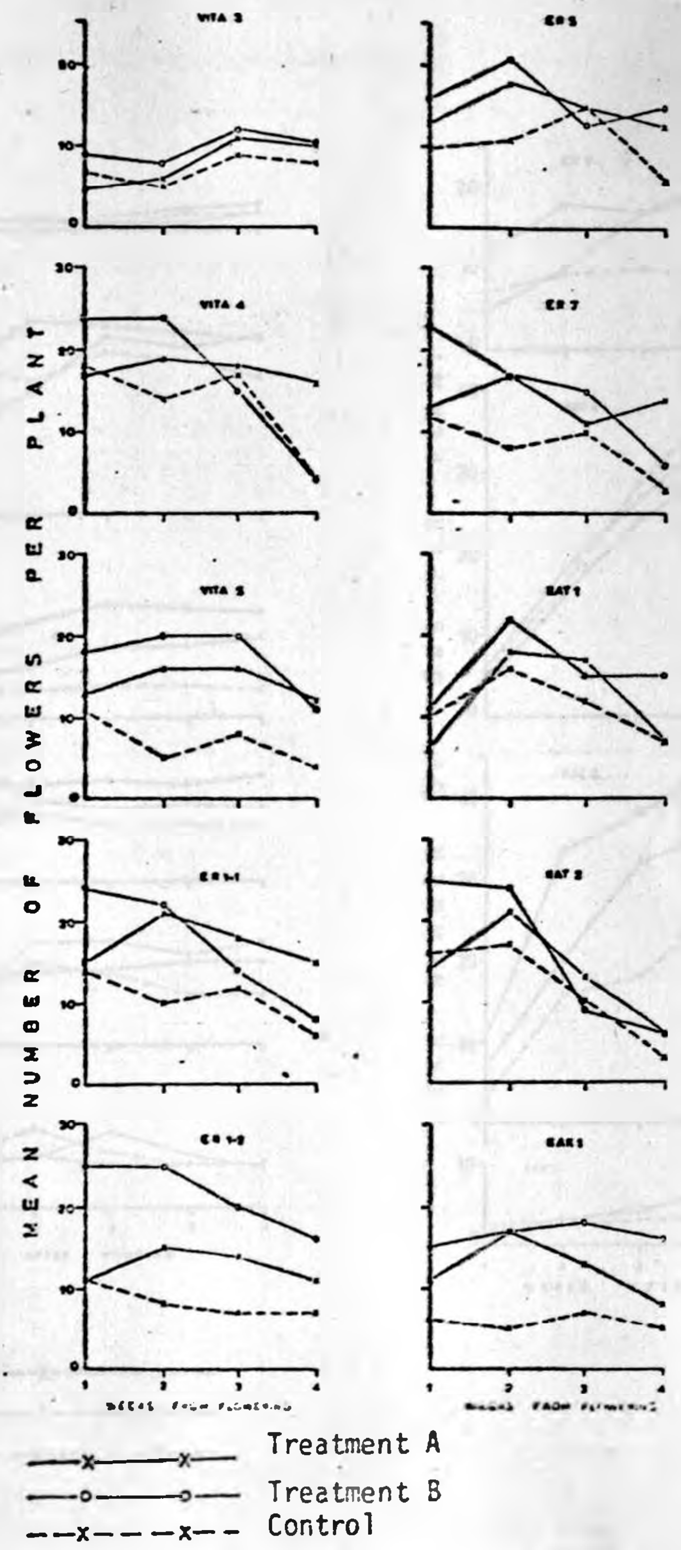


Figure 7 Effect of insecticide applications on pod formation patterns and pod production in ten varieties of cowpea.

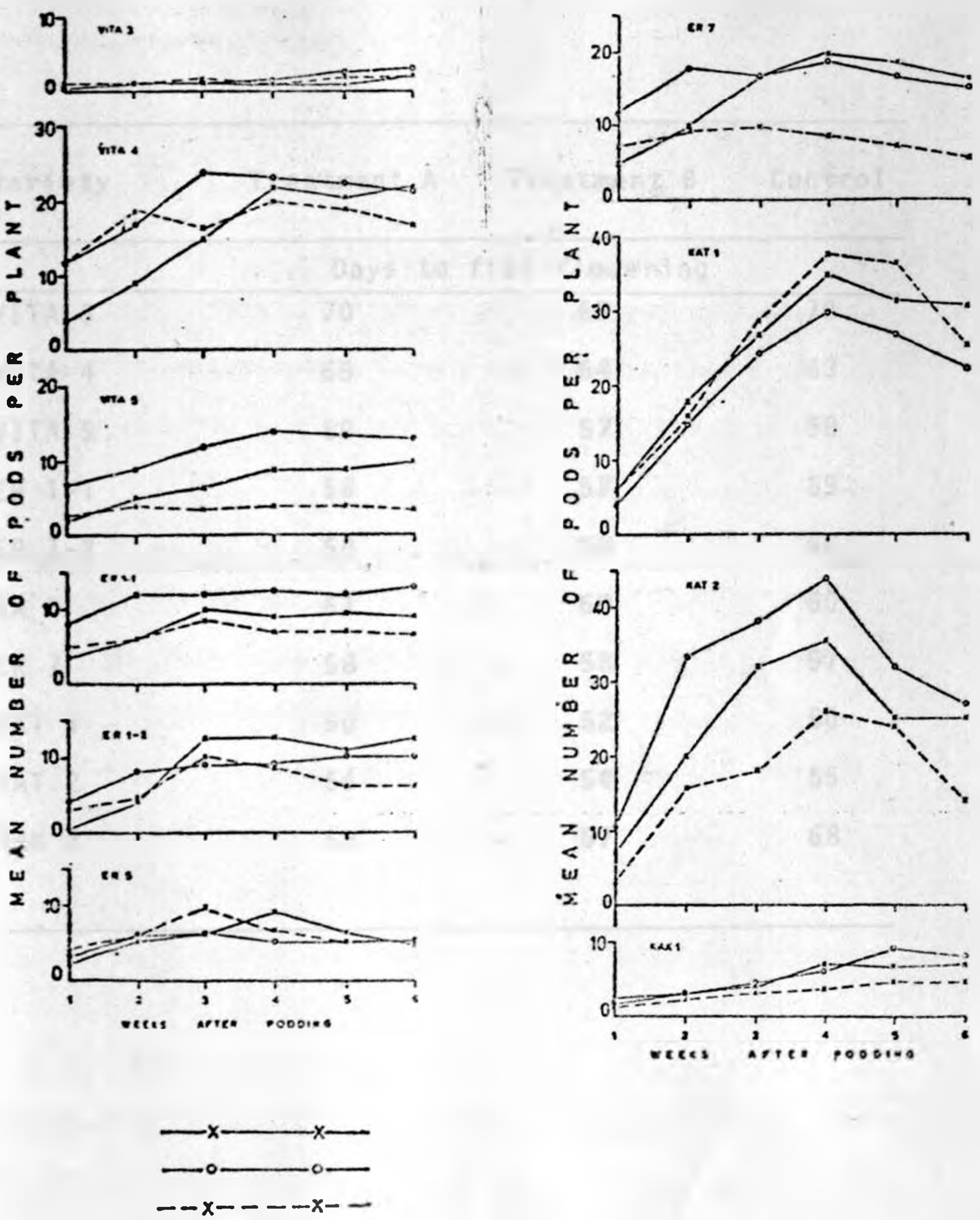


Table 5 Days to first flower appearance of 10 varieties of cowpea under different spray regimes at Katumani, 1979

Variety	Treatment A	Treatment B	Control
	Days to fist flowering		
VITA 3	70	69	70
VITA 4	65	64	63
VITA 5	59	57	58
ER 1-1	58	57	59
ER 1-2	58	58	58
ER 5	61	60	60
ER 7	58	58	57
KAT 1	50	52	50
KAT 2	54	54	55
KAK 1	68	67	68

yield results would only be influenced by pests and other unknown environmental factors.

3.22 Influence of various insecticidal spraying regimes against insect pests on seed yields by ten cowpea varieties

Cowpea yield performance during the short and long rainy seasons under different insecticidal treatment regimes are shown in Tables 6 and 7 respectively. Table 6 shows that during the short rains the crop under regime 2 produced higher seed yields than that under regime 1 and the untreated control. This was more obvious in varieties VITA 3, VITA 4, VITA 5, KAT 1 and KAK 1. In other words, crops protected against insect attack during post-flowering had higher seed yields than those protected only during pre-flowering period and those which were never protected. However, some unprotected varieties in the control, namely, VITA 3, VITA 4, ER 1-1 and KAK 1, produced higher yields than when they were under insecticidal protection in regime 1. It was also interesting to note that there was no significant difference in seed yields by varieties ER 5 and ER 7 under regimes 1 and 2 and the control. This indicated that other unknown factors, both environmental and biotic, such as resistance to pests, influenced seed yields of these two varieties.

Table 6 Seed yield performance by ten cowpea varieties grown during the short rains of 1978 at Katumani and treated with insecticide twice, at germination and at first flower appearance and with the control

	Seed Yield in kg/ha		
	Treatment A-At 50% germination & 1st flower appearance (Regime 1)	Treatment B - At 1st flower appearance and 50% podding (Regime 2)	Control
VITA 3	695	1243	855
VITA 4	919	1255	1162
VITA 5	440	807	259
ER 1-1	454	630	592
ER 1-2	492	579	281
ER 5	454	474	460
ER 7	410	459	453
KAT 1	1567	2027	1400
KAT 2	1421	1492	1211
KAK 1	1327	2525	1694
LSD P = 0.05	526	558	480

Table 7 Seed yield performance by ten cowpea varieties grown during the long rains of 1979 at Katumani and treated with insecticide four times at 14 days intervals from germination to 55 days after planting (D.A.P.) (Block A) (Pre-flowering); and from 55 to 97 D.A.P. (Block B) (Post-flowering), with the control

Variety	Seed Yield in kg/ha		
	Treatment A (Regime 3)	Treatment B (Regime 4)	Control
VITA 3	219	314	111
VITA 4	587	669	346
VITA 5	367	221	125
ER 1-1	152	246	96
ER 1-2	195	142	166
ER 5	116	161	130
ER 7	331	372	159
KAT 1	1042	1437	665
KAT 2	919	841	303
KAK 1	368	431	179
LSD P = 0.05	277	308	267

When local and exotic varieties were compared, the former had significantly higher seed yields than the latter in both regimes 1 and 2 and even in the control, except, for VITA 4. The performance of VITA 4 was similar to the local varieties. It is probable that local varieties, through long association with their local pests, have undergone an adaptive process and could resist pest attack more then imported forms.

For the long rains crop, an examination of Table 7 revealed existence of similar trends in relationship between regimes 3 and 4 and their controls as those observed in the short rainy season. However, there was no significant difference in seed yields between crops under regimes 3 and 4 applied during pre-flowering and post-flowering plant stages respectively. Perhaps this lack of differences in yields could be accounted for by the absence or low numbers of the target insect pests.

A comparison of the seed yields by crops grown in the short and in the long rains showed that the yield was lower in the long than in the short rains. This was unexpected because earlier observations had revealed that long rainy seasons were generally associated with relatively lower insect pest population levels in sole cowpea fields. The low yields by cowpeas in this season is probably explained by the fact that the long rainy season of 1979 was rather unusual in that it did not only start very late (towards end of March), but also it stopped raining after only three weeks. These unusual climatic conditions and other unknown factors must have influenced the cowpea crop performance and led to the low yields.

In summary, it appears from these results that it is possible to obtain yields of over 2000 kg/ha at Katumani if insect pest control is effectively applied (Table 6). These estimates concur with findings of similar researches conducted in Uganda by Nyiira (1971), and in Nigeria by Booker (1963, 1965a), Taylor (1965b), Assa (1976) and Raheja (1976c). The best spraying regimes are numbers 2 and 4 applied during the post-flowering growth stage of the cowpea plants because they resulted in much higher yields than numbers 1 and 3 applied during pre-flowering period. These results were consistent whether the treatments were applied to the short or long rains crops. Therefore, time of insecticide application is most critical except for local varieties. This fact is also stressed by earlier workers such as Booker (1963), Jerath (1968), Ayoande (1969), Nyiira (1971), Singh (1975a) and Dina (1977).

Thus for Kenya, cowpea yields would be considerably improved with accrueing savings to farmers on insecticide costs if the spraying could be performed only during the post-flowering period or by improving the yield output of the local varieties.

CHAPTER 4

DETERMINATION OF MINIMUM INSECTICIDAL USE FOR CONTROL OF THE DOMINANT COWPEA CROP INSECT PESTS WITH SPECIAL REFERENCE TO THE GROUNDNUT APHID *APHIS CRACIVORA* KOCH

4.0 INTRODUCTION

Aphis cracivora Koch was one of the most important pests of cowpea at Katumani which unlike other major pests occurred more frequently. These experiments were therefore conducted using aphids as the target pest. During a preliminary survey it was found that some varieties were heavily attacked by this pest while others were not. Both nymphs and adults fed on foliage, flowers and pods by sucking juice from them. Although the chemical control of these insects is known, the minimum use of insecticides that would give cowpeas maximum protection against pests occurring in both pre- and post-flowering stages and lead to high seed yields, have not been determined. This chapter is reporting experiments conducted at Katumani Dryland Agricultural Research Station, Kenya, on insecticide sprays with the objective of trying to evaluate the optimum number of sprays to control aphids for optimal seed yield in each of the ten cowpea varieties studied.

4.10 MATERIALS AND METHODS

The experiments were conducted during the short and the long rainy seasons of 1978 and 1979 respectively. Planting dates are as given in the general methods.

The experimental plot layout comprised of four replicates (Fig.1) in which ten cowpea varieties, three local and seven exotic from IITA, were randomised as already described. The exotic varieties were compared with the local varieties for seed yield performance in search of a minimum insecticide application regime. Lindane or gamma BHC insecticide was applied. Once weekly all the the subplots were examined for aphid infestation by observing all the 16 plants to assess for spraying. If three plants or more in any subplot were found attacked, insecticide was immediately applied to that particular entire subplot.

Examination for aphid infestation started as soon as 100 percent germination had been achieved and went on up to 97 days after planting. The plant growth habit for each variety was noted in order to verify the preliminary observations which showed that varieties with prostrate growth forms are more prone to aphid attack than erect ones. At harvest, all the pods from the plants of the two central rows of each subplot were picked and after hand-shelling, the weight in kg of each variety per hectare was calculated to compare the yields of each variety and subplot with the number of sprays made.

4.20 RESULTS AND DISCUSSION

In chemical control of grain legume insect pests, it is important to avoid the indiscriminate application of insecticides on a routine basis. Such use of insecticides is usually not only uneconomical, but also may even increase insect problems. These are some of the reasons which necessitate the establishment of minimum insecticidal use for pest control.

In these investigations, table 8 shows that during the short rainy season, four of the ten cowpea varieties under test for minimum insecticide protection, namely, VITA 5, ER 5, KAT 1 and KAT 2 were attacked by aphids on one occasion only during their growth stage. Except for KAT 2 which was attacked during the pre-flowering stage, the remaining three varieties were infested in the post-flowering stage. The corresponding control plots for the same varieties were similarly invaded by aphid populations almost at the same times. It is interesting to note from table 8 that seed yields between the sprayed and unsprayed plots in all the four varieties were almost equal, with unsprayed plots performing even slightly better.

The short rainy season with its warm and dry weather, favoured rapid increase of aphid populations which lived and fed on shoots and leaves in the

Table 8: Plant growth habit, dates of spraying, number of times sprayed and yields of the ten cowpea varieties studied at Katumani during the short rains crop of 1978

Variety	Plant Growth Habit	Date Sprayed	No. of Times Sprayed	Seed yield in kg/ha	
				a	b
VITA 3	Erect and busy	-	Nil	647	855
VITA 4	Erect	-	Nil	914	1162
VITA 5	Prostrate	24.1.79	1	291	257
ER 1-1	Semi-erect	-	Nil	378	592
ER 1-2	Semi-erect	-	Nil	520	281
ER 5	Semi-erect	16.1.79	1	373	460
ER 7	Erect	-	Nil	474	453
KAT 1	Postrate	16.1.79	1	1054	1400
KAT 2	Semi-erect	12.1.79	1	1128	1211
KAK 1	Erect and busy	-	Nil	1154	1694
LSD P=0.05				N.S.	480

N.S. = No significant difference

a = Sprayed in case of attack

b = Remained unsprayed even when attacked (Control) pre-flowering stage, and on pods in the post-flowering stage. It was, therefore, surprising that these large aphid populations did not appear to influence the final seed yields in the attacked and unprotected varieties. This suggested that even one application of insecticides to attacked cowpea fields as far as these varieties are concerned was unnecessary. The results further suggest that, although the characteristic symptoms of yellowing, leaf curling and stunted growth were visible on the particular attacked plants, the influence of aphids on flower and fruit production was negligable.

Table 8 also shows that the varieties which were attacked by aphids were either prostrate or semi-erect with respect to their growth habits or phenology. This sharply contrasted with unattacked varieties whose phenology was either erect or erect and bushy. This indicated that phenological characteristics of the plants may be important in the attraction of aphids in cowpea fields.

In the long rainy season, six of the ten cowpea varieties under study, namely, VITA 5, ER 1-1, ER 1-2, ER 5, KAT 1 and KAT 2, were infested with aphids in the post-flowering growth stages. Except for VITA 5 and KAT 1 which were attacked twice, the rest suffered one attack only (Table 9). Like in the short rains, when seed yields of spryaed and unsprayed plots were compared, there were no significant differences. The relationship

Plate 9 Plant growth habit, dates of spraying, number of times sprayed and yields of the ten cowpea varieties studied at Katumani during the short rains crop of 1979

Variety	Plant Growth Habit	Date Sprayed	No. of times sprayed	Seed yield in kg/ha	
				a	b
VITA 3	Erect and bushy	-	Nil	121	111
VITA 4	Erect	-	Nil	150	346
VITA 5	Prostrate	10.7.79 24.7.79	2	135	125
ER 1-1	Semi-erect	24.7.79	1	89	96
ER 1-2	Semi-erect	10.7.79	1	92	166
ER 5	Semi-erect	10.7.79	1	141	130
ER 7	Erect	-	Nil	189	159
KAT 1	Prostrate	26.6.79 10.7.79	2	480	565
KAT 2	Semi-erect	12.6.79	1	399	303
KAK 1	Erect & bushy	-	Nil	206	179
LSD P=0.05				125	267

LSD P = 0.05

a = Sprayed in case of attack

b = Remained unsprayed even when attacked (Control) between cowpea varieties, aphid attack, and phenological features of cowpea varieties, followed a similar pattern as described for the short rainy season crop, suggesting that there was no need to spray with insecticide at all.

In conclusion, these investigations showed that cowpea varieties used in this experiment do not require any insecticidal protection against Aphis craccivora to improve their seed yields. However, the role of phenological characteristics among the varieties appeared to be important in the overall pest management practices in cowpeas, and require intensified research, to identify the exact relationship with the pests. It is probable that a sound knowledge of such characteristics, combined with the use of natural enemies of aphids, such as ladybird beetles, lacewing fly larvae, syrphidfly larvae, hemipterous insects and predaceous mites, would completely remove any contemplation of using chemical controls against Aphis craccivora on cowpeas.

CHAPTER 5

GENERAL DISCUSSION

Scientific research into grain legume entomology has gathered tremendous momentum, particularly in developing countries, in the last decade and much has been discovered. This is because grain legumes are useful crops in providing less expensive vegetable proteins compared to meat, fish and other sources. Another special value is that legumes generally require no additional nitrogenous fertilizer for average growth. They have the capacity to provide their own nitrogenous fertilizer through bacteria that live in nodules of their roots. The bacteria chemically converts nitrogen gas from the air into soluble compounds that the plant absorb and utilize. This is advantegeous because commercial nitrogenous fertilizers are now extremely expensive for peasant farmers in developing countries like Kenya. Therefore, by using leguminous plants, farmers in developing countries can grow useful crops while avoiding that expense.

However, there is yet another expense which, unless it is reduced to the minimum, could greatly discourage farmers from growing grain legumes, namely, the inputs into chemical control of insect pests. The undoubted potential of improved new crop varieties is not always achieved in practice even in developed countries with sophisticated technologies for managing crop systems.

Crop pests are among the major factors responsible for this limitation of the development of our crop plants, thus causing reduction in yield and quality of grain, and variability from season to the next.

In this study, after a general introduction of the problems investigated and a review of literature, Chapter 2 aimed at providing Kenya farmers and others who have a practical interest in our grain legume crops, a guide to the many insect pests afflicting the cowpea crop in the field. While many countries in Africa, such as Nigeria (Taylor, 1964a, 1971, Booker 1965a, 1965b), Tanzania (Kayumbo, 1975 and 1978) and Uganda (Nyiira 1971, Mehta and Nyiira, 1973), have guides to cowpea insect pests, this is the first comprehensive guide of its kind to the cowpea insect pests of Kenya. Compiled from data collected from cowpea fields during the short and long rainy seasons, the 43 insect species found were actually observed damaging the cowpea crop. Those that were most abundant in numbers and/or that by the nature of their damage, affected reproductive parts and quality of the final grain yield, were classified as major pests. These were 10 out of the 43 species and their most distinguishing characteristics including an illustration for each have been described here to assist in their recognition in the field.

It is hoped that this species list of cowpea insect pests in Kenya will encourage other workers to make known their experiences in the practice of grain legume entomological management. It is by pooling our knowledge that we can obtain comprehensive lists of pest species which can greatly influence the dimensions of the pest problems and help to solve them.

Once the insect pests and nature of their damage to field cowpea have been identified it is possible to design appropriate effective control measures against individual species. The relationship between cowpea insect pests and yields has been studied in many countries like Nigeria (Booker, 1965a, Taylor 1968a), Uganda (Koehler and Mehta, 1972) and Mehta and Nyiira (1963). These workers have shown that use of chemical control against cowpea insect pests resulted in substantial increase in cowpea seed yields. However, routine spraying is not only expensive but also hazardous to the person applying it. To assist the Kenyan farmer in using insecticides and at the same time minimizing hazards, determination of the timing of application of insecticide is most crucial. The most vulnerable phase of crop growth was the reproductive phase, the period of greatest liability, because much higher yields were obtained when chemical control was applied in the post-flowering period. This was true regardless of the number of insecticide applications in each of the short or the long rainy season. Hopefully, this will serve as an initial step for further research in reducing the number of spray applications while at the same time aiming at attainment of high yields in cowpeas.

To avoid the indiscriminate application of insecticides on a routine basis necessitates the establishment of minimum insecticide use for pest control. This was demonstrated in Chapter 4 of this study. The results of this experiment helped to explain the avoidance of spraying on a routine basis regardless of the presence or absence of the target pest. Using groundnut aphid Aphis craccivora as the target pest, it was demonstrated that though the pest was abundant on the cowpea crop it did not affect yield and thus it was not even necessary to use insecticide to control this pest at the sight of it on the crops.

The role of phenological characteristics among the varieties also appeared to be important in the overall pest management practices in cowpeas. This phenomenon requires intensified research in order to identify the exact relationship with the pest insects. When additional studies on minimum use of insecticides against other insect pest species are completed, combined with other control measures, it will lead to further reduction of insecticide applications thus result in sound management of the cowpea ecosystems.

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