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STUDIES ON THE CONTROL OF INSECT PESTS IN VEGETABLES (OKRA, TOMATO, AND ONION) IN SUDAN WITH SPECIAL REFERENCE TO NEEM-PREPARATIONS.

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LIST OF ABBREVIATIONS

ANKE	Aqueous Neem Kernel Extract
ANKES	Aqueous Neem Kernel Extract applied into the soil
ANLE	Aqueous Neem leaves Extract
AZA	Azadirachtin
C	Control
CA	Cotton aphid
M.TEM	Mean Temperature
Naz	Neemazal
NKPS	Neem Kernel Powder applied into the soil
RH	Relative humidity
SUM	Sumicidin
WF	White fly

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ABSTRACT

Field trials were conducted for three years (1997-1999) to study the effectiveness of different neem formulations against the major insect pests complex and on yield of okra (*Hibiscus esculentus),* tomato (*Lycopersicon escculentum),* and onion (*Allium cepa).*

Neem kernel powder was applied into the soil (NKPS), sprayed as water extract on the target plants (ANKE) or applied as water extract into the soil (ANKES). The registered German formulated neem seed extract (NeemAzal), includes Azadirachtin as main active principle, and, the Japanese trade product (Sumicidin) were also used for comparison.

The experiments were conducted in the Shambat area of Khartoum in the Sudan.

ANKE showed significant increase on yield of okra during the two seasons 1997 (162%), 1998 (52%), tomato 1998 (74%). An increase by 28% of Okra 1999 was also obtained (nicht significant).

Against the insect pests of okra, the product reduced the number of cotton aphids *Aphis gossypii*, white fly *Bemisia tabaci* (Genn.), the number of plants infested by the larvae of the spotted boll worm *Earias vittella* and the number of leaves damaged by the adults of the flea beetle *Podagrica puncticollis* significantly. A reduction by 35% of the number of aphids on okra grown in the year 1999 was also recorded.

Against the insect pest complex of tomato, ANKE reduced the number of the leaves damaged by the larvae of the leaf miner *Liriomyza trifolii* significantly, while it reduced the number of aphids by 40%, and the number of white fly by 33% under the control.

The product increased the weight of onion grown in the year 1999 by 15% over the control.

A reduction by 21% and 26% of the number of cotton thrips *T. tabaci* on onion grown on the year 1998 and 1999 respectively, was also recorded.

NeemAzal increased the yield of okra grown in the years 1997, 1998, and 1999 significantly.

It succeeded also in the significant reduction of number of aphids on okra grown in the year 1998 and 1999, the number of plants infested with the larvae of spotted boll worm and the number of leaves damaged by the adults of flea beetle. It reduced the number of white fly not significantly by 58%.

On tomato, NeemAzal increased the yield by 38% over the control (nich significant). It reduced the number of the leaves damaged by the larvae of the leaf miner and white fly significantly, while it reduced the number of aphids only by 10% under the control.

On onion, NeemAzal showed similar results as that of ANKE.

NKPS increased the yield of okra grown in the year 1997 by 32% and the yield of tomato by 46%. On okra grown in the year 1998, it reduced the number of white flies and leaves damaged by the adults of flea beetle significantly, while it reduced the number of aphids only by 19%. On tomato, it reduced the number of white fly by 13% as compared with the control.

ANKES reduced the number of white fly on okra grown in the year 1998 significantly.

The results of NKPS and ANKES indicate a systemic movement of neem compounds from the root to the leaves.

Sumicidin gave almost the same results as ANKE and NeemAzal in significant reduction of the number of tomato leaves damaged by the larvae of the leaf miner. Against white fly on tomato, Sumicidin showed the same results as NeemAzal in significant reduction of the number by 60%, but better as ANKE, which showed non-significant reduction by 40%.

Against aphids on tomato, Sumicidin gave significant reduction of the number by 60%, while the reduction by ANKE and NeemAzal was not significant by 40% and 10% respectively.

Although Sumicidin showed generally better results as the three-neem products (NeemAzal, ANKE and NKPS) against the target insect pest of tomato, all neem products gave yield higher than it did.

On onion plants, Sumicidin showed better, but not significant effects on the weight and against cotton thrips than NeemAzal and ANKE.

The results are sammarized in Table 14, 15, and 16.

A strong positive effect on the growth rate, vigor, plant height and number of leaves of okra and tomato plants treated with ANKE and NeemAzal were observed.

1 INTRODUCTION

Synthetic insecticides are widely used in most developing countries to control insect pests of food crops. This has contributed to the environmental pollution through air or as residues in food. In the last years is the use of environmentally biopesticides, such as plant extracts widely increased.

Extracts from the Indian neem tree, *Azadirachta indica* A. Juss., or its most active principle, the limonoid azadirachtin (AZA), have been extensively investigated in recent years, with demonstrated activity reported against >200 species of insects from several orders (Saxena 1989, Isman et al. 1990a).

The diverse biological activities of neem or AZA include feeding and oviposition deterrence, repellency, growth disruption, reduced fitness, and sterility (Saxena 1989, Isman et al. 1990; Koul et al. 1990, Schmutterer 1990).

Despite of the sensitivity of insects of most orders to azadirachtin, neem products are selective as they do not harm important natural enemies of pests. They are also non-toxic to warm-blooded animals. Neem-seed extracts have, therefore, a considerable potential for integrated pest control measures especially in developing but also in industrialized countries (Schmutterer 1988).

Neem seed extracts cause various effects on insects. They acts as antifeedants, growth regulators and sterilants. Good results in insect control are obtained with azadirachtin containing seed extracts under field conditions. Neem has systemic activity (Larewy 1988, Isman & port 1990), it is active at low concentrations, has negligible mammalian toxicity (Jacobson 1989), degrades rapidly in the environment (Schmutterer, 1988) and it proved in most cases not to be harmful, or only slightly harmful, to important natural enemies of pests (Schmutterer, 1990).

The first requirement that a new pesticide should fulfil in order to become a valuable tool in pest management is its efficiency to control a pest.

Vegetables in tropical countries are the crops, which are often attacked most seriously by arthropod pests. Vegetables are grown mostly as intensive crops with considerable input, such as fertilizers, irrigation water, insecticides, etc, and often cultivated continuously in a limited area with narrow crop rotations. Thus insects find optimum conditions to develop high populations.

Because of high susceptibility of vegetables to insects, farmers tend to apply chemicals for protective purposes. Also, their high profitability combined with a lack of knowledge by the farmers has often led to improper use and handle of synthetic insecticides. This has resulted in great hazards to the environment and the health of users and consumers, as well as serious resistance problems.

In order to support sustainable vegetable production, it is important to develop alternative methods of pest control. Neem products, being practically non-toxic to man and warm-blooded animals and relatively harmless to beneficial insects, are very suitable for biological and integrated pest control programs. In addition in many third world countries, subsistence farmers who cannot afford to purchase synthetic pesticides and other chemical inputs produce vegetables. These reasons have led numerous entomologists to concentrate their neem research on pest of vegetables. The results obtained against a considerable number of key pests have been very promising. The conventional technology in the use of synthetic insecticides has not been very effective against numerous homopterans because they generally feed on the underside of foliage or within the plant canopy. Their small size, short cycle, short generation time, and high fecundity result in high reproductive rates, which often permit dramatic changes in population sizes and rapid differentiation of populations into insecticide-resistant strains, necessitating increased control actions.

The aim of these field trials is to study the effects of different neem products against the insect pest complex and on the yield of okra, tomato and the weight of onion.

2 LITERATURE REVIEW

2.1 Vegetable production in the Sudan

Vegetables are important components of human food. Regular intake of vegetable food is indispensable for good health, fitness and the feeling of well–being.

The main cash crops in Sudan are:

1) Cotton: the total is 500.000 acres, of which about 350.000 is irrigated and the rest is rain fed.
2) Sorghum: 10-15 million-acre, mainly rain fed.
3) Wheat: 800.000 acres, irrigated.
4) Sugar cane: 180.000 acres, irrigated.
5) Groundnuts: Total area about one million acres only 25% of which is irrigated.

Vegetables: The vegetable fields in addition to their concentration in the large towns and around the villages, they are also scattered in all cotton schemes. They are together with sorghum, maize, millet and wheat, the main subsistence crops.

Vegetables growing for the market in the Sudan are probably most developed in the Khartoum area. It is the largest center in the country and with high standard of living of its population and with high level of sophistication, high per capital incomes, it is the largest vegetable market in the Sudan.

2.2 Target Vegetable Crops

2.2.1 Okra (*Hibiscus esculentus*)

Okra (Malvaceae), the most popular vegetable crop in the Sudan is thought to be native to an area extending from Ethiopia to the Sudan. It′s early history and distribution are not known, but it was apparently introduced to Egypt in the seventh century. Okra then was carried through North Africa and areas bordering the Mediterranean and eastward.

Okra has moderate levels of vitamins A and C and of calcium, phosphorus, and potassium, and is higher than many vegetables in thiamin, riboflavin and niacin.

Climate and soils

Okra is warm season crop growing best during summer with irrigation or during rainy season, but can be grown all the year round in tropical, subtropical and temperate zones.
It thrives in a wide range of soils as long as they are well drained.

Harvest

Time to market maturity is 45-50 days after sowing. The harvest season continues for 3-4 months. Only the younger pod 2-3 days after flowering are desired in the market, as the older ones become tough and woody. More frequent harvest, for example 3 days, results in more yields, a longer picking period and better quality produce.

Common pest and diseases

Insects

Okra plants are subject to attack by flea beetle (*Podagrica puncticollis, P. pallida*) infest the seedlings and can cause damage of economic importance by feeding on the leaves. If more than 2-3 individuals appear per seedling, the chemical control measures should be initiated. However seed dressing is also recommended.
White flies (*Bemisia tabaci*), Jassids (*Empoasca lubica*) and Aphids (*Aphis gossypii*) attack okra also. These pests infest leaves, stems, branches and pods during the winter.
Pods and flowers are primary targets of spiny bollworm (*Earias insulanaa*), while the caterpillar of the American bollworm (*Heliothis armigera*) prefers the reproductive parts of the plant, including buds, flowers and fruits. Control measures against this pest are only recommended in intensive production areas.

Diseases

Okra plants are subject to attack by leaf curl virus (early protection against the vector, the white fly, is necessary).
Okra is subject to infection by some fungal disease such as powdery mildew (*Levillula taurica, a. o).* Protection sprays are recommended to minimize the infection rate, particularly in winter.

2.2.2 Tomato (*Lycopersicon esculentum*)

Tomato (Solanaceae) is originated in Peru, South America. In the Sudan it is the most important crop after Onion. It is produced on large areas around big cities along the Nile and on seasonally flooded plains.

Harvest

The first harvest is ready in 10-12 weeks after transplanting. The harvest period continues for 8-10 weeks. Tomatos are harvested ripe (in red color) for the local market.

Climate and soils

Tomato is cool season crop thriving best in the winter months, but it can be grown through the year in different parts of the country, provided that the temperature is suitable for tomato fruit set.

The best soil for tomato production is the silt soil or the loamy clay soil, but it can be grown in a wide variety of soils provided that they have good drainage and a sufficient fertility level.

Common pests and diseases

Insects

Tomato plants are subject to infestation by the sucking insects, white fly (*B. tabaci*) and cotton aphid (*A. gossypii*).

American bollworm (*Heliothis armigera*) attacks the ripped and pre-ripped fruits, contaminating them with fraises and exposing them to fungi and bacteria.

Cotton leaf worm (*Spodoptera littoralis*) primarily damages the Summer crops. It causes defoliation, but also it can bore into and feed on interior of fruits.

Leaf miner (*L. trifolii)* attacks also tomato leaves causing various losses.

Diseases

Tomato plants are subject to infestation by tomato leaf curl, spodoptera leaf spot, late blight (*Phytophthora infestans*), bacterial leaf spot (*Xanthomonas vesicatora*), Blossom-end rot (caused by water stress) and nematodes (Meloidogyne spp.).

2.2.3 Onion (A*llium cepa*)

Onion (Alliaceae) is the most important art of vegetables grown in the Sudan.

Climate and soils

It is basically a cool season crop thriving best in winter under tropical and subtropical climatic conditions.

Onion is grown on nearly all types of soils from sandy looms to clays. However, heavy clays may bake and form a crust and impede bulb expansion and therefore may result in smaller onion. Best soils are light soils.

Harvest

Time to market maturity is 4-5 months after transplanting. The best time to harvest is after 50% of the plants yellowed and dropped down their pseudostems.

Common pest and diseases

Insects

The onion thrips (*T. tabaci*) is the major pest found to be responsible for low yield of the crop.

The lesser armyworm (*Spodoptera exigua*) and the cotton leafworm (*S. littoralis*) are doing the same damage of growing economic importance especially in the central and northern parts of the Sudan.

Diseases

The fungal pathogen (*Pyrenochaeta terrestris*) is a common soil inhabitant that attacks the weakened roots of many plants, is more generally associated with onion (pink-root rot). Plants infected early usually produce no edible parts, while those infected later have stunted or soften bulbs. Drying foliage recognizes infected plants.

Onions are also subject to infestation by powdery mildew (*Levillula taurica*, a. o.) *Aspergillus* species, bacterial rots (*Erwina carotovora*) and nematodes.

Insects as a production limiting factor

Insects can cause great damage to crops. Many farmers, therefore, use synthetic pesticides in order to minimize their damage. Many of these synthetic pesticides are also highly poisonous for human and livestock. Moreover, these substances destroy a great number of useful insects, which are important factor in the natural control of pests. As a result, the plants are left unprotected against pests and increased pesticides are thus necessary.

These disadvantages can be avoided by using biological pesticides such as extracts from the neem tree, which are both effective in controlling pests and, at the same time, harmless to humans and other warm-blooded organisms.

2.3 Target Insects of this study

2.3.1 Cotton Aphid *Aphis gossypii* (Glover) (Homoptera: Aphididae)

Distribution

The cotton aphids *A. gossypii* (Homoptera: Aphididae) is found in many countries with tropical, subtropical and temperate climates. However its optimum environment lies in areas with higher temperatures. In Sudan the cotton aphid occurs in all parts of the country where suitable host plants grow (Schmutterer, 1969). In particular it is found in the cotton growing areas in the Gezira, Gash delta, white Nile, Blue Nile, schemes, Nuba mountains, and in the vegetable growing areas around Khartoum, Kassala, and northern provinces (Ripper and George, 1965 and Schmutterer 1969).

Life Cycle

Only the female adults are found, which may be winged or wingless, blackish-green, small to medium-sized about 1-2 mm. The adult may live for 2-3 weeks.

In 1986, Sharaf eldin reported that cotton aphid usually occurs in apterous and alata forms, with the former type having a higher reproductive potential than the later. Therefore, the apterous form contribute more actively to the build-up of infestation in the field. Matthews (1989) found that the colonies of *A. gossypii* were present on the under surface of the older leaves near the base of the plant.

Many authors reported on the biology of *A. gossypii* (Gaffand & Tissor 1932) stated that the average life cycle of cotton aphid was 31 days. The nymphal period ranges between 3-

20 days with an average of 13 days. The reproductive period ranged between 2-31 days with an average of 15 days.

Host plants

A. gossypii spends the hot summer months in the central eastern and northern Sudan in small colonies on weeds and irrigated crops. The aphid is often very small in size during this period, even in the adult stage. During the rains and in the first half of the winter a continues build-up is observed which may lead to heavy out breaks on cotton, okra and other vegetables. Winged forms leave the old host plants and fly actively or aided by wind to new, vigorously growing hosts and forms new colonies on them. The winged aphids develop mainly on overcrowded plants. They are, especially during the first winter months (northern, eastern and central Sudan) or in the middle of rainy season (western Equatoria), usually blackish colored insects. Black forms have been also found on young twigs and leaves in the Marra Mountains after the rains. The winged aphids give birth to a first generation, which is mostly dark green in color. Later on the season when the host plants become woodier and yellowish of amino acids in the leaves and twigs decreases, the insect may be smaller yellow forms are predominant or exclusive during summer month in the central and northern Sudan. No sexual forms of this species are known in the tropics so that reproduction is most probably exclusively parthenogenetic. Many generations occur during the year in the Sudan and elsewhere, only 3-5 days at 28-30°C and 10-12 days at 25-28°C are required to complete the development from the first nymph instar to the adult. The number of nymphs, which are produced by one female under favorable conditions may reached up to 150 (Schmutterer, 1969).

The cotton aphid takes its food up from the phloem of the host plant by means of its style. The later usually penetrates the plant tissue intercellularly.

A. gossypii is sometimes attended and fostered by various ant species, especially in Equatoria. These ants may play an important role in the preservation of the dry season colonies of the aphid.

The cotton aphid is an extremely polyphagous pest. In the Sudan it infests cotton, okra, kenaf chilli, eggplant and tomato.

It is generally found on those plants belonging to families Malvaceae, Cucurbitaceae, Solanaceae and Euphorbiaceae. They also breed on some weeds when the main host plants are absent or when conditions in the field are unfavorable.

Damage

The leaves are cupped, otherwise distorted with clusters of soft, greenish or blackish aphids on young shoots and on the undersides of young leaves.

Drops of sticky honeydew and or patches of sooty mold on the upper sides of leaves.

The pest prefers to attack the tender shoots and the lower of the young leaves of the host plant but it can also exist on older leaves. A heavy infestation leads, especially on cotton, okra, cucurbits, to leaf curl and stunting in growth. The honeydew, which is produced by the aphids in considerable amounts collects on the upper surface of the leaves. The honeydew can also attract the moths of *Heliothis armigera*, which take it up as food. Cucurbits are sometimes so heavily infested that the plants die or produce hardly any fruit.

A. gossypii is in general a minor pest of cotton and vegetables in the Sudan. However, locally, it may reach the status of a major pest if the application of unselective insecticides against other pests destroys the natural enemies of the aphids and may increase its fecundity.

A. gossypii can also play an important role as vector of viruses especially on cucurbits.

In the Sudan its ability to transmit the pea mosaic virus and the Lucerne mosaic virus to different legumes has been demonstrated during recent years.

Ecology

Ecological studies on the cotton aphid include the effect of temperature, moisture, nutrients and light on the different biological aspects of the species. Iseely 1948 stated that the temperature accelerated development of *A. gossypii* on cotton when the temperature increased from 17-28 ^{0}C.

In 1986, Sharaf eldin reported about the variation of aphid incidence from one area to another and, from season to season in the same area, depending on a number of biotic and abiotic factors. In 1991, Nur showed that *A. gossypii* was found to be unevenly distributed in the cotton and okra fields.

The results of Satti in 1997 showed the great variations in intro- and inter- plant distributions and the seasonal abundance by *A. gossypii*.

Control

The chemical control of *A. gossypii* should not be carried out in cases of local outbreaks of medium intensity when numerous numbers of predators are present in the colonies of the plant. The ladybirds and their larvae are usually able to destroy the pest population before they can cause serious damage. This is often observed in the central Sudan.
Only heavy outbreaks over large areas call for immediate chemical control.

2.3.2 Cotton White fly *Bemisia tabaci* (Genn.)(Homoptera: Aleyrodidae)

This serious leaf-sucking pest also transmits the leaf curl disease of okra and beside many other agricultural plants.

Distribution and Host plants
It covers wide range of countries in the world. In the Sudan, it occurs wherever suitable host plants exist (Schmutterer, 1969; Gameel; 1972).
The insect has a very wide range of cultivated and wild-plants. In the Sudan in 1972, Gameel reported as many as 115 species, in a total of 31 families (e g. Malvaceae, Solanaceae, Cucurbitaceae and leguminose) to be among alternative hosts for this pest.

Biology
According to Schmutterer (1969), the white flies are known to reproduce bisexually or parthenogenetically, and hence numerous generations can occur during the year.
Both adults and nymphs suck the plant sap.

Damage
In addition to removing plant nutrients and transmission of a number of viral diseases among different crops such as leaf curl viruses, it produces numerous chlorotic spots on infested leaves. Wilting and shedding of leaves, fruits and branches is associated with very heavy infestation. The honeydew excreted by the juvenile stage cover the leaves. Both result in decrease in yield and quantity. 200 adult per 10 leaves indicate that spraying, using recommended insecticides, is required.

Ecology

In 1960 El Khidir in Shambat area found that during January and February the temperature dropped greatly and accordingly the population of the insects decreased.

With the increase in temperature during April and May, the pest infestation increased markedly. On the other hand, the high RH (80-90%), coupled with relatively high temperature (36-38°C) were found to favor the development and a sharp increase of WF population during September-October.

Control

Cultural control

The clean-up measures (e g. removal of weeds and alternative hosts) (Schmutterer, 1969), reducing the frequency of irrigation (Farah and Abdel rahman, 1988) and modifications of the spacing of plant populations (Sharafel Din et al., 1986) were reported by many authors to reduce the population build-up of WF.

Natural enemies

Number of hymenopterous parasites have been found attacking WF in the Sudan, e.g. *Eremocrus mundus* and *Encarsia lutea* (Schmutterer, 1969; Gammeel and abdel rahman, 1986).

Among important predators are members of the family Coccinellidae and Chrysopidae, which are general feeders.

2.3.3 The flea beetle *Podagrica puncticollis* (Weise) (Coleoptera: Halticinae)

Description

The species of the genus Podagrica are widely distributed in the world. In Africa they were found in Sudan, Congo, Uganda, Nigeria, Chad, Somaliland, and Ethiopia.

In the Sudan, Pollard (1955) stated that *Podagrica pallida* is distributed across the central region of the Sudan in the east-west direction extending from Eritrea to Darfur, while *Podagrica puncticollis* occupies a north-south direction, from, extending southwards into Uganda and Kenya. There are thus areas of overlapping in the Gezira, Nuba Mountains and Gash Delta, where both species occur together in approximately equal preparations.

Biology

Four stages were recorded during the life history, an egg, larval, pupa and adult stage. The egg stage as recorded by Bedford, took 7-13 days to hatch, being shortest in August and longest in January.

Manolache (1940) observed that larvae of this beetle live in the soil and feed on the epidermis tissues of the roots of the plant. Bird (1948) described the larvae as white in color, with dark head, and feeds mainly on the fine roots and root hairs, but sometimes attacks the surface of the main root. The larval stage takes about three to four weeks, followed by a pre-pupa and pupa period of about two weeks. Schmutterer (1969) found that the newly hatched larvae of P*odagrica puncticollis* fed for a period of 11-28 days on the rootlets, then pupation takes place in the soil. The pupation period was 10-17 days.

According to Schmutterer (1969) cotton flea beetle *P. puncticollis* belongs to the family Halticidae. The adult is 3-4 mm long.

Distribution

In 1969 Schmutterer reported the cotton flea beetle from Saudi Arabia, Ethiopia, South Yemen and Sudan. In Sudan the flea beetle was recorded from northern Khartoum, Dadrfur and Equatoria states. The pest seems to be most common in irrigated areas such as the Gezira.

Host plants, damage and economic importance:

The main host plants of the cotton flea beetle are the members of Malvaceae such as cotton and okra.

The most serious damages are caused to young seedlings. Also they cause damage of economic importance by feeding on leaves. The small plant are thus either badly stunted in growth or destroyed on older plants a typical (shot-hole) effect is caused on the leaves.

Okra plants in gardens are also badly infested and injured by the cotton flea beetle. The larvae of *P. puncticollis* feed on the rootless causing damage of economic importance.

Life cycle

Schmutterer (1969) reported that the female lays its small yellow eggs into the soil at the base of the host plant .The larva hatches after 7–11 days and feed for a period of 11-28 days on the rootlets.

Pupation takes place in the soil and the adults emerge after 10-17 days from the pupa. There are many generations in the season.
The adult remains after rain on the host plant for as long as they can find suitable food. They always prefer young growth.

Control
Corrected timing of sowing date can play an important role in reducing flea beetle infestation and damage. Application of insecticides can reduce the damage.

2.3.4 Spotted boll worm *Earias vittella* (Fabricius) (Lepidoptera: Noctuidae)

E. vittella belongs to the Lepidoptera order that is considered as one of largest orders of the class insect.

Distribution
Three species were known as indigenous in Sudan, namely *E. insulana*, *E. zapreoiridis*. The occurrence of *E. vittella* in Sudan was first reported in 1977 in Blue Nile between Sennar and Khartoum.
It was first identified in the Sudan in 1986. In the early stage of the crop the larvae entered the terminal buds of shoots and tunnel downward from the growing points.
Any outbreak of this insect will to economic damage since it will completely destroy at the species of the host plant later on the lower buds and green bolls or fruits.

Host plants
E. vittella is the major pest of cotton and it attacks also few other malvaceous plant such as Hibiscus.
The closely related species *E. insulana* and *E. capreovridis* attack slightly range of host plants (Schmutterer 1977).

Damage and economic importance
In the early stage of the crop the larvae enters the terminal buds of shoots and tunnels downward from the growing points.

The larvae feed on and damage growing vegetative parts developing seed in the cotton bolls, shoots of the main axes, succulent internodes, tops of side branches, young leaves and flower buds (Musa 1989).
This damage finally leads to flowers and bolls shedding, delayed flower formation, premature opening of the attacked bolls, hollowing of the seeds and weakening and staining of cotton fibers.

Morphology
Eggs are small and bluish green. Newly hatched larva is 1-5 mm long; brownish-white has a dark head and prothoracic shield.
A well-developed larva has a brown dorsum showing a white median shriek and a pale yellow or green vender. Dark brown Pupa is enclosed in a dirty white to buff color cocoon (Schmutterer and Koch 1977).

Ecology
The insect was found to occur in high population during rainy season and its number drop in Summer as the temperature increases.
The development period of different stages prolonged during winter, the longevity fecundity and coloration of the adult also fluctuate with environmental temperature and humidity (Schmutterer 1977).

2.3.5 Leaf miner on tomato *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae)

Distribution
Different species of Lm *Liriomyza* were found to occur in many countries throughout the world. However, two species, viz. *L. trifolii* and *L. sativa* Blanchard were the most important ones recorded to cause serious damage to different crops worldwide. Such species are found in many countries in Africa (Fagoone and Toory, 1984).
The pest is recorded, at present, in South Africa, South Eastern and Eastern Asia, in Iraq and Saudi Arabia. In the Sudan, L. spp. are very common insects in northern Shendi, Atbara, Khartoum, Blue Nile, Wad Medani, Kordofan, Kadugli, Kassala, Yambio, Yei, Juba etc., it seems to be absent or very rare in Marra Mountains Darfur and in the extreme North.

Host plants, damage and economic importance

The host –range of the mentioned species of LMs were found to be very wide. *L. trifolii* was found to damage many vegetables and field crops, the pest was mainly reported from families Solanacae, e. g. tomato eggplant, pepper and potato Cucurbitacae, e. g. cucumber and watermelon, legumenosae e. g. common bean and cow pea, Malvaceae, e. g. cotton and Alliaceae, e. g. onion. Some researchers reported that faba bean was found to be as the main host-plant for *L. trifolii*.

Both species of LMs were recorded as major pests attacking the foliage cucurbits and they found on the plant simultaneously Johnson (1987).

Johnson (1987) found that *L. trifolii* was predominant agromzid species found in some localities in Hawaii and composed more than 70% of LMs reared from Solanaceae fields.

On the light of the previous account, LMs were reported to cause considerable damage to tomato and other crops worldwide. It is reported by Johnson (1987) that LMs can cause serious crop losses to the extent that daily pesticides application over 2-5 months was applied to control *L. trifolii* on a single tomato plant action in Oahaio Hawaii.

The larvae of the LMs feed and mine in the parenchatous tissue of the youngest tender leaves.

Ecology

The plant stage and climatic conditions seems to be the main factors affect influencing the occurrence of the *Liriomyza spp*. in the field and their distribution on individual plant. According to Babikir (1989) the infestation of tomato with *L. trifolii* was found to occur early in the season, with the peak being reached by the mid-season. However the infestation was found to be concentrated in the lower half of the individual plant.

Apart from the effect of climatic factors, it has been found in Brazil that the LMS infestation on cucumber was found to be low in summer and progressively increased during autumn and winter. The population size was inversely related to temperature (Lorini and Forester, 1985).

Life history and bionomics

According to observations in India, the mother lays 40-80 eggs singly on the underside of the youngest tender leaves, mainly near the mid ripe. The larvae hatch after 2-6 days and penetrate immediately into the plant tissue. The development takes place under the epidermis, where the caterpillars cause a silvery shining transparence mine. The excreta of the larvae are visible as a dark stripe in the middle of the mine.

The larvae are fully-grown after about a week and usually 10 days. The insect is found in varying numbers the whole year round and there are numerous generations per year.

In his study of the level of infestation and, hence the population build-up of leafminer. In 1997, Satti found the peak of *Liriomyza* spp. to be 6.9-8.6 infested leaves/50leaves.

Cultural control

The removal of weeds and alternative hosts during the dead season may help in reducing the infestation.

2.3.6 Cotton Thrips *Thrips tabaci* (Thysanoptera, Thripidae)

Description

Thrips are minute too small, winged or wingless insects with a very elongate and flat, slender body. Its mouthparts are the piercing-sucking type.

Distribution

Cotton thrips *T. tabaci* are found in many parts of the tropics and sub-tropics. In Sudan the onion thrips is abundant in Kordofan, Kassala, and Blue Nile. The pest is most probably present in the entire country wherever crops grown and sufficient weeds occur (Schmutterer, 1969).

Biology

The metamorphosis is incomplete (hemimetabolous) but certain regarded it as complete (holometabolous). Males are in general very seldom found and are unknown in the Sudan, so that the reproduction in this country is most probably parthenogenetic. The female lays about 50 white bean-shaped eggs by means of ovipositor, in the tissue of host plant the nymphs hatch after an incubation period of a few days and the two nymphal instars pass within a short time.

The first and second instar resembles the adults in appearance and habits, but have no wing pods. The two following instars are called pre-pupa and pupa. They possess distinct wing-pods, do not feed and are inactive. Pupation takes place either on the host plant, on debris on the ground or in the soil about as long as nymph period. The short life cycle enables the pest to develop a number of generations per year and to build up its populations in the favorable conditions.

T. tabaci feed general only, on the paranchymatic tissue of their host plant. They empty the cells, which become silverish after awhile due to the entry of air, when the damage is heavy the plant tissue turns brown and dry up.

Ecology

T. tabaci attacks many host plants of economic importance. Onion transplanted in October and November are well-established before thrips infestations occurrence (January-February) and usually produce high yield without application of insecticides (Burgstallar 1984).

Cool and dry winter months are favorable. Loose, sandy soils are very suitable for pupation whereas heavy clay soils are less suitable (Schmutterer 1969).

Damage

The onion thrips (*Thrips tabaci*) is the major pest found responsible for low yield of a crop. The pest punctures the leaves or stems and suck up the exuding sap, causing the appearance of whitish blotches on the leaves. As the attack increases in severity the tips of the leaves first become blasted and then distorted and later the whole plant may turn brown or yellow, wither and fall over. The insects may be found in greatest numbers between the leaf sheaths and the stem. The bulbs become distorted and remain undersized. A heavy thrips attack can kill young plants, on older plants the yield is considerably reduced.

2.4 Problems of use of synthetic insecticides in the world

Rachel Carson (1962) stated that the large number of chemicals (approximately 500, many were pesticides introduced each year) was possibly making the earth unfit for all life. Insecticides were becoming deadlier and deadlier. Specialists were concerned only about efficacy and were losing the overall picture. Before world war ll, inorganic chemicals were the main pest controls. Arsenals were greatly used, and toxicological problems occurred. Carson emphasized chlorinated hydrocarbons and organophosphates as the main problems leading to bird and fish kills human nervous system disorders, and deaths. She explored the surface and ground water contamination and pointed to leaching, runoff and direct spray as main contamination problems. She explained that water treatment plants did not remove chemicals because multiple chemicals in catch basins could interact to form toxic compounds, and thus cancer hazards from polluted waters would increase in the future.

Carson stated that chemical treatment of soils led to the destruction of beneficial biological species, and that such destruction resulted in imbalance to the ecosystem. Also, wildlife that ate chemically killed worms died as well. She noted the long-term persistence of hydrocarbons in soil and the possible transfer of chemicals into plants grown in such soils. She stated that those government officials had aerial sprayed areas without notifying the public, and that these officials underestimated the safety problems of chemicals. Carson highly praised the desirability and great potential of using biological controls in place of chemicals, as well as use of natural products and less toxic chemicals (e.g., pyrethrins). She pointed out those scientists and government officials' concerns addressed only classical toxicity of pesticides and that no testing was done on effects to wildlife. Regarding residues in food, she stated that Drug Administration was minimal and the tolerance provided a false sense of security, because usually only minimal safety data was available.

Carson discussed the resistance of insects to insecticide at length and indicated that the U.S. Department of Agriculture's solution at the time was the recommended more frequent sprays or greater quantities. She stated that DDT brought on the age resistance and noted that chemical treatment was treadmill that, once started, could not be stopped.

2.5 Problems of vegetable protection in the Sudan

The success of vegetable production depends on:

1) Suitable variety or cultivar

2) Required environment

3) Optimum cultural practices including pest and disease management

4) Efficient marketing channels

If we take the third point, which includes the field of this study, we can observe that the chemical control take the great interest, while the other means of control such as land preparation, seed treatment, sowing date, spacing, method of planting, Transplanting, irrigation, fertilization, and crop rotation are not given the necessary care.

Concerning the chemical control, it is clear that the intensive use of pesticides lead to many problems such as hazards and impacts of the pesticides on the environment, the poor control of pest as consequences of improper use and handle of pesticides and the continuous development of resistance against pesticides by the pest.

Most of the growers of vegetables in Sudan depend mainly on pesticides as tools to minimize the damage caused by pest.

The farmers without the required technical supervision conduct Pest control in vegetable fields.

The insecticides, which are recommended for vegetables, are not much and usually difficult to get, knapsack sprayers are difficult to purchase and to maintain. Under such circumstances the vegetable growers use what ever they could purchase from unauthorized dealers and applies it by any means, even by a bunch of herbs. In central Sudan all most all the vegetable farmers apply synthetic pesticides of which 90% are insecticides.

The work in the field of vegetable protection has been given a significant attention for the whole reasons:

The vegetable fields are concentrated in and around urban areas and also scattered in all cotton schemes the important vegetable pests and their important indigenous natural elements more or less the same target species in cotton fields.

Most insecticides used (illegally) on vegetables are recommended and purchased for cotton.

Most of the misuse of insecticide is taking place in the vegetable fields where the hazards are more pronounced specially in the case of the vegetable which are conSUMed uncooked.

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2.6 Introduction and Distribution of neem in the Sudan

Neem is introduced in the Sudan in 1921 and it is frequent in Kassala area in the east, in towns and villages along the Blue and White Nile, in irrigated areas of the central Sudan and in rained regions in Kordofan and Darfur provinces.

Neem trees, which are grown widely in the Sudan could be a potential source of natural plant protection agents to minimize the yield losses caused by different pest with minimum impacts on the environment cause by synthetic insecticides.

Neem research in the Sudan

Prof. Dr. S. A. Siddig started neem research in the Sudan since 1967. In this respect he started some field trials concerning the control at some vegetable pests using crude extract from neem seeds and leaves. Additionally some extracts were used against some stored grain pests, such as *Trigoderma granarium*. Promising results were obtained from these experiments which leads to additional research studies conducted at Shambat research station.

Which insect pests can be controlled with Neem?

About 413 different species/subspecies of insect pest have been listed by Schmutterer 1995 found to be susceptible to neem products. The listed species/subspecies belong to different insect orders most of them were Lepidoptera (136) and Coleopteran (79).

2.7 Active principals of Neem

Several biologically active compounds have been isolated from different parts of neem tree. Several vilasinin derivatives, salanins, salanols, salasnolactomes, vepaol, isovepaol, epoxyazadirachdone, gedunin, 7-deacetylgedunin have been isolated from neem kernels.
Azadirachtin is the most potent growth regulator and antifeedant (Butterworth and Morgan, 1968; Warthen et al., 1978).

2.7.1 Azadirachtin

Chemical Structure and biosynthesis

The triterpenoid azadirachtin was first isolated from the seeds of the tropical neem tree by Butterworth and Morgan (1968). (C35 H44 O16). Its definite structural formula, which resembles somewhat that of ecdysone, was finally explained in 1985 by kraus et al. and by Bilton et al. (Fig. A).

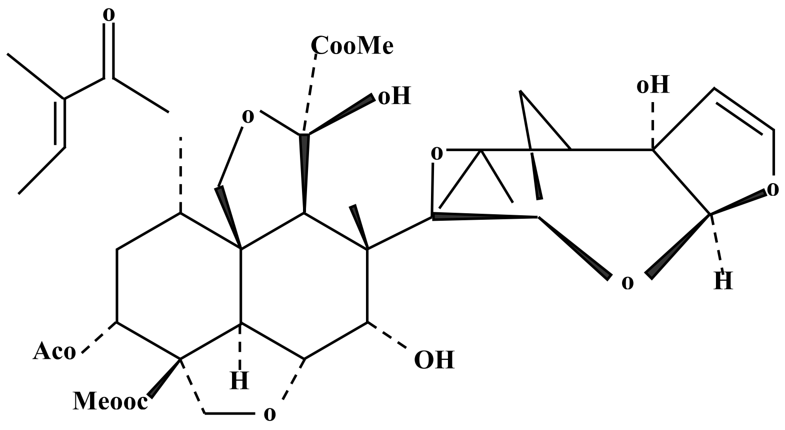

Fig. A Structural formula of azadirachtin

Azadirachtin is a limonoid alleliochemical (Butterworth & Morgan, 1971, Broughton et al., 1986) present in the fruits and other tissues of the tropical Neem tree (*Azadirachta indica*). The fruit is the most important aspect of neem that affects insects in various ways. The leaves, which may also be used for pest control, may reach a length of 30 cm.

2.7.2 Mode of action of Neem

1) Settling Behavior

Settling behavior of both *R. padi* and *S. avenae* was strongly based towards the untreated seedlings of those treated with low concentrations of azadirachtin. Concentrations of <500 PPM were effective with topical application and probing activity was reduced for at least 4 days after application (West, 1992).

Crude neem extracts deters settling and reduces feeding in *M. persicae* (Griffiths et al., 1978, 1989).

2) Oviposition Behavior

The females of some lepidopterous insects are repelled by neem products on treated plant parts or other substrates and will not lay eggs on them under laboratory conditions. This has been observed in the cabbage webworm, *Crocidolomia binotaliS*, THE Afro-Asian cotton bollworm, *Helicoverpa armigera,* and the fall armyworm, *Spodoptera frugiperda*. The dipterous insect, *Lucilia serricata,* was also deterred from egg lying, as were some beetles (*Callosobruchus* spp.).

3) Feeding Behavior

Azadirachtin is a potent insect antifeedant.

(I) Effects on deterrent and other chemoreceptors resulting in antifeedancy

The antifeedant effects of azadirachtin have been reported for many species of insects (Warthen, 1989). The trials carried out by Grill & Lewis showed that desert locusts *(S. gregaria*) were deterred form feeding on the aerial parts of plants growing in treated composts as a result of systemic movement of azadirachtin from roots of bean plants.

AZA completely inhibited feeding of the very sensitive locust when it was offered on sucrose-treated filter paper as a 1.5-6 X.10-8M solution, i.e. 10-40 µg/1- (Butterworth, J. H.; Morgan, E. D. 1971) (Haskel, et al. 1969).

Reduction of feeding was also observed after topical application or injection of neem derivatives, including AZA and alcoholic neem seed kernel extract. This means that the reduction of food intake by insects is not only gustatory-which means that sensory organs of the mouth parts-but also non-gustatory regulate it. These two phagodeterrent/antifeedant effects were called primary and secondary (Schmutterer, 1985).

When given by injection to tobacco hornworm caterpillars, *Manduca sexta*, the allelochemical azadirachtin inhibits growth without reducing food intake.

4) Metamorphosis

Azadirachtin has different influence on the metamorphosis of the insects resulting in various morphogenetic defects as well as mortality, depending on the concentration applied.

The IGR effect of neem derivatives such as methanolic neem leaf extract and azadirachtin in larvae and nymphs of insects was first observed in 1972 in Heteroptera (Leuschner, 1972) and Lepidoptera (Ruscoe, 1972).

Injection of azadirachtin (0.75µg/g body weight) into last-instar nymphs of the American cockroach*, periplaneta americana*, delayed the molting process by a number of days (Quadri, et al. 1978).

Molting, if it occurred, was incomplete and resulted in the death of the tested insects.

Steets & Schmutterer (1975) in the Mexican bean beetle first observed the effect of azadirachtin on the fecundity of the insects, *E. varivestis* Muls. One-year later Steets (1976) reported similar results with L. *decemlineata*, in a short- term (44 days) experiment with a few females. In the meantime several other authors discovered fecundity-reducing and sterilizing effects of neem on Heteroptera, Homoptera, Lepidoptera and Diptera (Ochse, 1982; Ascher et al., 1984; Von der Heyde et al., 1984; Stein 1984).

Azadirachtin is an effective sterilant. After uptake of active material, females of some insect pest species, for instance the Coleopteran potato beetle, *Leptinotarsa decemlineata*, are sterilized to a high degree, sometimes completely (Steels, 1976; Schmutterer 1987). The life span of treated females is prolonged but their food consumption is very low.

5) Fitness (Vigor; Quality)

Indirect effects on most tissues studied resulting in an overall loss of fitness of the insect (Mordue, & Blackwell 1993).

The fitness of insects is often reduced after application of dosages so low that molting is not disrupted. Adults resulting from such treatments are for instance unable to copulate, such as males of *Oncopeltus fasciatus* (Dorn, 1986, Dorn et al., 1987), or cannot recognize the male pheromone, such as females of the fruit fly *Ceratitis capitata* (Steffens and Schmutterer, 1982). In addition, adults of these flies and those of *Phormia terrae*-novae lost their fling ability (Bayer, 1986; Wilps, 1987).

In some Coleopteran neem ingredients caused a prolongation of lifespan of the adults, in others, a reduction. In homopterous insects, the longevity was negatively influenced by neem derivatives.

3 MATERIALS AND METHODS

3.1 Description of experiments

1) Location and years

The experiments of this study were conducted on research fields belonging to Shambat research Station and others belonging to the University of the Sudan.
The research fields are situated on the eastern bank of the river Nile in the Shambat area located in Khartoum north, in the Sudan.
Sudan is the largest African country, covering an area of nearly one million square miles. It shares borders with Egypt and Libya to the north, Ethiopia and the Red Sea to the east, Kenya Uganda and Zaire to the south, Chad and the Central African Republic to the west.
The Nile, the longest river in the world (6,671km) runs through the country from south to north.
The capital, Khartoum, is situated at the confluence of the Blue and White Niles. With Omdurman, the old national capital and Khartoum North it forms one unit called the Three Towns Capital.
The climate is hot and dry from April to October with relative humidity (RH) 16-54%, mean temperature (M. TEM.) 31-35º C, and pleasantly warm from November to March, RH 24-31% and M. TEM. 21-29º. The rainy season in Khartoum is July and August, RH 44-54% and M. TEM. 31-35º C). The table of frequency of weather phenomena for Shambat area can be seen in the appendix (table 13a).
The experiments were conducted during the years 1997-1999.

2) Soil

The soil in the experiments area is alkaline clay with ph 7 ; deficient in nitrogen. To correct the defiecncy amount of 120 kg/feddan (ca. 300 kg /ha) urea was added to each crop in two different splits with 3 weeks intervals.

3) Lay out of experiments

The land for each crop was divided into 15 plots in the first and second season, while in the third season the number was reduced to 12 plots according to the lower number of treatments which were 4 in this season compared with 5 in the first and second. Each treatment had three replications.

The plot size was 6 x 7 m with a different number of ridges, depending on the vegetable crop.

In okra plots, 70 and 30 cm were left as spaces between and in the rows, respectively. While in tomato the spaces were 100 and 50 cm, respectively.

For onion the spaces were 60 cm between the rows and 10 cm in the rows.

4) The design of the experiments:

Completely randomized block design (CRBD) was used in this study.

5) Cultural practices

The normal agronomic practices (e. g. soil preparation, irrigation, fertilization) recommended for growing vegetables in the trial area taken from the Handbook of Vegetable Production edited by Burgstaller et al. 1984, were followed.

The seeds were sown directly and the necessary thinning was done later.

3.2 Crops and treatments

The results detected that the aqueous neem seed kernel powder water extract was very effective in reducing the number of cotton aphids. *A. gossypii* infesting okra, particularly, when applied as foliar spray. The application of the same extracts in the soil showed poor activity when applied as drench. Accordingly, it was clear that the method of application affects the effectiveness of the extract.

Okra

The local Cultivar Khartoumia (spiny) was used in this study.

The treatments in the years 1997 and 1998 were as follows:

(A) Untreated control (C)

(B) NeemAzal.(Naz)

(C) Aqueous Neem Kernel Powder Extract (ANKE)

(D) Neem Kernel Powder in soil (NKPS)

(E) Sumicidin (SUM)

In the year 1999, the effects of compounds with the best effects, namely, ANKE and NeemAzal was compared with the commonly used synthetic pyrethroid, Sumicidin, so the treatments were as follows:

(A) Untreated control

(B) NeemAzal

(C) Aqueous Neem Kernel Powder Extract

(D) Sumicidin

Tomato

The variety Strain B, which has a good heat tolerance, was used in this study.

The treatments were as follows

(A) Untreated control

(B) NeemAzal

(C) Aqueous Neem Kernel Powder Extract

(D) Neem Kernel Powder in soil

(E) Sumicidin

Onion

The local Cultivar Kamleen Asfar with yellow bulbs was used.

The treatments in the year 1998 were as follows:

(A) Untreated control

(B) NeemAzal

(C) Aqueous Neem Kernel Powder Extract

(D) Aqueous Neem Leaf Extract

(E) Sumicidin

In the year 1999 they were as follows:

(A) Untreated control

(B) NeemAzal

(C) Aqueous Neem Kernel Powder Extract

(D) Sumicidin

3.3 Insects

The effects of the above listed treatments against the following insect were studied:

White fly (*Bemisia tabaci*) on okra and tomato

Cotton aphid (*A. gossypii*) on okra and tomato

Spotted boll worm(*E. vittella)* on okra

Flea beetle (*P. puncticollis*) on okra

Leaf miner (L. *trifolii*) on tomato

Thrips (*T. tabaci*) on onion

3.4 Chemicals

NeemAzal (Naz)

Research samples of NeemAzal T/S 1% were prepared by the firma Trifolion in Germany. The main active ingredient in this formulation is azadirachtin (A), the main principle of neem *Azadirachta indica.* The product was applied at a concentration of 5ml/liter water.

Aqueous Neem kernel Extract (ANKE)

The spray solution was prepared as water extract of the kernel of neem fruits at conc. of 50g/l water with the following method:

3.4.1 Preparation of Neem kernel powder

The dry fruits of neem were crushed lightly to break them, after their separation, the seed kernel were then powdered using an electronic blender.

3.4.2 Preparation of spraying solutions.

The kernel powder was mixed then with sesame oil at rate of 35g oil /50g neem kernel. One liter of water had to be added to the mixture, which had to be stirred and left for at least 5 hours (The shaking during this period at different intervals is important for the extraction process). The solution had to be filtered through fine gauze (cloth) to remove the bigger particles; the filtered solution was then ready for field application (spraying). The spraying was done in the evening using knapsack sprayer, keeping in mind that good coverage of the treated target is important to increase the effect of the applied chemicals.
For comparing the effectiveness of different methods of application, local neem was applied additional to the spraying in the form of powder and liquid into the soil.

Neem Kernel Powder applied into the Soil (NKPS)

The dry fruits of neem were crushed lightly to break them. After their separation, the seed kernels were then powdered using an electronic blender. The kernel powder was then applied by hand into the soil at the plant base.

Aqueous Neem kernel Extract applied into the Soil (ANKES)

The aqueous extract was prepared, as it had been described in (B) without addition of sesame oil. The same knapsack sprayer was used to deliver the neem extract under pressure into the soil at the plant base after removing the nozzle from the device.

Aqueous Neem Leaf Extract (ANLE)

Fresh leaves of the neem tree were left for 24 hours in the sun and then kept for several days in room conditions to dry. The preparation of the spray solutions thereafter took the same steps as had been described in (B) without addition of sesame oil.

Sumicidin (SUM)

The trade product of Sumitomo Chemical Co. ltd. Japan was used, which contains the synthetic pyrethroid fenvalerate at conc. of 20% w/w. the product was used at 2ml/l water.

3.4.3 Application of Chemicals

The spraying was done in the evening using a knapsack sprayer, keeping in mind that the good coverage of the treated target is important to increase the efficiency of the applied chemicals.

The data collected in this experiment beside other experiments in this study showed that the number of aphids reached its minimum at the fourth day after each treatment and then increased again to reach its maximum within seven days after treatment. According to these observations, the application of neem was then carried out until the end of this study with weekly intervals.

Foliar sprays were applied 8 times (seven-day interval) using the knapsack sprayer. The rate of application was 50g/l.

Average spray volume/plot for young plants was (0.5), and later it was (1L).

The application of the ANKE into the soil was also done by using the same knapsack sprayer used for spraying after removing its nozzle and injecting the solution in the soil around the plant.

Neem powder was placed by hand into small holes around the plant crowns into the soil at rate of 2g/plant applied in two different splits with about three weeks intervals starting three weeks after the sowing of the seeds.

3.5 Data collection and the evaluation of the effects of the treatments

Different criteria were taken to evaluate the effect of different insecticides used in this study.

A) The count of insects:

This was done by counting the number of insects on 10 different plants, which were selected randomly (5 plants from each crossed line of the plot).

In each plant 5 leaves were selected, two from the upper, one from the middle, and two leaves from the lower section of the plant.

At the beginning, the count was done twice weekly, 4 days after treatment and one day before the next treatment. Later, it was done once weekly.

The result of this experiment was demonstrated by a continuous number of insect counts. The average number of each insect detected in each count was computed for each treatment.

B) The count of damaged leaves

The number of damaged leaves per plant was counted to study the effects of the treatments on the leaf miner and the flea beetle. The number of plants per plot was 10, selected as it was described in (A).

C) The count of infested plants:

In order to study the effects on the spotted bollworm. The number of the infested plants in each plot was counted.

D) The yield

The yield was the second criteria taken into consideration to evaluate this effect.

The yield of okra was done by picking-up the fruits every two to three days. The weight of the collected fruits in each plot was registered and later subjected to statistical analysis.

The harvest period was continued for 9-10 weeks.

The harvest period of tomato ripe fruits was continued for about seven weeks with 4-7 days intervals.

Onion was harvested in one day at the end of the season. A number of 200 bulbs from each plot were weighed.

E) Plant growth

The height of the plant, number of leaves, and number of branches were also considered as parameters by the evaluation of the effect on okra.

3.6 Statistical analysis

The data collected were transformed using log (x+1) to remove dependency of the variances on the means. Transformed values were then subjected to an analysis of variance **(ANOVA),** while following the Least Significant Differences test **(L.S.D.)** using the program statistical packet for social science **(SPSS)** version 10 for Windows. To compare means of treated plots with control plots, significant differences were noticed for P = 0.05 for all trials.

For the weight ascertainment of onion 200 bulb of each plot were harvested and their kg-weight was recorded. To provide sufficient data on the efficiency of different treatments, the means of yield from control plots were set at 100 %.

4 RESULTS

4.1 The effects of different treatments against *A. gossypii* on Okra 1998

Control Treatment

Figure1 shows the number of insects in the control treatment was found to follow the normal seasonal trend of population incidence. The number of aphids follows an increase to reach the peak (ca. 41 individuals/leaf) during the last week of February and reaches the minimum during the first week of April. The mean number of aphids in these untreated control plots was about 21 individuals/leaf (fig. 2).

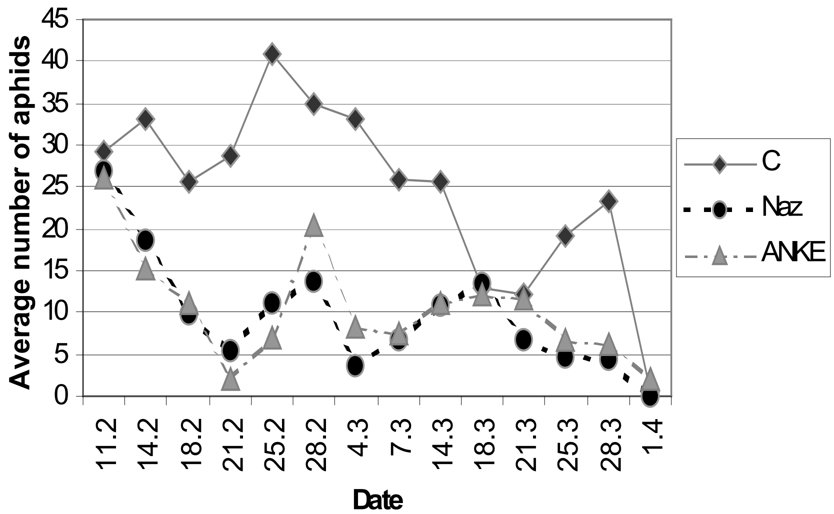

Fig. 1: Average number/leaf of cotton aphids in the Control, NeemAzal (Naz) and ANKE treatments of Okra 1998

NeemAzal Treatment

As it can be seen in fig. 1, the treatments of infested okra plants with NeemAzal led to a clear reduction of the aphid population, which showed a continuous decrease starting from about six days after the first spraying (February 6) to reach about 5 individuals by February 21. After that, the population showed alternated increases and decreases, but the number was still kept under 15 indivduals/leaf, and then reached the minimum during the first week of April.

The mean number of aphids in this treatment was about 8 individuals/leaf (fig. 2). The total reduction of aphid number was by ca. 62%. The result of the statistical analysis of the data revealed significant difference between the untreated control and NeemAzal treatment (table 1).

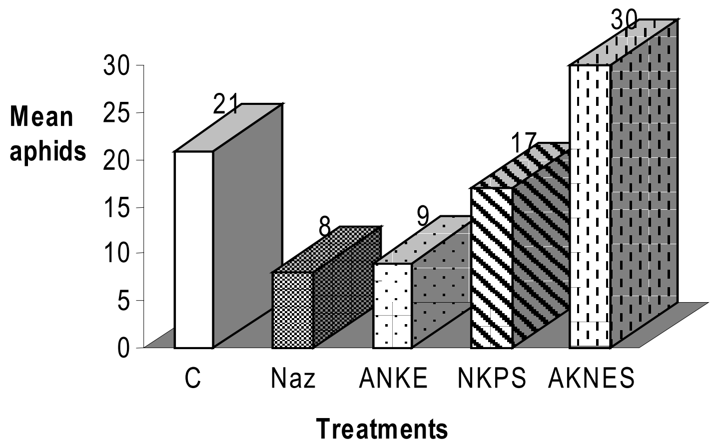

Fig. 2: The mean number of individuals/leaf of *A. gossypii* on Okra 1998

ANKE Treatment

The aphids on okra plants treated with ANKE found to follow a similar trend of population incidence as the NeemAzal treatment. The reduction of aphids to about 9 individuals/leaf (ca. 57%) lower than the control was also significant.

NKPS and ANKES Treatment

In NKPS treatment, the number of aphids was found to be about 19% lower than that of the untreated control, but the statistical analysis of the data revealed no significant difference between the two treatments.

ANKES treatment showed a number of aphids higher than that of the untreated control .

The statistical analysis showed significant difference between both of these treatments on one side and ANKE and NeemAzal on the other side (table 1).

Table 1: The result of the statistical analysis of the effects of different treatments against *A. gossypii* on Okra 1998

	Control	NeemAzal	ANKE	NKPS	ANKES
Control					
NeemAzal	*			*	*
ANKE	*			*	*
NKPS					
ANKES					

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

(more details about the results of the statistical analysis are to be found in the appendix)

4.2 The effects of different treatments against *A. gossypii* on Okra 1999

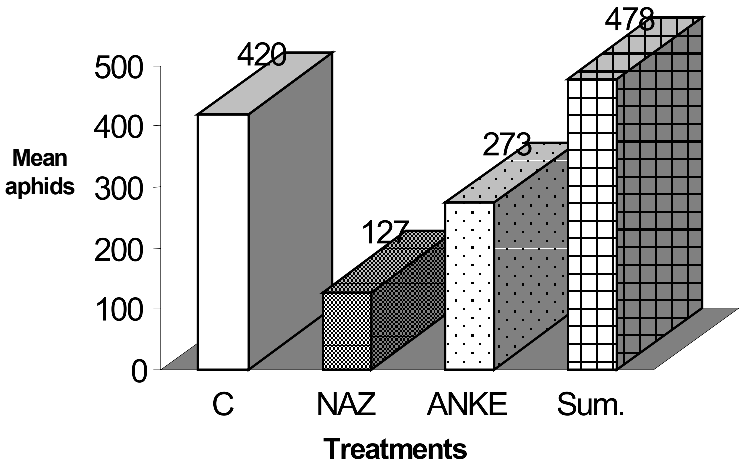

Fig. 3: The Mean number of cotton aphids in each treatment of Okra 1999

Control Treatment

The mean number of aphids was much higher in the control of Okra 1999 (fig. 3) than that of Okra 1998 (fig. 2) (420 and 21, respectively).

NeemAzal Treatment

As it can be seen in fig. 3, the mean number of aphids in NeemAzal treatment is lower than that of the control and reached ca. 127 individuals /leaf. The reduction was about 70% of the untreated control. According to the result of the statistical analysis, the difference was significant (table 2).

ANKE Treatment

The treatments of okra plants with ANKE resulted in the reduction of aphids number to a mean of ca. 273 individuals / leaf. The reduction was ca. 35% . The statistical analysis of the results showed no significant difference between the two treatments.

Sumicidin Treatment

Unexpectedly, the number of aphids in the Sumicidin treatment was higher than in the control, but this was not significant.

Table 2: The result of the statistical analysis of the effects of different treatments against *A. gossypii* on Okra 1999

	Control	NeemAzal	ANKE	SUM
Control				
NeemAzal	*			*
ANKE				*
SUM				

Multiple Range Tests: LSD test with significance level 05
(*) Indicates significant differences

4.3 The effects of different treatments against *Earias vittella* on Okra 1998

Control Treatment

As it can be seen in fig. 4, the number of okra plants infested with the larvae of *E. vittella* increased gradually to reach the peak (about 16) during by the 6th count in 23 of March and then decreased. A mean of ca. 10 infested plants per plot were recorded (fig. 5).

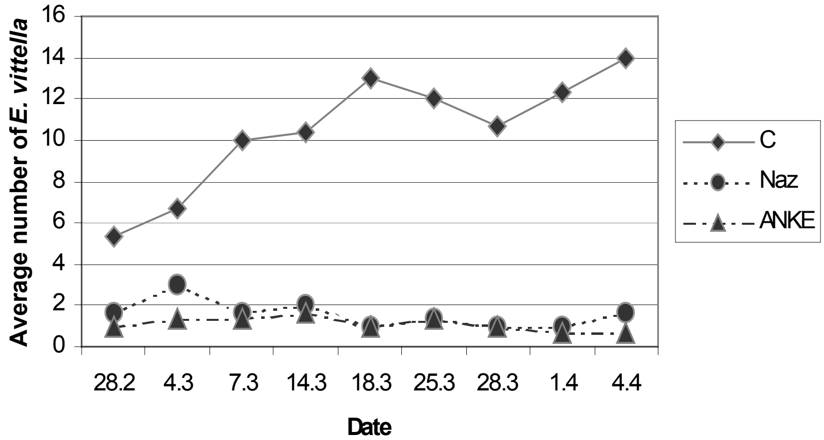

Fig. 4: The average number of plants/plot infested with the larvae of *E. vittella*

NeemAzal Treatment

NeemAzal showed very high efficacy in the reduction of the infestation with *E. vittella*. Only two infested plants per plot were recorded (80% reduction). In comparison with the control, the differences of NKPS and ANKES were significant.

ANKE Treatment

ANKE treatment exhibited the highest rate of reduction of infestation in this experiment. Only one plant found to be infested with the larval stage of *E. vittella* (90% reduction). The result of the statistical analysis of the data shown in table 3 reveals a lower significant difference than the control NKPS and ANKE.

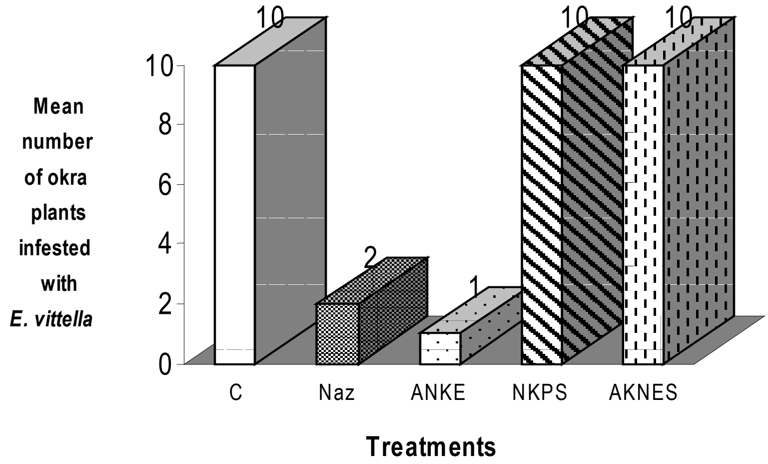

Fig. 5: The mean number of plants infested with *E. vittella* in each treatment of Okra 1998.

NKPS and ANKES Treatments

The number of infested plants in NKPS and ANKE treatments was almost the same as in the untreated control. In both of the treatments, about 10 plants were infested. The application of NKPS and ANKE did not lead to any reduction of the infestation with the target insect in this experiment.

Table 3: The result of the statistical analysis of the effects of different treatments against *E. vittella* on Okra 1998

	Control	NeemAzal	ANKE	NKPS	ANKPES
Control			-		
NeemAzal	*			*	*
ANKE	*			*	*
NKPS					
ANKES					

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.4 The effects of different treatments against *P. puncticollis* on Okra 1998

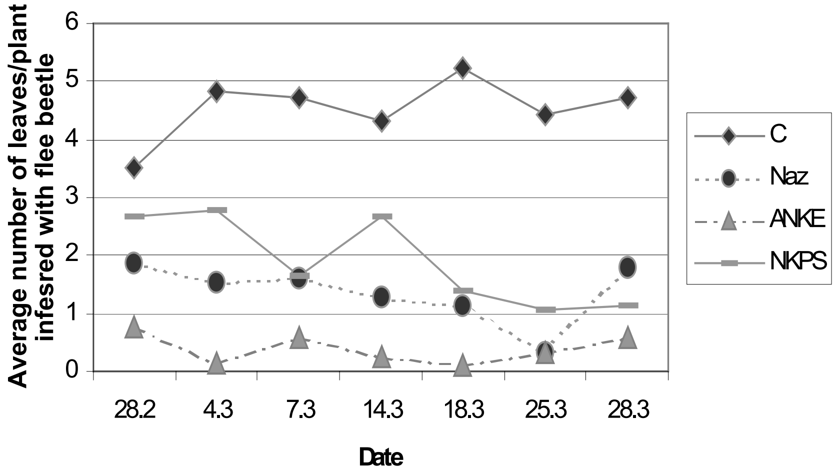

Fig. 6: The average number of leaves/plant damaged by *P. puncticollis* in each treatment of Okra 1998

Control Treatment

The mean number of leaves/plant damaged by adult of flea beetle was ca. 5 (fig. 7).

NeemAzal Treatment

Low number of leaves/plant damaged by flea beetle was found in this treatment (fig. 7). The rate of the reduction of the number to 1 is equal to 80% lower than the number in the control.

As it can be seen in table 4, the statistical evaluation of the result revealed significant difference between this treatment and the untreated control.

ANKE Treatment

The lowest number of infected leaves was recorded in this treatment. The reduction to a mean of .4 was about 91% less than the control.

Statistically, this number differs from the number in the control significantly.

NKPS Treatment

About a 60% reduction of the number of the damaged leaves was recorded in this treatment. The difference was significant in comparison with the ANKE and NKPS.

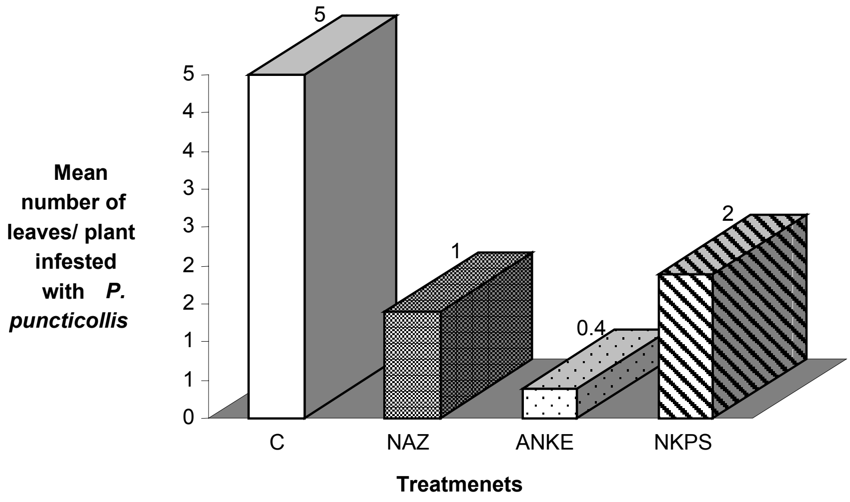

Fig. 7: The mean number of leaves damaged by *P. puncticollis* on Okra 1998

Table 4: The result of the statistical analysis of the effects of different treatments against *P. puncticollis* on Okra 1998

	Control	NeemAzal	ANKE	NKPS
Control				
NeemAzal	*			
ANKE	*			
NKPS	*			

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.5 The effects of different treatments against *Bemisia tabaci* on Okra 1998

Control Treatment

In the control treatment the number of insects found to follow the normal seasonal trend of population incidence. It increases continuously by the different counts (except the 5th count on of March 7) to reach the peak (about 28 adult/leaf) on 25th of the same month, and then dropped down (fig. 8). A mean number of 12 adults per leaf was recorded (fig. 9).

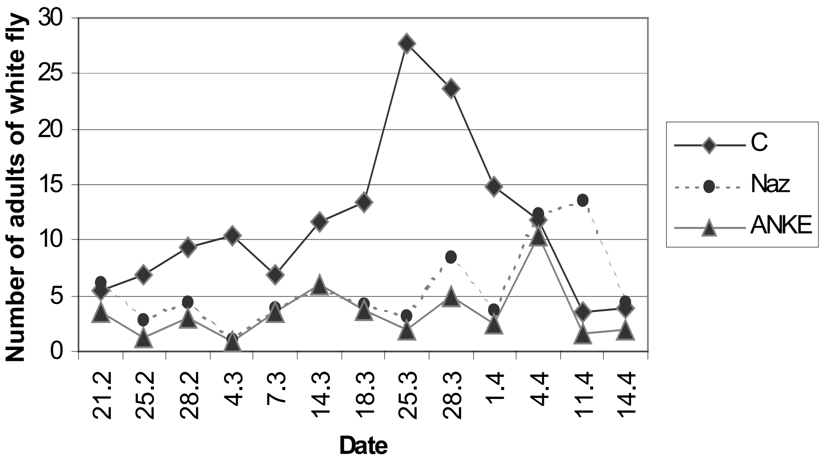

Fig. 8: The average number of adults/leaf of *B. tabaci* in the Control, NeemAzal and ANKE treatments of Okra 1998

NeemAzal Treatment

As it can be seen in fig. 8, the spray application of NeemAzal suppressed the population of *B. tabaci* continuously under the level of the untreated control except for the last three counts. The mean number of insect in this treatment was 5 adults/leaf (fig. 9). The reduction of the adult number by about 58% was statistically different from the control (table 5).

A mean of 5 insects was recorded in this treatment. The statistical analysis of the result (table 5) revealed no significant difference between this number and that of the control.

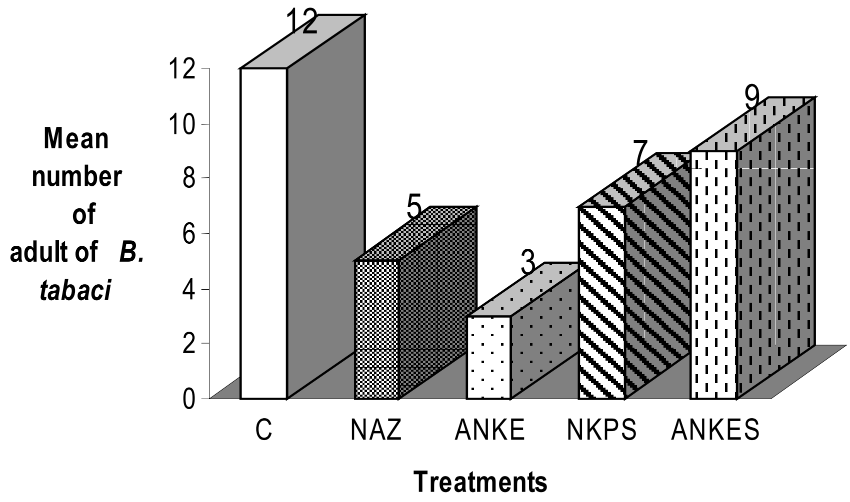

Fig. 9: The mean number of adults/leaf of *B . tabaci* in the Control and each treatment of Okra 1998

ANKE Treatment

ANKE succeeded to keep the population incidence of *B. tabaci* under that of the control and NeemAzal treatment (fig. 8). A mean of only 3 adults/leaf (fig. 9) was recorded in this treatment, where the reduction was about 75% under the control. The result of the statistical analysis (table 5) showed a significant difference between the number in this treatment and that in the control.

NKPS Treatment

As it can be seen in fig. 10, the level of infestation with *B. tabaci* was always kept under that of the control. ANK applied into the soil reduced the number of white fly by about 42% under the control (A mean of 7 and 12 respectively) (fig. 9). A significant difference between the two treatments is shown in table 5.

ANKES Treatment

As it can be seen in fig. 10, the application of ANKE into the soil resulted in a clear reduction of the number of white flies. The mean number of the insects in this treatment was about 9 adults (fig. 9), which equals to a reduction in the number in the control by 33%. The difference with the control was significant (table 5).

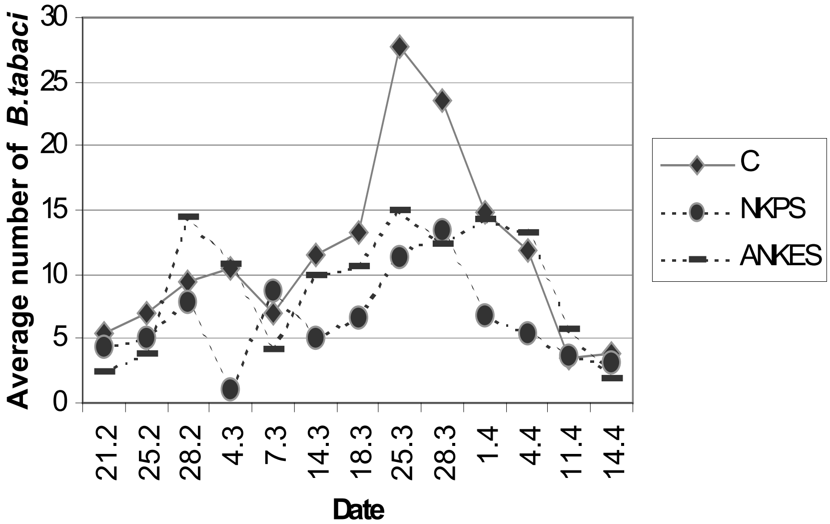

Fig. 10: The average number of adults/leaf of *B. tabaci* in the Control, NKPS and ANKES treatments of Okra 1998

Table 5: The result of the statistical analysis of the effects of different treatments against *B. tabaci* on Okra 1998.

	Control	NeemAzal	ANKE	NKPS	ANKES
Control					
NeemAzal	*				
ANKE	*				
NKPS	*				
ANKES	*				

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.6 The effects of different treatments on the yield of Okra 1997

Control Treatment

As it can be seen in fig. 11, the yield started very low and increased to reach the peak (about 1000 g) during the first week of May and then dropped.

An a mount of about 28.3 kg of okra fruits was harvested from these untreated control plots (fig. 12). This yield is relatively lower than the normal rate, which can be seen in fig. 14 (about 37 kg).

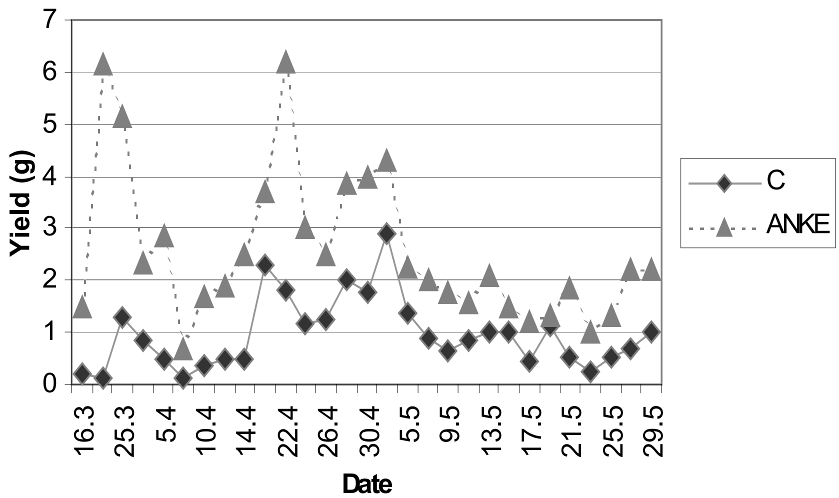

Fig. 11: The average yield (g/plot) in the Control and NeemAzal treatment of Okra 1997

NeemAzal Treatment

The yield of okra in this treatment showed almost the same trend as in the control, but on a higher level.

The application of NeemAzal on okra plants resulted in the increase of the yield to about 69.4 kg (an increase of about 145%).

The statistical analysis of the collected data (table 7) revealed a significant difference between this yield and that of the control. The difference is significant also in comparison with the NKPS and ANKE treatments.

ANKE Treatment

The spray application of ANKE led to an increase in okra yield during the first week of harvest to about 300% over the control (fig. 11). The yield then decreased and start to increase again to reach another peak (>2000 g) during the first week of May and then dropped.

About 162% increase in yield was obtained in this treatment. A total amount of about 73.9 kg was recorded. The difference is significantly higher over the control, NKPS and ANKES.

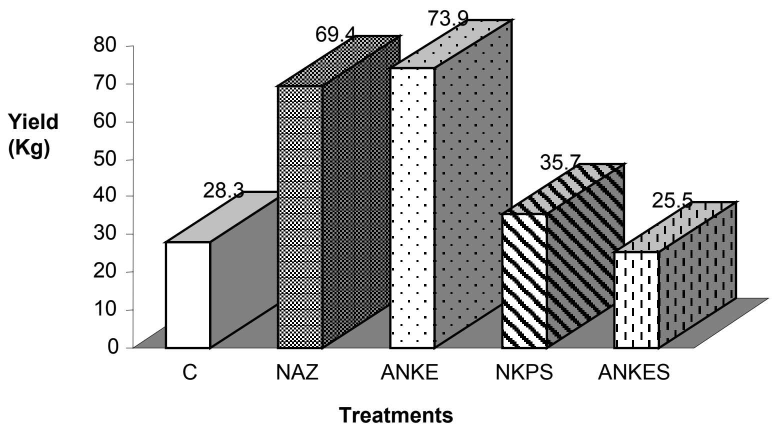

Fig. 12: The total yield in (kg/3plots) of the Control, NeemAzal, ANKE, NKPS and ANKES treatments of Okra 1997

NKPS Treatment

NKPS treatment gave about 32% increase in the yield. The total yield of this treatment was about 37.7 kg of okra, which has no significant difference with the control and at the same time significantly lower than ANKE and NeemAzal treatments.

ANKES Treatment

The yield of okra in this treatment was less than in the control. Only about 25.5 kg were collected from this treatment. This yield is significant lower than that of ANKE and NeemAzal.

Table 6: The result of the statistical analysis of the effects of different treatments on the yield of Okra 1997.

	Control	NeemAzal	ANKE	NKPS	ANKES
Control					
NeemAzal	*				*
ANKE	*				*
NKPS					
ANKES					

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.7 The effects of different treatments on the yield of Okra 1998

Control Treatment

The relatively high temperature degrees together with the relatively low rate of aphid population led to better growth and yield of okra during this trial period. The curve of yield of okra of this untreated control plots was found to follow the normal trend (fig. 13). Amount of about 37,8 kg of okra fruits (fig. 14) was harvested from these untreated control plots. In comparison with the total yield of the first year trial (fig. 12), an increase of > 60% was recorded.

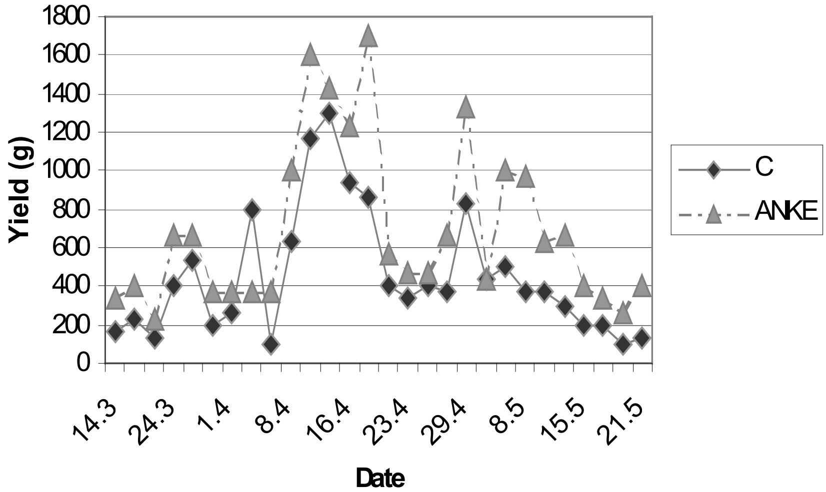

Fig. 13: The average yield (g/plot) in the Control and ANKE treatment of Okra 1998.

NeemAzal Treatment

In contrast with the yield in the control, the yield of NeemAzal treatment in this year (fig. 14) was lower than the previous year (fig. 12), which was 69.4 kg and 51 kg respectively. Consequently the increase in yield was also lower, which was only about 30% in comparison with 145% in the previous year, but the difference with the control was still significant (table 7).

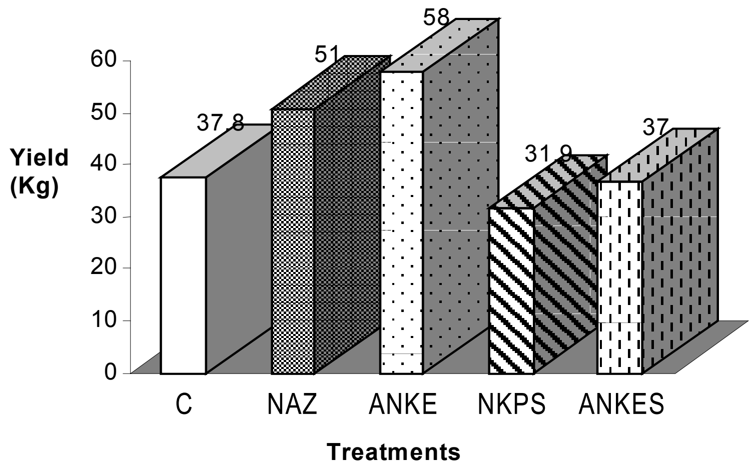

Fig. 14: The total yield (kg/3plots) of the Control, NeemAzal, ANKE, NKPS and ANKES treatments of Okra 1998

ANKE Treatment

The trend of yield of okra in this treatment is similar to that in NeemAzal treatment. The rate of increase in yield in this year was about 52%, compared to 162% in the previous year. The difference with the control was still significant.

NKPS and ANKES Treatments

NKPS treatment gave a yield lower than the control, while the yield in ANKES was almost the same as that in the control.

Table 7: The result of the statistical analysis of the effects of different treatments on the yield of Okra 1998

	Control	NeemAzal	ANKE	NKPS	ANKES
Control					
NeemAzal	*			*	*
ANKE	*			*	*
NKPS					
ANKES					

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.8 The effects of different treatments on the yield of Okra 1999

Control Treatment

A total yield of about 29kg (fig. 16) was recorded from these untreated plots. Generally, the yield in this experimentation period was less than the previous year, but almost the same as the first year (97). This could be attributed to the heavy infestation of aphids (fig. 3).

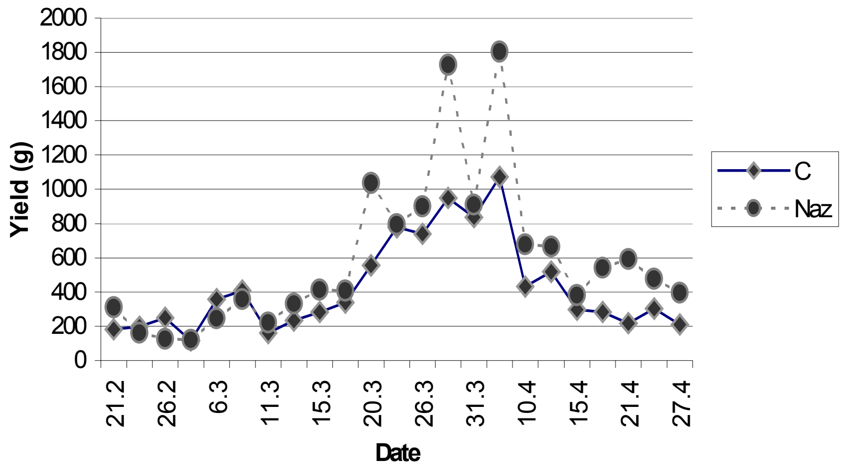

Fig. 15: The average yield (g/plot) of the Control and NeemAzal treatment of Okra 1999

NeemAzal Treatment

The treatment of okra plants with NeemAzal resulted in high yield. A total of about 41.4 kg was recorded (fig. 16). The increase was about 43% over the control. Statistically, this increase in the yield of okra was found to be significant in comparison with the control and Sumicidin treatments (table 8).

ANKE Treatment

The yield in the plots treated with ANKE was more than that in the control and SUM treatments and reached about 36.9 kg. The increase was about 28% over the control. The statistical analysis of the yield data revealed no significant difference with the control and the other treatments.

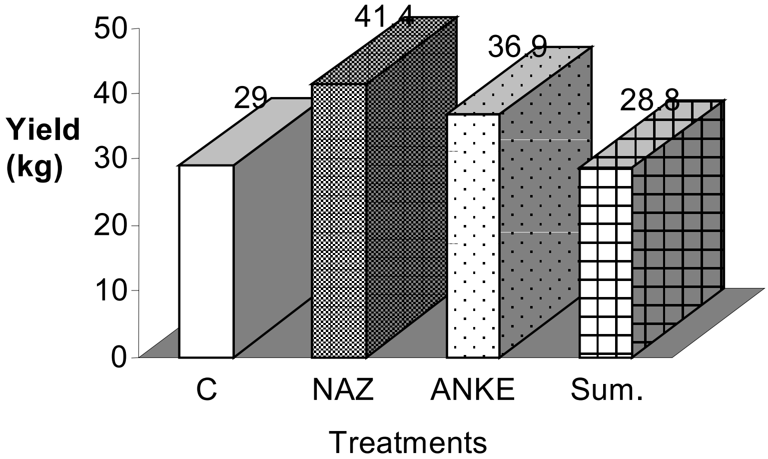

Fig. 16: The total yield (kg/3plots) of the Control, NeemAzal, ANKE, and Sumicidin treatments of Okra 1999

Sumicidin Treatment

The yield of this treatment was almost the same as in the control. The difference in yield was significant in comparison with NeemAzal treatment.

Table 8: The result of the statistical analysis of the effects of different treatments on the yield of Okra 1999

	Control	NeemAzal	ANKE	SUM
Control				
NeemAzal	*			*
ANKE				
SUM				

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.9 The effects of different treatments against *Aphis gossypii* on Tomato 1998

Control Treatment

The number of aphids in the control treatment follows the normal trend of population incidence. It increased to reach the peak (about 32 individuals during the last week of January and then decreased (Fig. 17). A mean of 10 individuals was recorded (fig. 18).

NeemAzal Treatment

NeemAzal succeeded in the reduction of aphids to about 9 individuals/leaf (10%), but the difference with the control was not significant (table 9).

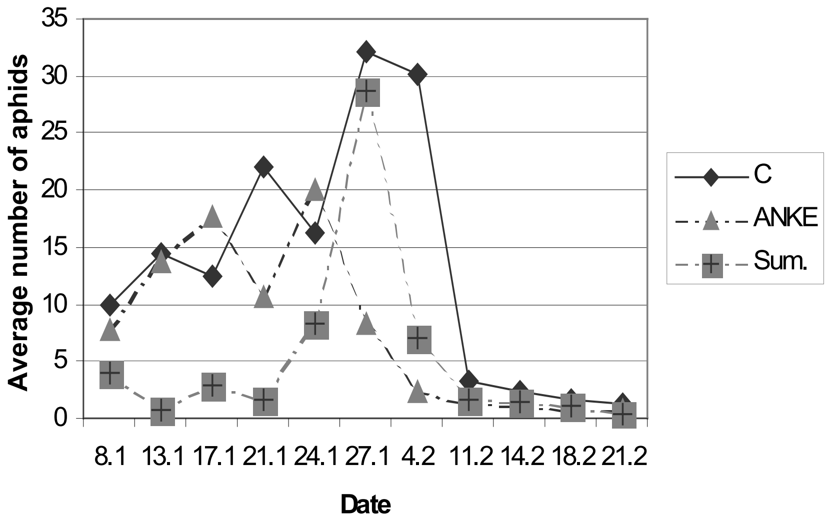

Fig. 17: The average number/leaf of *A. gossypii* in the Control, ANKE, and Sumicidin treatment of Tomato 1998

ANKE Treatment

The number of aphids increased to reach the peak (about 20 individuals) on January 24 and then dropped (fig. 17). The number of aphids in this treatment was 40% lower than in the control and NKPS. About 6 individuals/leaf were found (fig. 18). The statistical analysis showed no significant difference between this treatment and the control (table 9).

NKPS Treatment

In this treatment the population of aphids was the same as in the control (fig. 18).

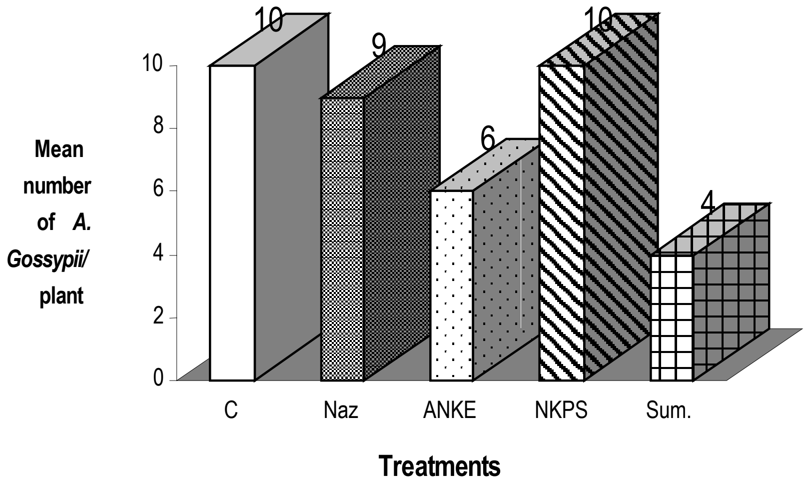

Fig. 18: Mean number of aphids/leaf in each treatment of Tomato 1998

Sumicidin Treatment

The spray application of Sumicidin on tomato plants resulted in a high reduction of aphid population during the first period until of January 21 and then the number increased to reach the peak (about 28 individuals) on the 27th of the same month and then dropped (fig. 17). The mean number of aphids in this treatment was about 4 individuals/leaf (fig. 18). The reduction was about 60% lower than the number in the untreated control. The difference between this treatment and the control is significant (table 9).

Table 9: The result of the statistical analysis of the effects of different treatments against *A. gossypii* on Tomato 1998

	Control	NeemAzal	ANKE	NKPS	SUM
Control					
NeemAzal					
ANKE					
ANKES					
SUM	*	*		*	

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.10 The effects of different treatments against *L. trifolii* on Tomato 1998

Control Treatment

The number of leaves damaged with the larvae of *L. trifolii* increased to reach the peak (about 7 leaves/plant) on the February 25 and then decreased (fig. 19). The mean number of leaves infested with *L. trifolii* in this treatment was about 3 (fig. 20).

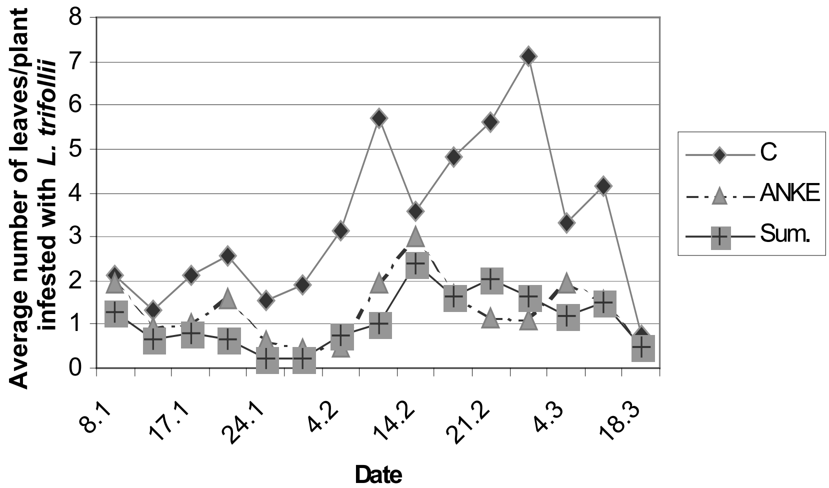

Fig. 19: Average number of leaves/plant infested with *L. trifolii* in the Control, ANKE, and Sumicidin treatments of Tomato 1998

NeemAzal Treatment

As it can be seen in fig. 20, the mean number of leaves/plant infested with *L. trifolii* in this treatment was about 2 (33% lower than in the control). According to the statistical analysis of the collected data, the difference with the control was significant (table 10).

ANKE Treatment

ANKE succeeded to keep the number of the leaves infested with *L. trifolii* under the level of the control. The peak of the infestation in this treatment was on the February 14, which was 3. The mean of the infested leaves/plant in this treatment was 1 (fig. 20). The reduction, which was about 67% lower than the control, is significant (table 10).

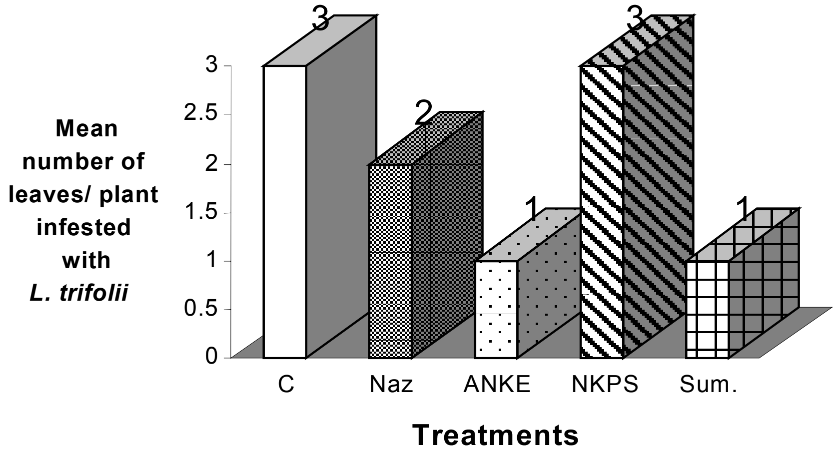

Fig. 20: Mean number of leaves/plant infested by *L. trifolii* in each treatment of Tomato 1998

NKPS Treatment

The mean number of leaves/plant infested with *L. trifolii* in this treatment was almost the same as in the untreated control (fig. 18).

Sumicidin Treatment

Sumicidin gave the highest reduction (67%) of the number of leaves/plant infested with *L. trifolii.* The difference between this treatment and the control was significant (table 10).

Table 10: The result of the statistical analysis of the effects of different treatments against *L. trifolii* 1998

	Control	NeemAzal	ANKE	NKPS	SUM
Control					
NeemAzal	*			*	
ANKE	*			*	
NKPS					
SUM	*			*	

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.11 The effects of different treatments against *Bemisia tabaci* on Tomato 1998

Control Treatment

As it can be seen in fig. 21, the infestation with *B. tabaci* reached the peak (about 12 adults /leaf) during the last week of January and then dropped. The mean number was about 5 adult/leaf (fig. 22).

NeemAzal Treatment

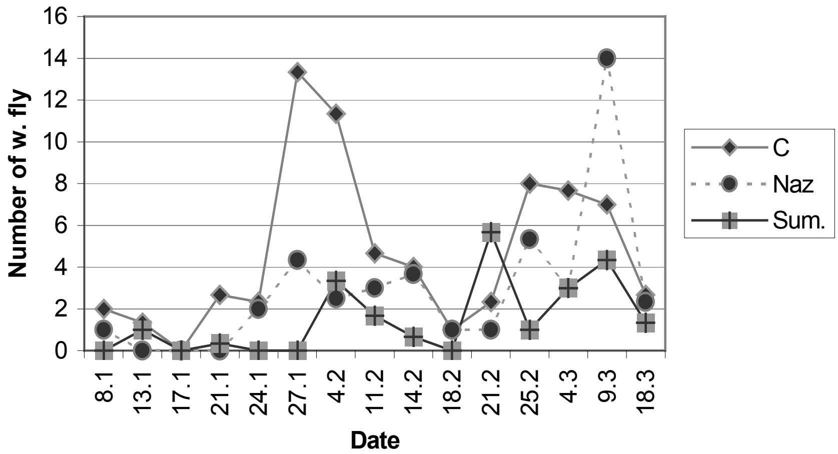

Fig. 21: Average number of adults/10 leaves of *B. tabaci* in each treatment of Tomato 1998

A mean of 3 adults was found in this treatment (fig. 22). The plots treated with NeemAzal showed 67% lower number of *B. tabaci* than in the control. Statistically, the difference was significant (table 11).

ANKE Treatment

Although a reduction of the number of *B. tabaci* by 33% lower than the control was recorded, the difference was not significant.

NKPS Treatment

The application of neem powder into the soil resulted in about a 13% reduction of the number of *B. tabaci* without significant difference with the control.

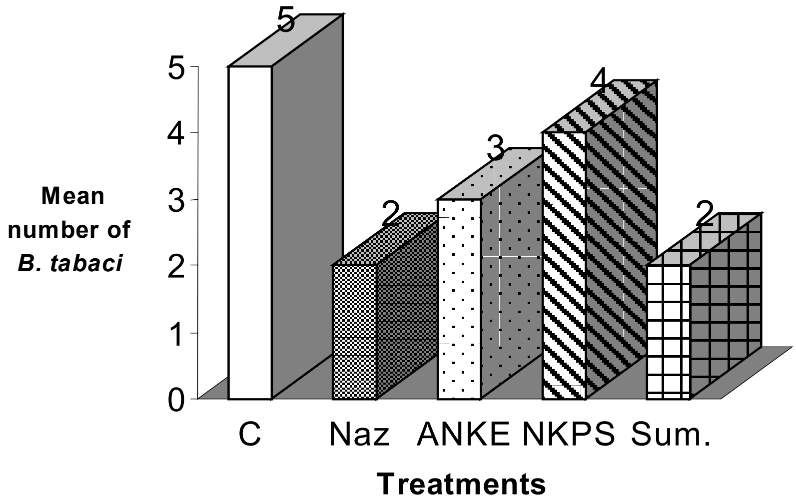

Fig. 22: Mean number of adults/10 leaves of *B. tabaci* in each treatment of Tomato 1998

Sumicidin Treatment

Sumicidin succeeded in reducing the number of adult *B. tabaci* by 69% lower than the control. The difference was significant in comparison with the untreated control and NKPS treatment.

Table 11: The result of the statistical analysis of the effects of different treatments against *B. tabaci* on Tomato 1998

	Control	NeemAzal	ANKE	NKPS	SUM
Control					
NeemAzal	*			*	
ANKE					
NKPS					
SUM	*			*	

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.12 The effects of different treatments on the yield of Tomato 1998

Control Treatment

The untreated plots showed a normal trend of yield of tomato fruits. A total of about 39 kg was recorded (fig. 24).

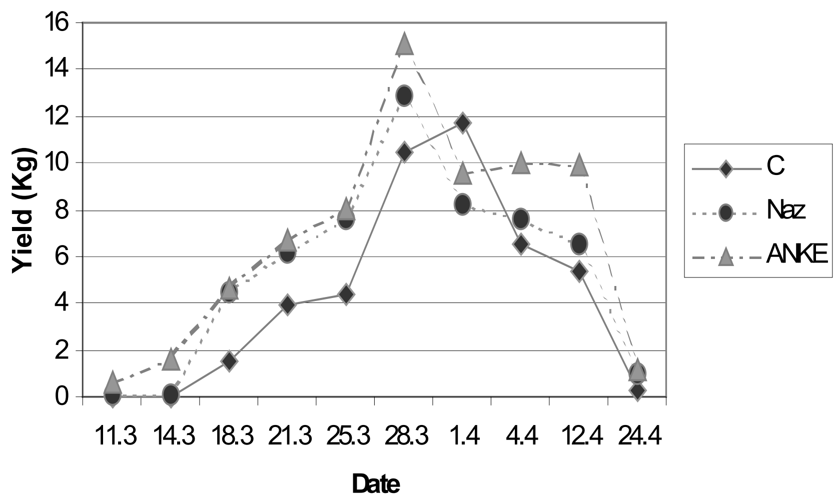

Fig. 23: Average yield kg/plot in the Control, NeemAzal (Naz), and ANKE treatments of Tomato 1998

NeemAzal treatment

The plots treated with NeemAzal yielded a total of about 46 kg, which equals to an increase of 38% over the control. As table 12 shows, the difference is not significant in comparison with control.

ANKE Treatment

The spray application of ANKE on tomato plants resulted in a yield (about 68kg) higher than the control. The increase in tomato fruits is equal to 74% over the control. The difference is significant higher over the untreated control.

NKPS Treatment

An increase of about 46% over the untreated control was recorded in this treatment (about 57 kg), but the difference was not significant in comparison with the control.

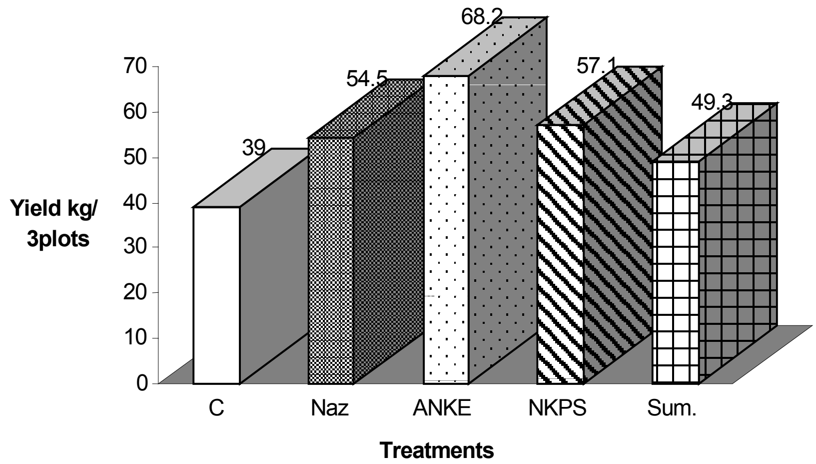

Fig. 24: The total yield (kg/3plots) for each treatment of Tomato 1998

Sumicidin Treatment

A small increase (total 49 kg) was obtained in these plots (equal to about 28%) as a result of the treatment with the commonly used insecticide, Sumicidin.

Table 12: The result of the statistical analysis of the effects of different treatments on the yield of Tomato 1998

	Control	NeemAzal	ANKE	NKPS	SUM
Control					
NeemAzal					
ANKE	*				
NKPS					
SUM					

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.13 The effect of different treatments against *Thrips tabaci* on Onion 1998

Control Treatment

The population of *T. tabaci* follows the normal trend of incidence. A mean of 39 individuals/plant was found (fig. 25).

NeemAzal Treatment

The treatment of onion with NeemAzal resulted in the reduction of the number of *T. tabaci* by 21%.
The statistical analysis revealed no significant difference between this number and that of the control.

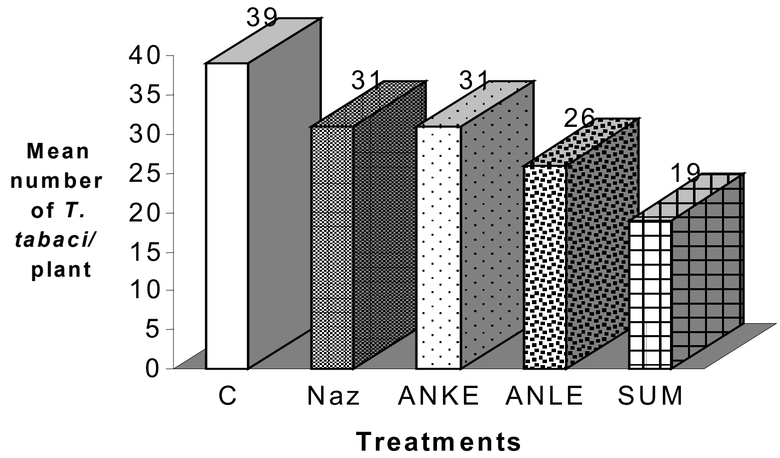

Fig. 25: The mean number of *T. tabaci* in each treatment of Onion 1998

ANKE Treatment

The spray application of ANKE resulted in the same rate of reduction as in the NeemAzal treatment.

ANLE Treatment

The onion plants treated with ANLE showed a number of *T. tabaci* individuals lower than the that of the untreated control by 31%. The difference was not significant.

Sumicidin Treatment

The number of *T. tabaci* was reduced to about 19 individuals per plant as a result of the treatment with Sumicidin. The reduction, which equal 51%, was statistically significantly lower than the control.

Table 13: The result of the statistical analysis of the effects of different treatments against *T. tabaci* on Onion 1998

	Control	NeemAzal	ANKE	ANLE	SUM
Control					
NeemAzal					
ANKE					
ANLE					
SUM	*				

Multiple Range Tests: LSD test with significance level .05

(*) Indicates significant differences

4.14 The effects of different treatments on the weight of Onion1998

Control Treatment

The weight in the untreated control plots was about 4 kg for 200 bulbs (fig. 26).

NeemAzal Treatment

The treatment of onion plants with NeemAzal and ANKE treatment did not result in an increase of the weight over the control.

ANLE Treatment

The weight of the plots treated with ANLE was slightly lower than in the control.

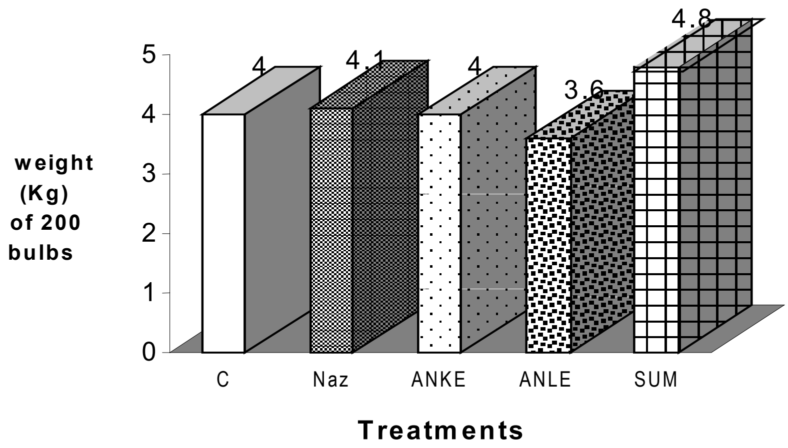

Fig. 26: The means of weights in kg of 200 bulbs of each treatment of Onion 1998

Sumicidin Treatment

An increase of about 20% was recorded in the plots treated with Sumicidin, but the statistical analysis revealed no significant difference with the control.

4.15 The effects of different treatments against *T. tabaci* on onion 1999

Control Treatment

The mean number of individuals of *T. tabaci* in these untreated plots of the year 1999 (fig. 27) was lower than that of the previous year, which were 39 and 23, respectively.

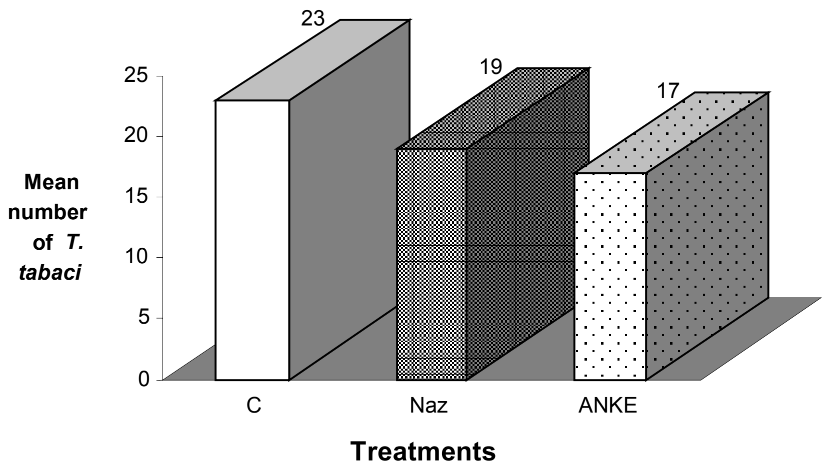

Fig. 27: The mean number of *T. tabaci* in the Control, NeemAzal and ANKE treatments of onion 1999

NeemAzal Treatment

The treatment of onion plants with NeemAzal resulted in a reduction of the number of *T. tabaci* by about 17% under the control, but the difference was not significant.

ANKE Treatment

About a 26% reduction of the number of *T. tabaci* was obtained in this treatment, but the difference with the control was not significant.

4.16 The effects of different treatments on the weight of onion 1999

Control Treatment

As it can be seen in fig. 25, the weight in the control in this trial (1999) was almost double of that of the previous trial period (98) (4 and 7.8 kg respectively).
A small increase in weight (about 15%) was obtained in all treatments, but the difference, with the control were not significant (fig. 28).

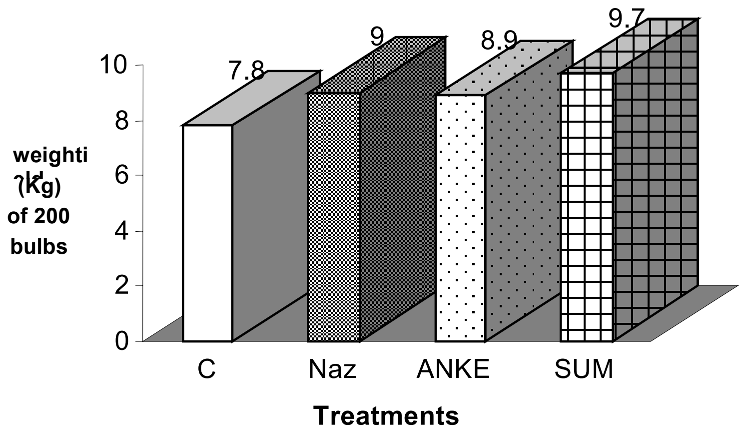

Fig. 28: The means of weight in kg of 200 bulbs in each treatment of onion 1999

4.17 The effects of different treatments on plant growth

Many investigations conducted by Alhory 1998 into the effects of the different treatments on plant height, number of leaves and number of branches of Okra 1998 of this study showed the following results:

4.17.1 The effects of the treatments on the plant height (cm)

NeemAzal and ANKE significantly affected plant height only during the 11th and 13th week from okra sowing ($p<0.01$) and $p<0.05$ respectively in the 11th week spraying with ANKE resulted in a significantly higher mean of plant height compared to the control and neem seed powder in soil. On the other hand NeemAzal had a significantly higher mean of plant height only with neem seed powder in soil, where as there were no significant differences between both the neem seed powder in soil and the neem seed kernels water extract drench in soil and in their control.

4.17.2 The effects of the treatments on the number of leaves/plant

Statistical analysis revealed that the number of leaves was significantly affected by the neem components only during the 11^{th} and 13^{th} weeks $p<0.01$ and $p<0.05$ respectively.

4.17.3 The effects of the treatments on the number of branches/plant

There were no significant effects observed between the different weeks under studies of the number of branches per plant. There was no significant difference between the means in all treatments.

The final evaluation of the of the effects of the different treatments revealed significant differences in plant height and number of leaves per plant.

The overall results are sammarized in table 14 (effects on insect pests), table 15 (effects on yield), and table 16 (effects on plant growth).

Table 14: Sammarizing table of all experiments with significant reduction of insect attack (+). 0 = no significant effect. % = not studied

<table>
<tr><th rowspan="2">Crop</th><th rowspan="2">Insect Pest</th><th colspan="4">1998</th><th colspan="3">1999</th></tr>
<tr><th>ANKE</th><th>NKPS</th><th>NAZ</th><th>ANKES</th><th>ANKE</th><th>NAZ</th><th>SUM</th></tr>
<tr><td rowspan="4">Okra</td><td>A. gossypii (cotton aphid)</td><td>+</td><td>0</td><td>+</td><td>0</td><td>0</td><td>+</td><td>0</td></tr>
<tr><td>E. vittella (spotted bollworm)</td><td>+</td><td>0</td><td>+</td><td>0</td><td>%</td><td>%</td><td>%</td></tr>
<tr><td>P. puncticollis (flea beetle)</td><td>+</td><td>+</td><td>+</td><td>0</td><td>%</td><td>%</td><td>%</td></tr>
<tr><td>B. tabaci (white fly)</td><td>+</td><td>+</td><td>+</td><td>+</td><td>%</td><td>%</td><td>%</td></tr>
<tr><td rowspan="4">Tomato</td><td rowspan="2">A. gossypii (cotton aphid)</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td>SUM</td><td rowspan="4">%</td><td rowspan="4">%</td><td rowspan="4">%</td></tr>
<tr><td>+</td></tr>
<tr><td>L. trifolii (leaf miner)</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>B. tabaci (white fly)</td><td>0</td><td>0</td><td>+</td><td>+</td></tr>
<tr><td rowspan="2">Onion</td><td rowspan="2">T. tabaci (Thrips)</td><td rowspan="2">0</td><td>ANLE</td><td rowspan="2">0</td><td>SUM</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">%</td></tr>
<tr><td>0</td><td>+</td></tr>
</table>

Table 15. Sammarizing table of all experiments with significant yield increase (+). 0 = no significant effect. % = not studied

<table>
<tr><th rowspan="2">Crop</th><th colspan="4">1997</th><th colspan="4">1998</th><th colspan="3">1999</th></tr>
<tr><th>ANKE</th><th>NKPS</th><th>NAZ</th><th>ANKES</th><th>ANKE</th><th>NKPS</th><th>NAZ</th><th>ANKES</th><th>ANKE</th><th>NAZ</th><th>SUM</th></tr>
<tr><td>Okra</td><td>+</td><td>0</td><td>+</td><td>0</td><td>+</td><td>0</td><td>+</td><td>0</td><td>0</td><td>+</td><td>0</td></tr>
<tr><td rowspan="2">Tomato</td><td rowspan="2" colspan="4">%</td><td rowspan="2">+</td><td rowspan="2">0</td><td rowspan="2">0</td><td>SUM</td><td rowspan="2">%</td><td rowspan="2">%</td><td rowspan="2">%</td></tr>
<tr><td>0</td></tr>
<tr><td rowspan="2">Onion
(weight)</td><td rowspan="2" colspan="4">%</td><td rowspan="2">0</td><td>ANLE</td><td rowspan="2">0</td><td>SUM</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">%</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

Table 16: Sammarizing table of the effects on plant growth of okra 1998 with significant increase (+). 0 = no significant increase

	NAZ	ANKE	NKPS	ANKES
Plant height	+	+	0	0
Number of leaves	+	+	0	0
Number of branches	0	0	0	0

5 DISCUSSION

5.1 Control of cotton aphid *A. gossypii*

The spray application of an aqueous neem kernel extract (ANKE) at the rate of 50g/l and NeemAzal-T/S 1% (Naz) applied at 5 ml/L water on okra plants grown in the trial in 1998 reduced the number of cotton aphids *A. gossypii* significantly (table1). In this trial period both of the above mentioned neem products proved their high effectiveness against aphids, one of the most important okra insect pest. The reduction of aphid numbers in this year of ANKE treatment was higher than that in NAZ treatment (45 and 36 per cent, respectively).

In 1999, the number of aphids in the control were very much higher than the number in 1998 (a mean of about 11 and 420, respectively). In this year, NAZ also reduced the number of aphids significantly (table 2) by 70%, while ANKE did not reduce the number significantly, but only by 40%. The lower effect of ANKE in this year in comparison with 1998 appears to result from the lower quality of neem seeds, which were relatively old.

In the trial 1999, ANKE reduced the number of aphids to about 35% lower than that of the untreated control, but the difference was not significant.

The reduction of aphid numbers in this year of both neem-based insecticides ANKE and NAZ was significantly higher than the synthetic insecticide Sumicidin, which failed to reduce the numbers of aphids.

(In the year 1997 a high number of aphids was observed on okra plants, but according to many technical reasons it was not recorded).

These results agree with that obtained by Siddig 1991, who mentioned that ANKE at different concentrations was effective for the control of some okra insect pests including *A. gossypii*.

The cotton aphid, *A. gossypii* was controlled well on okra by four weekly sprays of ANKE 50 g/l, the effects being on a par with those of synthetic carbamate butocarboxin (Dreyer and Helpap, 1991).

The application of ANKE and NeemAzal on tomato resulted in the reduction of aphid numbers by 40 and 10 per cent respectively. In both cases the difference with the control was not significant. It is remarkable that the effects of the same dose of both of the neem compounds on the same insect pest (*A. gossypii*) differed from okra to tomato. This finding demonstrated the variability of neem effects from one host plant to another.

The influence of the effects of neem-based insecticides by the host plant was reported by Lowery and Isman 1993, who found that the effective concentration of formulated neem seed oil resulting in 50 percent mortality (LC_{50}) of second-instar green peach aphids, *Myzus persicae* (Sulzer) on corn was more than 20 times higher than on mustard cabbage.

The efficacy of ANKE and NAZ against cotton aphid on tomato was lower than the synthetic insecticide Sumicidin, which reduced the numbers significantly by 60% in comparison with 40 and 10 per cent by ANKE and NAZ respectively.

The weak effect of neem-based insecticides on tomato appears to be resulted from the weak intake of neem compounds into the tomato tissues, leading to their accumulation in concentrations lower than the required for the control of aphids.

Moreover the current study indicates that 50g/l might be a suitable recommended dosage rate ANKE to control aphid infestation on okra without phytotoxicity on the host plant.

The results showed that the local neem seed kernel water extract if fresh seeds are used, had similar effect as the formulated neem product, NeemAzal when used as foliar spray against *A. gossypii*. It is clear that the fresh water extracts have very prominent effect on the vegetative growth of the treated plants.

It is important to note that, in the 1999 trial both NeemAzal and ANKE gave better effects than the commercial product Sumicidin.

These results suggest that NeemAzal and ANKE could be an effective biocide for the control of cotton aphids and represent the best tools to be used in an IPM program.

The results detected that the aqueous neem seed kernel powder water extract can be very effective in reducing the number of cotton aphids *A. gossypii* infesting okra, particularly when applied as a foliar spray.

According to Lowery and Isman 1993, the control of aphids results in the failure of nymphs to molt and from inhibition of adult reproduce.

The laboratory studies of Mudathir 1995 demonstrated the strong inhibition effects of neem-based insecticide (NeemAzal) on the reproduction of *Metopolophium dirhodum* (Wlk.).

The death of the insects on plants treated with neem could be attributed to its systemic antifeedant and growth inhibitory action.

As aphids feed mainly from the sieve elements of their host plants, active concentrations of antifeedant are required to be present in the phloem sap (Nisbet 1993), the complete intake of active principle in the plant tissues require 3-5 days after treatment.

Lowery et al.1993 who did not find a significant difference in the reduction of aphid numbers, when the spraying with neem was done 48 hours after the infestation or immediately before the infestation of aphids (no effects within the first 48 h after the treatment). Based on their results they suggested that contact toxicity does not contribute significantly to the reduction in aphid numbers.

According to Schmutterer 1990 neem has relatively weak contact toxicity. The delayed effect of neem which had been reported by (Schmutterer, 1990) says that after application of neem products, most insect pest continue to feed on the treated plants for some time, but as a rule, the amount of food ingested is considerably reduced, owing to the influence of the "secondary" antifeedant effect.

Contact with neem is known to disrupt food intake and increase insect locomotory activity. (Schoohoven, 1992).

The variable levels of control for *A. gossypii* on okra as compared with tomato indicate that the host plants of the aphid influences the effectiveness of neem treatment.

5.2 Control of white fly *B. tabaci*

On okra plants the treatment with ANKE, NeemAzal, NKPS and ANKES showed fewer numbers of white fly than the control by 75, 52 42 and 33 per cent respectively. The differences from the control were significant for all the above mentioned treatments in comparison with the untreated control. The results indicate neem-based compounds are potentially very efficient in the control of white fly.

In comparison with aphid on okra as above explained, white fly is more susceptible to neem.

The effects of neem products against white fly *B. tabaci* on okra were reported by Siddig (1981), who obtained a reduced occurrence of adults, with seed extracts.

On tomato, the plots treated with NeemAzal, ANKE and NKPS showed a fewer number of white fly than the untreated plots (67, 33 and 13 per cent respectively).

The differences were significant only in case of NeemAzal compared with the control.

Sumicidin gave the best reduction of white fly (69 per cent less than the control).

So the effects of NeemAzal against the sucking insect white fly in this trial were equal to with the synthetic pyrethroid Sumicidin and superior to ANKE.

The sucking insects white fly and aphids also attack cotton plants causing serious damages, so this indicates promising results in cotton as a member of the same family as okra.

The results are in agreement with Serra, 1992; Serra and Schmutterer, 1993, who used 50g/l ANKE, 1.5% neem oil and two different combinations, one of them including mineral oil and found the population of *B. tabaci* remained at a very low level.

Less promising results were obtained by (Ostermann 1992) using 50g/l ANSE, 25g/l ANLE and NSP at weekly and fortnightly intervals. Only ANSE reduced the number of *B. tabaci* adults, whereas NSP and ANLE had no effect.

The white fly was repelled and fewer adults alighted on cotton treated with neem seed extract than on untreated cotton (Coudreit et al.1985).

5.3 Control of Spotted boll worm *E. vittella*

In the early stage of the crop the larvae enters the terminal buds of shoots and tunnels downward from the growing points.

ANKE and NeemAzal reduced the number of plants infested with *E. vittella* to about 91 and 81 per cent respectively, less than the untreated control. For both of the treatments the difference was significant compared to the control.

In general, lepidopterous insects have show a remarkable sensitivity to neem-based products (Schmutterer, 1990b), either by direct wetting of the larval instars or by consumption of sprayed plant parts.

This result indicates the high sensitivity of this insect pest to neem compounds. The order Lepidoptera, to which the insect belongs, was classified as one of the insects to be very well controlled with neem. This result indicates a promising control against the other members of this order, which attack okra and cotton, which classified with it in the same botanical family.

Similar results were obtained by Anon. 1992, who obtained significant reduction of the damage of *E. vittella* on cotton.

The most probable effect of neem in lepidopterans is the disruption of the larval-pupal molt (i.e. pupation), which has been frequently reported (e g. Schmutterer et al., 1983, Koul and Isman 1991).

5.4 Control of flea beetle *P. puncticollis*

ANKE and NeemAzal decreased the number of the leaves infested with the flea beetle *P. puncticollis* to about 91 and 80 per cent, respectively. According to the statistical analysis, the differences were significant.

NKPS also succeeded in reducing the number of leaves damaged by the flea beetle significantly by 60%. This result indicates the systemic effect of neem.

The results are comparable with that of Siddig (1991), who reported an antifeedant effect of ANKE against *P. puncticollis* on okra.

Redknap (1981) reported an antifeedant effect on an ANKE against the flea beetle *P. sjostedii* and P. *uniforma* as results of field trials.

Damage by the flea beetle *Eptrix fuscula*, and the Colorado beetle, *Leptinotarsa decemlineata*, was significantly reduced by weekly applications of an ethanolic extract of neem seeds (REED, 1985).

It was reported that the application of neem-based pesticides against adult insects, for instance bugs and beetles, does not normally lead to obvious mortality, but may result in a substantial reduction in the fecundity of these insects, so that the following generation may be reduced below the economic threshold level (Schmutterer 1987).

Some types of beetle larvae feed on leaves causing great damage. Their feeding on leaves treated with neem disrupt their growth, reduce their activity and finally they die off. On the other hand, the types of adult beetles, which feed on the leaves, react differently to neem. Some are totally repelled while others are only slightly deterred. Egg lying may be strongly reduced.

5.5 Control of leaf miner *L. trifolii*

The plots treated with Sumicidin, ANKE and NeemAzal showed a significantly lower number of leaves infested with *L. trifolii*. Sumicidin gave the highest reduction (64%) followed by ANKE 61% and NeemAzal (46%).

Many authors reported about the effects of neem on *L. trifolii*:

Freisewinkel (1989), using ANKE at 12.5 obtained less promising results against *L. trifolii*, 25 and 50g/l. none of the treatments reduced the pest incidence significantly.

In greenhouse trials with lima beans, Larew (1987) found that a neem kernel extract and the neem-based commercial product Margosan-O, applied as soil drench or foliar spray, prevented the development of adults of *L. trifolii* and thus were almost as effective as the synthetic compound cyromacine.

STEIN (1984) studied the effect of methanolic NSKE on the leaf miner, *L. trifolii*. The concentrations used were 0.1% in the early larval in stars, and 0.5% in 3rd larval instars. The number of eggs from flies derived from treated larval was significantly lower than in control flies. He reported also about the effect on the longevity of the adults, where he found an average lifespan of 5-8 days after treatment compared with 9-17 days by the untreated.

In recent study, the improved formulation applied in a shipping carton to the growth medium surrounding the roots of leafminer-infested chrysanthemum cuttings, produced an 80.6% reduction in the number of adults emerging after subsequent unpacking and planting (Sanderson et al., 1989).

5.6 Effects on the yield of tomato

Despite the different results between the treatments against the different insect pests investigated in this experiment, all the treatments increased the yield of tomato in comparison to the untreated control, that only the ANKE treatment proved to be significant.

ANKE gave the highest increase (74%) followed by NKPS (46%) NeemAzal (38%) and the lowest increase was recorded in Sumicidin treatment (28%).

The synthetic insecticides, Sumicidin, succeeded to keeping the target insects in this trial at the lowest level compared to neem treatments. Despite these results, neem treatments succeeded to give a yield more than it does. The plants in neem treatments were more healthy and vigorous than the control and Sumicidin treatment. Hence there is another factor responsible for the increase of yield, which is probably the growth regulatory effect. It is also possible that insects infesting tomato plants could not feed on them due to an antifeedant effect of neem.

Ostermann (1992) obtained a considerable increase in the fruit yield of tomato after weekly and fortnightly treatments with ANSE 50g/l. In these trials, ANKE was better than ANLE, NKPS and deltamethrin.

This result indicates systemic movement of neem principles inside tomato tissues in an amount sufficient to stimulate the growth, but too low to decrease the aphid number.

5.7 Effects on the yield of Okra

The yields of the control treatments in the years 1979 and 1999 were relatively lower than that in 1998 (ca.28, 29 and 38 kg, respectively). This appears to be due to the higher occurrence of aphids in 1997 and 1999 in comparison to the year 1998.
ANKE and NeemAzal increased the yield of okra by 162 and 145, respectively. The statistical analysis of the data revealed a significant difference to both ANKE and NeemAzal.
The increase of yield in this year was the highest of the three years of this study. The good quality of relatively fresh neem seeds, early treatment of the plants, addition of sesame oil and the high occurrence of aphids are among the factors responsible for this large difference between the yield of ANKE treatment and that of the control. NKPS increased the yield by 32 per cent in comparison to the untreated control. These positive effects on the yield indicate a systemic movement of neem compounds from the roots to the leaves. ANKES treatment gave a yield lower than that of the untreated control. The amount of neem active principles accumulated in okra plant tissues might be too low to reduce the high infestation of aphids and to maintain a good yield. Neem showed a clear effect on the vegetative growth. The plants treated with NeemAzal and ANKE were dark green, vigorous, healthy and as large as the untreated ones.

In the trial in 1998, the application of ANKE and NeemAzal resulted in an increase in the yield of okra by 52% and 24% respectively. By The differences of both ANKE and NAZ with the untreated control were significant. The lower occurrence of aphids in this year in comparison to the other two years appears to be responsible for higher yield of control and consequently the lower difference.
The lower yield of ANKE and NAZ (58 and 51 kg) in this year, in comparison to the yield in 1997 (74 and 58 kg, respectively) appear to result from the quality of the chemicals or to the relatively late treatments of the plants and consequently lower effects on their growth and yield. In this year the other two treatments, NKPS and ANKES did not increase the yield over the control.

In the year 1999 the yield of the control was lower than the two previous years; this could be attributed to the high occurrence of aphids. NeemAzal and ANKE succeeded to increase the yield of okra by 63 and 28 per cent, respectively. Only for NeemAzal was difference to the control significant. The relatively old neem seeds, with consequently low contents of active principles, used in this year appear to be responsible for the low yield of ANKE treatment. The relatively late application of ANKE and NAZ (caused by the unavailability of neem seeds) might be another factor responsible for the low yield of these two treatments in comparison to the yield of the three different years.

From the data collected, it can be concluded that the application of neem on okra plants could increase the yield as well as the reduction of okra insect pests without having side effects on the environment and natural enemies

5.8 Control of cotton thrips *T. tabaci*

The spray application of NeemAzal, ANKE and ANLE reduced the number of thrips by 26, 22 and 33 per cent, respectively, but all the differences were not significant. The synthetic pyrethroid Sumicidin gave the best result by reducing the thrips number by 52% less than the control. Only this difference was significant.

There are relatively few publications on experiments using neem products against thrips.

PREISWINKEL (1989) applied aqueous neem seed extracts (NSKE) (12.5-50g/l) against the cotton thrips, *T. tabaci*, in field trials in the Dominican Republic. There was a reduction in the number of infested leaves only at concentrations of 25g and 50g/l + molasses.

GRAHN (1989) found some reduction of nymphs and to a lesser extent adults of *T. tabaci* on onion one day after application of aqueous NSKE (2-4%).

ASCHER, et al, (1993) reported succeed control of *T. tabaci* nymphs by watering of cotton plants with NeemAzal diluted with water, due to strong systemic effect.

Schmutterer, (1995) concluded that some thrips species can be controlled during their first two nymph instars, whereas other stages, especially adults and eggs, are not sensitive to neem products.

Wood et al (1993) also obtained inconsistent results against thrips, using the commercial product ‘Azatin` in the U.S.A.

It is remarkable here that the leaf extract ANLE of neem gave better effect against thrips as seed extracts ANKE and NAZ It is most probable that leaf extract contain one or more ingredients, which affect thrips better than seed extracts.
The result agreed with that of Hongo and Karel 1986 who found that an aqueous extract of leaves at 4% reduced the incidence of *Megalurothrips sjostedti* (=*Taeniothrips sjostedti*) by 50% in beans.

5.9 Effects on the weight of onion

In 1998, the weight of onion did not increase in all neem treatments. Phytotoxicity damages observed on onion plants might be responsible for the negative effects on the yield.
Sumicidin increased the weight of onion by 20%, but the difference was not significant.
In 1999, ANKE and NAZ increased the weight by 15% without significant difference to the control.
Sumicidin increased the weight of onion by 24%, but also without significant difference to the control.
The result is comparable with that of FREISWINKEL (1989), who observed phytotoxicity symptoms resulting in a lower weight in plots treated at 12.5, 25 and 50g/l of neem kernel extracts.

5.10 The application of neem kernel powder into the soil (NKPS)

The treatment of okra plants with NKPS in the year 1998 resulted in about 19% reduction of aphids in comparison to that of the control (fig. 2).
The application of neem powder into the soil resulted also in a significant reduction of the number of adults of white fly feeding on okra plants (table 1).
A significant reduction of the leaves damaged by the flea beetle adult *P. puncticollis* was also recorded (table 4).
About 32% increase of the yield of Okra 1997 was obtained from the plots treated with NKPS (fig. 10).
All these positive results indicate a systemic translocation of neem compounds to the shoot system after their intake in the root system of okra plants.

The application of NKP into the soil around tomato plants grown in 1998 resulted in about 13% reduction of the number of adult of sweet potato white fly *B. tabaci* in comparison with the control (fig. 20). The yield of tomato in this treatment was increased by 46% (fig. 22) (not significant).

These results indicate also a systemic movement of some neem active ingredients inside tomato plants.

The application of the aqueous neem kernel powder into the soil (ANKPS) caused a significant reduction of the number of adult white fly feeding on the plants of Okra 1998 (table 5).

ANKES

The application of the ANKES showed poor activity except against white fly when applied as drench. These field results support the laboratory results of the own research of the author (Mudathir, 1995), who demonstrated the systemic movement of NeemAzal applied into the soil to the roots of oats seedlings and obtained 100% mortality of L_1 of *M. dirhodum* feeding on the shoot system. Isman (1990) also demonstrated systemic action of neem seed substances against Pieris brassiae after treatment of the soil with neem seed powder or neem solution.

Gill & Lewis (1971) demonstrated the systemic movement of azadirachtin from the roots of bean plants by showing that desert locusts (*Schistocerca gregaria*) were deterred from feeding on the aerial parts of plants growing in treated compost.

On the other hand the application of NKPS did not give positive effects on the control of *E. vittella* larvae on Okra 1998 and *L. trifolii* larvae on Tomato 1998. This negative effect appears to result from the absence of the volatile compounds of neem when it is applied into the soil, and consequently the absence of the repellent effect against the adults. Another reason can be explained by the nature of feeding of the tow larvae species, which allows only a small amount of neem active ingredients to come into contact with them or to be ingested by them.

The application of the same extracts in the soil showed poor activity when it is applied as drench.

The effectiveness of soil application as powder or drench appears to be host- dependent and possibly restricted to a few plant species. It has been previously demonstrated that the control of whiteflies with foliar applications of neem is influenced by the species of neem plant (Schmutterer 1990 b). Soil drenches with Margosan-O reduced the number of leafhoppers on marigold and chrysanthimum but not on Zinnia (Knadel-Monz et al, 1985). The cause of this difference is currently unknown, but systemic activity of neem may vary with the species of plants.

According to all of these facts the application of neem as powder into the soil could represent an another effective method of control besides the spraying. The application in the soil could improve the properties of neem as an IPM insecticide:

a) The application in the soil minimizes the side effects on the natural enemies, which occur as a consequence of their contact with neem principles by their presence on the shoots after spraying.
b) Reduction of application costs and the number of application's rounds.
c) The possibility of control of some soil pests such as nematode.
d) Avoidance of the drift impacts on the environment, which resulted from the aerial application (spraying).
e) The application of neem into the soil does protect the active principles against the photochemical degradation. (Von der Heyde et al 1984), reported that if a systemic effect takes place, indicating the uptake and translocation of the active material by the treated plant, the residual effect is prolonged. (Von der Heyde et al, 1984).

   Mudathir, 1995 reported about the residual effect of NeemAzal continued to about 18 days after an application of the product into the soil in comparison with one week by spray application.

The application of ANKES in the year 1998 did not succeed in the significant reduction of the number of aphids in comparison with the control. The concentration used in this experiment was probably not sufficient to control the aphids.

Rather unexpectedly, the number of aphids in this treatment (soil drench) was more than the control. Here the question arises of stimulation effect of neem at levels lower than the effective concentrations.

Accordingly it was clear that the method of application affects the effectiveness of the extract. Also it was clear that the foliar application is more suitable.

5.11 Effects on plant growth

The final evaluation of the effects of the different treatments showed the strong positive effects of NeemAzal and ANKE on the plant growth. Both of the products increased the plant height and the number of leaves per plant significantly.

The treated okra showed a very active vegetative growth and consequently vigorously growing, which can help plants to resist the detrimental effects of insect pest damage. This active and healthy growth resulted in lower infestation with insects and finally led to significantly higher yields in these two treatments (NeemAzal and ANKE) when compared to the untreated control and the other treatments (NKPS and ANKES). It is also clear that freshly prepared aqueous extract gave better results when compared to NeemAzal and other kinds of extracts.

The results showed no significant increase in the number of branches (table 16).

5.12 Points to be considered for application of neem

The results of this study showed the high influence of neem effectiveness by the quality of seeds, preparation and application of neem products, so the following recommendations could help much to obtain high level of effectiveness by use of neem.

The use of fresh or well-stored neem seeds increases the efficacy of neem products considerably.

Increased efficacy of neem derivatives could be achieved by the use of additives such as sesame oils as to protect the bioactive components against photochemical degradation by the ULV light or to improve their penetration into the plant tissues.

Evening is the more suitable time of day for spray application of neem because then the plants have a good opportunity to absorb the active ingredients during the night, during which exposure to the ULV light could be minimized.

The early treatments of the plants as they are still young could result in higher positive effects either directly on their growth or indirectly on their protection against different harmful pests and diseases.

As the insects can differentiate between the treated and untreated sites, the good coverage of the treated target or at least the even distribution of spray deposits over the treated target can improve the efficiency of the spraying of neem.

Lindquist et al. (1990) also showed that coverage of both the top and the bottom leaf surfaces improved efficacy.

The early treatment with neem at the beginning of the infestation by diseases vector insect such as aphid and white fly might improve the protection of plants against diseases transmitted by such vectors.

No repellent effect to be expected from the soil application of neem.

The repellent action of neem may result from the presence of volatile sulfur-containing compounds (Balandrin et al, 1998). Neem seed 'bitters' and azadirachtin lack volatility, which is why they do not repel homopterans.

5.13 The possibility of control of cotton insect pests with neem

Cotton is considered as a main cash crop in the Sudan and other countries. Its plants are subjects to attack by the same insect pests of okra Malvaeceae. The intensive use of pesticides for their protection led to many negative effects on the environment beside the increase of the production costs resulted to a large extent from the increase of the number of spraying of many insect pests/ which had developed resistance to many synthetic insecticides. As this study demonstrated the high effectiveness of neem in the control of okra insect pests, this indicates the promising role, which neem can play in the control of insect pests of cotton.

6 Zusammenfassung

Freilanduntersuchungen zur Bekämpfung von Schadinsekten an Okra, Tomaten, und Zwiebeln

Die intensive Anwendung von synthetischen Insektiziden hat zu Belastungen von Menschen und Umwelt mit giftigen Rückständen, zur Störung von Gleichgewichten in der Natur und zur Entwicklung von Resistenz bei vielen Schadinsekten geführt.

Die Ergebnisse aller bisher durchgeführten Untersuchungen bestätigten, daß Niemsamenextrakte aufgrund ihrer besonderen Wirkungsweise, keiner oder höchstens geringer Nebenwirkungen auf natürliche Gegenspieler und ihre Ungiftigkeit gegenüber Warmblütern ein vielversprechendes natürliche Schädlingsbekämpfungsmittel, bevorzugt beim Einsatz gegen Insektenlarven, darstellen und die Anforderungen an solche Pflanzenschutzmittel erfüllen, die für integrierte und biologische Schädlingsbekämpfungskonzepte erforderlich sind. Gerade für den Sudan als eines der Entwicklungsländer, wo Niembäume in großer Anzahl verbreitet sind, bieten sie eine Alternative zu den hochgiftigen, mit negativen Wirkungen auf das Agroökosystem behafteten synthetischen Insektiziden.

Der Einfluß von Niem ist von Insektenart zu Insektenart unterschiedlich. Neben seinen fraßabschreckende Effekten auf einige Insektenarten, kann Niem in den Lebenszyklus anderer Insektenarten eingreifen, wo das Wachstum gestört wird oder die Insekten sterilisiert werden.

Es ist das Ziel dieser Arbeit, die Wirksamkeit von verschiedenen Niem Formulierungen gegen einen Schadinsekten-Komplex und den Ertrag von Okra (*Hibiscus esculentus*), Tomate (*Lycopersicon esculentum*), und das Gewicht von Zwiebeln (*Allium cepa*) unter Freilandbedingungen zu untersuchen.

Die Wirkungen auf Pflanzenwachstum (Höhe und Anzahl den Blättern und den Zweigen) wurden ebenfalls untersucht.

Der Versuchsstandort war Khartoum Nord im Sudan. Die Feldversuche wurden auf Versuchsfelder, die der Schambat Forschungsstation und der Sudan Universität gehören, in der Zeit von 1997 bis 1999 durchgeführt.

Die Versuchsanlage erfolgte in 7 X 6 m großen Parzellen unter zufälligem Blockentwurf mit dreifacher Wiederholung.

Lokal Niem Samen Kernel Pulver (NKPS) wurde im Boden (2g/Pflanze) eingearbeitet, mit Sesamöl vermischt, danach mit Wasser extrahiert (ANKE) und auf die Pflanzen gespritzt (50g/l) oder als Wasserextrakt in den Boden um die Pflanzen gegossen (ANKES).
Das deutsche Produkt NeemAzaal T/S 1% enthält Azadirachtin als Hauptwirkstoff und das japanische Produkt Sumicidin enthält Fenvalerate als Wirkstoff wurden zum Vergleich verwendet.
Die gesammelte Daten wurden transformiert mit der Benutzung von log (x+1), um die Abhängigkeit der Varianten von den Mittelwerten zu beseitigen. Transformierte Werte wurden mit Analysis of variance **(ANOVA)** mit nachfolgendem Least Significant Differences test **(L.S.D.)** unter Verwendung des Statistical Packet for Social Science **(SPSS),** Version 10 für Windows analysiert.
Zum Vergleich von Mittelwerten in behandelten und unbehandelten Parzellen wurden, signifikante Differenzen notiert bei P = 0.05 für alle Versuche.
Für den Ertrag von Zwiebeln wurde 200 Zwiebeln von jeder Parzellen geerntet und ihr kg-Gewicht wurde registriert.
Um genügend Daten auf die Wirksamkeit von den verschiedenen Behandlungen darzustellen, wurden die Mittelwerte der Erträge der Kontrolle auf 100% gelegt.
Die Ergebnisse haben die starke Wirksamkeit von (ANKE) gegen wichtige Schadinsekten belegt: baei Okra, wurde die Anzahl der Baumwoll-Blattlaus (cotton aphid) (*Aphis gossypii*), die Weiße Fliege (white fly) (*Bemica tabaci*) die Anzahl der mit punktierten Kapselwurmlarven (spotted boll worm) (*Earias vittella*) befallenen Blättern und die Anzahl der durch Adulten von Flohkäfer (flea beetle) (*Podagrica puncticollis*) geschädigten Blätter im Jahr 1998 signifikant reduziert. Eine Reduzierung bei 35% von *Aphis gossypii* wurde im Jahr 1999 gefunden.
Bei Tomaten hat die Anwendung von (ANKE) zur signifikanten Reduzierung der Anzahl der durch blattminierende Larven (leaf miner) (*Liriomyza trifolii*) geschädigten Blätter geführt. Hingegen war die Reduzierung von *Aphis gossypii* und *Bemica tabaci* nicht signifikant mit 40%, respektive 35%.
Die Anwendung von (ANKE) hat die Anzahl der Baumwollthrips (cotton thrips) an Zwiebeln mit 21% und 26 % im Jahr 1998, resp. 1999 nicht signifikant reduziert.
Der Anstieg des Ertrages bei Okra war bei der Anwendung von ANKE signifikant bei 162% und 52%, im Jahren 1997 resp. 1998 und nicht signifikant mit 28% im Jahr 1999.

Hingegen lag der Anstieg der Erträge von angebauten Tomaten im Jahr 1998 signifikant bei 74%.

Beim Zwiebelgewicht wurde ein Anstieg von 15% gefunden (nicht signifikant).

Das zum Vergleich verwendete deutsche Produkt, NeemAzal, reduzierte die Anzahl von *Aphis gossypii* bei Okra im Jahr 1998 und 1999, die Anzahl der mit punktierten Kapselwurmlarven (spotted boll worm) (*Earias vittella*) befallenen Blätter, und die Anzahl der durch Adulten von Flohkäfer (flea beetle) (*Podagrica puncticollis*) geschädigten Blättern im Jahr 1998, signifikant. Eine nicht signifikante Reduzierung von (*Bemica tabaci*) wurde bei 58% registriert.

An Tomaten wurde die Anzahl von (*Bemica tabaci*) und die Anzahl der durch blattminierende Larven (leaf miner) (*Liriomyza trifolii*) geschädigten Blättern signifikant reduziert, während die Anzahl von (*Aphis gossypii)* nur um 10% reduziert wurde.

Die Anwendung von (ANKE) hat die Anzahl der Baumwollthripse (cotton thrips) an Zwiebeln nicht signifikant bei 21% und 26 % im Jahr 1998, respektive 1999, reduziert.

Der Anstieg des Ertrages von Okra bei der Anwendung von NeemAzal war in den Jahren 1997, 1998 und 1999 signifikant. Hingegen lag der Anstieg des Ertrages bei angebauten Tomaten im Jahr 1998 nicht signifikant bei 38%.

Ein Anstieg beim Zwiebelgewicht um 24% wurde gefunden (nicht signifikant).

Das zum Vergleich verwendete japanische Produkt, Sumicidin, hat gleich wie bei NeemAzal und ANKE die Anzahl der durch blattminierende Larven (leaf miner) (*Liriomyza trifolii*) geschädigten Blätter signifikant reduziert. Das Produkt hat wie NeemAzal auch die Anzahl von *Bemica tabaci* signifikant reduziert (bei ANKE war die Reduzierung nicht signifikant).

Auch hat es die Anzahl von *Aphis gossypii* signifikant reduziert, während die Reduzierung bei ANKE und NeemAzal nicht signifikant war.

Die Untersuchungen über die Wirkungen auf Pflanzen beim Wachstum von Okra haben einen signifikanten Anstieg der Pflanzenhöhe, der Anzahl der Blätter bei ANKE und NeemAzal Behandlungen im Vergleich mit einer unbehandelten Kontrolle gezeigt. In der Anzahl der Zweige wurde kein signifikanter Unterschied gefunden.

Obwohl Sumicidin bessere Wirkungen als die anderen drei Niem Produkte (ANKE, NeemAzal, und NKPS) gegen die Schadinsekten an Tomaten gezeigt hat, haben Niem Produkte höhere Erträge gegeben.

Alle Ergebnisse sind in Tabellen 14, 15 und 16 zusammengefaßt.

Die Ergebnisse dieser Studien haben demonstriert, daß Niem Produkte sowohl bei der Schadinsektenbekämpfung als auch bei der Pflanzenproduktion eine vielversprechende Rolle spielen können.

Da die Baumwollpflanzen von gleichen Insekten wie Okra befallen werden können, begründen die Ergebnisse eine große Hoffnung zur Bekämpfung von Schadinsekten bei Baumwolle mit Niem.

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8 APPENDIX

Table A1: Average number of aphids/leaf at different days for each replication and for each treatment of okra 1998
A: Control (C) B: NeemAzal (Naz) C: Aqueous Neem Kernel Extract (ANKE) D: Neem Kernel Powder in the Soil (NKPS) E: Aqueous Neem Kernel Extract in the Soil (ANKES)

Reps. \ Date	11.2	14.2	18.2	21.2	25.2	28.2	4.3	7.3	14.3	18.3	21.3	25.3	28.3	1.4	4.4	11.4
A1	38.7	51.4	35.2	49.1	64.3	26.6	40.1	25.1	17.4	9.6	19.0	23.6	22.9	0.3	3.8	4.0
A2	18.1	30.7	20.7	28.5	19.9	40.4	16.3	26.4	38.9	13.5	7.9	25.3	42.6	0.9	0.0	0.0
A3	30.6	17.2	21.1	8.9	38.7	37.6	43.0	25.7	20.8	16.0	9.9	8.6	4.6	0.7	0.5	0.0
A(C)	29.1	33.1	25.7	28.8	41.0	34.9	33.1	25.7	25.7	13.0	12.3	19.2	23.4	0.6	1.4	1.3
B1	21.1	25.4	15.3	7.8	19.2	8.6	6.8	9.3	9.9	19.7	7.3	1.7	1.8	0.0	0.0	0.0
B2	24.1	11.1	6.5	3.0	5.1	11.2	3.7	4.0	10.6	19.5	6.2	7.9	7.9	0.0	0.0	0.0
B3	35.7	19.0	7.8	5.6	8.7	21.2	0.7	6.9	12.4	1.2	6.8	4.3	3.8	0.0	0.6	0.0
B(Naz)	27.0	18.5	9.9	5.5	11.0	13.7	3.7	6.7	11.0	13.5	6.8	4.6	4.5	0.0	0.2	0.0
C1	27.6	21.6	16.0	2.3	10.9	12.6	2.0	6.6	12.4	18.3	23.9	4.4	1.9	0.8	0.0	0.0
C2	23.7	12.1	6.5	2.3	4.4	33.5	20.4	10.8	12.8	17.3	9.6	11.0	13.7	5.1	2.5	0.0
C3	26.1	15.1	11.1	2.1	7.00	20.3	8.4	7.6	11.1	12.1	11.7	6.8	6.3	2.0	1.2	0.0
C(ANKE)	25.8	16.3	11.2	2.2	7.4	22.1	10.3	8.3	12.1	15.9	15.1	7.4	7.3	2.6	1.2	0.0
D1	20.5	25.1	19.4	22.5	36.7	39.6	48.6	31.4	23.3	15.1	18.5	7.4	8.3	0.0	2.3	0.5
D2	24.2	21.5	27.9	12.5	41.5	33.8	10.1	41.2	10.6	15.2	11.4	24.7	27.4	0.0	3.3	0.0
D3	32.3	13.6	26.4	3.0	24.7	47.6	31.0	19.8	9.0	6.1	25.6	14.3	14.1	0.0	4.5	0.0
D(NKPS)	25.7	20.1	24.6	12.7	34.3	40.3	29.9	30.8	14.3	12.1	18.5	15.5	16.6	0.0	3.4	0.2
E1	43.8	42.9	15.9	45.5	85.2	69.1	145	85.2	66.0	47.4	53.2	38.6	30.1	10.0	47.2	1.0
E2	22.9	30.5	13.6	21.2	48.0	57.8	47.1	45.9	44.2	26.1	12.0	10.8	28.0	2.4	4.6	0.0
E3	37.2	17.2	11.3	9.2	11.2	29.6	36.4	6.6	22.4	38.1	25.6	12.6	30.5	0.0	4.7	0.0
E(ANKES)	34.6	30.2	13.6	25.3	48.1	52.2	76.1	45.9	44.2	37.2	30.3	20.7	29.5	4.1	18.8	0.3

Table A2: Average number of aphids/leaf at different days for each replication and for each treatment of okra 1999

Rep. Or trea. \ Date	21.2	25.2	6.3	23.3	1.4
A1	332	601.9	101.1	710	472
A2	132	89.9	260.4	478	346
A3	162	103.1	79.1	870.5	933
A(C)	208.7	265	146.9	686.2	583.7
B1	332	73	17.2	225	153.6
B2	132	79.2	93.6	173.7	407
B3	162	72	25.2	142	68.9
B(Naz)	208.7	74.73	45.33	180.2	209.8
C1	332	232	130.8	212	487.5
C2	132	62	62.8	319	650.1
C3	162	20.6	48.9	479.5	574
C(ANKE)	208.7	104.9	80.83	336.8	570.5
D1	332	196.5	233.8	692.5	540.5
D2	132	243	326.3	680.5	656.5
D3	162	439.5	561.5	599	867.5
D (SUM)	208.7	293	373.9	657.3	688.2

Table A3: Average number of leaves/plant infested with *P. puncticollis* at different days for each replication and for each treatment of okra 1998

NR. of count \ Treatment	A	B	C	D
1	4.83	1.87	0.77	2.67
2	4.73	1.53	0.13	2.77
3	5.23	1.6	0.57	1.63
4	4.3	1.27	0.27	2.67
5	3.5	1.13	0.1	1.4
6	4.43	0.33	0.33	1.07
7	4.73	1.8	0.57	1.13

Table A4: Average number of plants/plot at different days infested *by E. vittella* days for each replication and for each treatment of okra 1998

Rep. \ Date	28.2	4.3	7.3	14.3	18.3	25.3	28.3	1.4	4.4
A1	6	6	7	12	14	20	14	10	8
A2	1	7	9	11	12	14	13	12	12
A3	3	9	10	11	12	13	15	12	10
A(C)	3.3	7.3	8.7	11.3	12.7	15.7	14.0	11.3	10.0
B1	2	5	2	5	1	2	2	2	2
B2	1	2	1	1	1	1	0	1	2
B3	2	2	2	0	1	1	1	0	1
B (Naz)	1.67	3.00	1.67	2.00	1.00	1.33	1.00	1.00	1.67
C1	1	2	2	2	1	2	2	1	0
C2	1	1	1	2	1	1	0	1	1
C3	1	1	1	1	1	1	1	0	1
C(ANKE)	1.00	1.33	1.33	1.67	1.00	1.33	1.00	0.67	0.67
D1	5	11	15	10	14	23	15	11	5
D2	4	9	14	12	12	12	12	10	6
D3	5	2	11	12	10	11	7	5	3
D(NKPA)	4.67	7.33	13.33	11.33	12.00	15.33	11.33	8.67	4.67
E1	7	12	11	11	17	15	12	11	9
E2	5	10	9	13	11	10	12	13	11
E3	1	3	4	20	15	11	9	9	8
E(ANKES)	4.33	8.33	8.00	14.67	14.33	12.00	11.00	11.00	9.33

Table A5: Average number of adults/leaf of *B. tabaci* at different days for each replication and for each treatment of okra 1998

Date / Rep.	11.2	14.2	18.2	21.2	25.2	28.2	4.3	7.3	14.3	18.3	21.3	25.3	28.3
A1	2.2	1.5	4.6	1.8	2.5	9.7	2.7	4.2	22.1	1.3	5.4	3.4	2.1
A2	5.2	4.3	7.8	6.4	11.3	11.6	13.5	28	44.1	28.3	22	1	4
A3	8.9	15	15.9	23	6.9	13.4	23.8	50.9	4.6	15.1	8.1	6.1	5.6
A(C)	5.433	6.933	9.433	10.4	6.9	11.57	13.33	27.7	23.6	14.9	11.83	3.5	3.9
B1	6.6	2.5	1.8	0.1	1.9	4.3	4.6	2	10.9	3.1	9	0.5	2.6
B2	5.7	3.2	6.6	1.6	5.3	6.5	4.6	3.3	7.8	3.6	6.4	27.6	5.3
B3	6.3	2.6	5.033	1.467	4.5	6.267	3.7	4.333	6.767	4.167	21.63	12.83	5.3
B (Naz)	6.2	2.767	4.478	1.056	3.9	5.689	4.3	3.211	8.489	3.622	12.34	13.64	4.4
C1	3.5	0.6	2.9	0	1.6	6	3.6	1.2	6.1	0.6	4.4	2.4	1.7
C2	1.3	0.9	2.3	2.2	4.8	6.7	4.2	0.7	6.2	1.3	10.8	0.6	2
C3	5.8	2.1	3.8	0.3	4.2	5.4	3.2	3.8	2.3	5.4	15.9	1.8	1.9
C(ANKE)	3.533	1.2	3	0.833	3.533	6.033	3.667	1.9	4.867	2.433	10.37	1.6	1.867
D1	2.2	3.9	1	0	7.8	2.9	5.4	13.7	23.2	1.4	4	1.4	0.7
D2	4.3	4.5	7.2	2.5	14.8	6.5	7.6	10.8	10.4	14.9	9.8	5.6	3.3
D3	6.4	6.8	15.1	0.6	3.7	5.9	6.9	9.4	6.6	4.3	2.3	4	5.5
D(NKPS)	4.3	5.067	7.767	1.033	8.767	5.1	6.633	11.3	13.4	6.867	5.367	3.667	3.167
E1	2.5	0.9	3.7	0.1	2.1	4.3	6.5	1.6	4.8	3.5	2.1	1.1	0.6
E2	2.3	0.4	25.1	31	4.2	18.4	9.8	31.5	0.2	19.4	10.7	2.4	2.2
E3	2.7	10	14.8	1.2	6.3	7	15.4	11.9	32	20.1	27	13.9	2.8
E(ANKES)	2.5	3.767	14.53	10.77	4.2	9.9	10.57	15	12.33	14.33	13.27	5.8	1.867

Table A6: Total yield (g) at different days for each treatment of okra 1997

Treatment / Date	A (C)	B(Naz)	C(ANKE)	D(NKPS)	E(ANKES)
16.3	200	1300	1500	450	25
20.3	110	5500	6150	1700	800
25.3	1290	5500	5150	1940	1290
3.4	850	1650	2350	1150	500
5.4	500	2630	2870	740	300
8.4	130	660	666	335	400
10.4	350	2250	1700	800	550
12.4	480	1800	1900	850	630
14.4	480	1550	2500	685	1960
18.4	2290	6880	3700	3034	1450
22.4	1800	3600	6200	1800	1190
24.4	1180	3070	3030	1960	851
26.4	1250	2220	2480	170	1480
28.4	2000	4930	3850	2150	1780
30.4	1770	3000	4070	2300	1780
3.5	2880	3300	4295	3000	1776
5.5	1370	2040	2260	1813	1074
7.5	888	1900	2000	1285	814
9.5	624	1220	1776	925	814
11.5	851	1554	1554	1000	740
13.5	1000	2333	2111	1111	1111
15.5	1000	1501	1501	777	518
17.5	444	851	1221	333	629
19.5	1110	1332	1332	740	444
21.5	518	1554	1852	740	535
23.5	260	838	1000	555	481
25.5	535	999	1332	444	681
27.5	666	2000	2220	666	666
29.5	1000	1332	2232	660	444

Table A7: Average yield (g) at different days for each treatment of okra 1998

Rep. / Date	A(C)	B(Naz)	C(ANKE)	D(ANKES)	E(ANKES)
14.3	166.7	133.3	333.3	100.0	0.0
18.3	233.3	266.7	400.0	400.0	0.0
21.3	130.0	233.3	233.3	266.7	166.7
24.3	400.0	566.7	666.7	366.7	400.0
28.3	533.3	600.0	666.7	333.3	533.3
30.3	200.0	266.7	366.7	200.0	200.0
1.4	266.7	600.0	366.7	266.7	300.0
4.4	800.0	366.7	366.7	200.0	233.3
6.4	100.0	500.0	366.7	166.7	233.3
8.4	633.3	933.3	1000.0	666.7	833.3
11.4	1166.7	1333.3	1600.0	1166.7	1133.3
13.4	1300.0	1366.7	1433.3	1366.7	1566.7
16.4	933.3	1333.3	1233.3	666.7	733.3
19.4	866.7	1100.0	1700.0	700.0	1033.3
21.4	400.0	500.0	566.7	300.0	366.7
23.4	333.3	466.7	466.7	333.3	333.3
25.4	400.0	433.3	466.7	300.0	266.7
27.4	366.7	500.0	666.7	300.0	400.0
29.4	833.3	1133.3	1333.3	600.0	933.3
2.5	433.3	566.7	433.3	266.7	366.7
5.5	500.0	733.3	1000.0	400.0	633.3
8.5	366.7	900.0	966.7	433.3	566.7
10.5	366.7	533.3	633.3	233.3	366.7
13.5	300.0	466.7	666.7	200.0	300.0
15.5	200.0	266.7	400.0	76.7	126.7
17.5	200.0	266.7	333.3	106.7	116.7
19.5	93.3	266.7	266.7	100.0	73.3
21.5	133.3	366.7	400.0	133.3	113.3

Table A8: Average yield (g) at different days for each treatment of okra 1999

Treatment / Date	A(C)	B(Naz)	C(ANKE)	D(SUM)
21.2	181.3	310	233.7	0
24.2	197.3	161.7	108	0
26.2	249.7	126	74	74
28.2	117	120	154	135.7
6.3	357.7	244.3	309	329
8.3	406.7	357.7	370	190.3
11.3	160	222	203.3	141
13.3	234	333	193.3	141.7
15.3	283	413.3	348.7	259
17.3	339	407	320.7	351.3
20.3	555	1036	697	838.7
23.3	777.7	796	591.7	963.3
26.3	739.7	900.3	789.3	826
29.3	950.3	1726	1172	1259
31.3	836.7	910.7	1119	1008
4.4	1073	1804	1727	1221
10.4	431.7	678.3	801.7	345.3
13.4	518	664	777	345.3
15.4	296	382.3	203.7	148
17.4	283.7	542.7	652.3	185
21.4	217.5	592	502.3	257.7
24.4	302	477.3	468.7	212.7
27.4	209.7	394.7	339	160.3

Table A9: Average number of aphids/leaf at different days for each replication and for each treatment of tomato 1998

Date / Rep.	8.1	13.1	17.1	21.1	24.1	27.1	4.2	11.2	14.2	18.2	21.2	25.2	4.3	9.3	18.3	21.3
A1	6	6	9.6	14.2	15.7	21.6	24.2	4.3	2.4	2.2	2.2	4.3	0.9	0.3	0.3	0
A2	15.2	24.1	15.4	37	12.1	39.5	43	2.9	2.9	0.6	0.1	1.2	0.7	0.7	0.3	0
A3	8.5	13.1	12.3	15	20.9	35.2	23.4	2.7	1.9	1.9	1.7	1.7	0.9	0.7	0.2	0
A(C)	9.9	14.4	12.43	22.07	16.23	32.1	30.2	3.3	2.4	1.567	1.333	2.4	0.833	0.567	0.267	0
B1	3.4	4.4	3.7	6.2	7	20	20.6	3.8	1.9	1.8	0	1.2	1	0	0.2	0.4
B2	4.8	2.3	7.3	11.8	8.5	30.2	31	3.3	2.3	1.3	0.8	0.7	2.3	0.9	0.3	0
B3	14.6	16.7	15.2	31.9	23.2	63.2	20.9	5.2	3.5	0.7	0.6	2.2	1.5	0.9	0	0
B (Naz)	7.6	7.8	8.733	16.63	12.9	37.8	24.17	4.1	2.567	1.267	0.467	1.367	1.6	0.6	0.167	0.13
C1	3.3	1.3	7	6.1	8.7	2.2	1.2	0.6	1.2	1.4	0.6	0.7	0.2	0.2	0	0.8
C2	8.8	18.1	15.4	14.4	27.2	11.5	1.3	2.1	1.2	1	1	0.8	0.3	0	0	1
C3	11	21.5	30.8	11.4	24.1	11.1	4.6	1.1	1	0	0.8	1	0.3	0.2	0	1
C(ANKE)	7.7	13.63	17.73	10.63	20	8.267	2.367	1.267	1.133	0.8	0.8	0.833	0.267	0.133	0	0.93
D1	12.4	8.1	11	16.7	17.2	23.5	1.3	5.3	2	1.2	1.5	0.8	3.9	0.3	0.5	0.9
D2	11.3	10.6	24.1	23	21.8	42.4	41.9	5.6	4.6	1.6	0	0.4	1.3	0.6	0.3	0
D3	16.8	12.1	24.4	27.2	26.4	28.2	29.1	2.3	0	1.9	0.2	1.9	1.6	1.9	0.3	0
D(NKPS)	13.5	10.27	19.83	22.3	21.8	31.37	24.1	4.4	2.2	1.567	0.567	1.033	2.267	0.933	0.367	0.3
E1	2.6	1	3.5	0.6	7.2	35.7	4.6	1.2	1.2	1.4	1.1	3.5	1.5	0.7	0.1	0
E2	6.4	0.6	2.5	2.6	5.4	22.1	4.2	2.1	2.2	0.6	0	1	1.2	0.6	0	0
E3	2.9	0.5	2.9	1.7	12.2	28.2	12.1	1.8	1.2	1.1	0.1	1	1.4	1.2	0.1	0
E (SUM)	3.97	0.7	2.97	1.6	8.3	28.7	6.97	1.7	1.5	1.03	0.4	1.8	1.4	0.8	0.07	0

Table A10: Average number of leaves/plant infested with *L. trifolii* at different days for each replication and for each treatment of tomato 1998.

Rep \ Date	8.1	13.1	17.1	21.1	24.1	27.1	4.2	11.2	14.2	18.2	21.2	25.2	4.3	9.3	18.3	21.3
A1	2.9	1.6	2.3	3.2	2	1.6	2.4	4.4	3.9	7.3	5.1	8.8	3.4	5	0.9	1.3
A2	1.5	0.9	1.4	2.2	0.7	2.3	3.6	7.2	0.6	1.2	7	8.5	4.1	3.4	0.7	1.2
A3	1.9	1.5	2.7	2.3	2	1.8	3.4	5.5	6.2	6	4.8	4	2.5	4	0.7	0.9
A(C)	2.1	1.33	2.133	2.57	1.57	1.9	3.13	5.7	3.567	4.833	5.63	7.1	3.33	4.13	0.767	1.13
B1	1.9	1.3	0.5	1.8	1.4	2	1.9	3.7	3.8	4.6	3.9	0.9	2.3	1.8	0.4	0.4
B2	1.3	1.3	1.2	2	1	0.4	2.7	1.9	2.4	1.4	1.3	2	0.8	1.8	0.8	1.1
B3	1	0.9	1.1	1.4	1.5	0	2	2.6	2.8	3.8	1.8	2.1	1.2	4	0.2	1.9
B(Naz)	1.4	1.17	0.93	1.73	1.3	0.8	2.2	2.73	3	3.27	2.33	1.67	1.43	2.53	0.467	1.13
C1	2.7	0.9	0.9	1.7	0.3	0.5	0.6	2.3	4.8	1.2	1.4	1.4	1.7	0	0.3	0.8
C2	1.3	0.9	1.3	1.7	0.9	0.5	0.5	1.2	2.7	0.8	1.1	1.3	1.3	3	0.7	1
C3	1.8	1	0.8	1.4	0.6	0.3	0.6	2.3	1.5	3	0.9	0.6	2.8	1.6	0.5	1
C(ANKE)	1.93	0.93	1	1.6	0.6	0.43	0.57	1.93	3	1.67	1.13	1.1	1.93	1.53	0.5	0.93
D1	12.4	8.1	11	16.7	17.2	1.4	2.4	3.3	4.9	6.4	3.9	3.9	3.9	1.7	1	1
D2	11.3	10.6	24.1	23	21.8	3	3.1	4.5	4.9	6	2.1	4.3	2.4	2.6	1	1.5
D3	1.9	1.6	2.7	1.8	1.1	1.3	2.1	3.4	5.4	7.1	3.8	4.6	2.6	4.5	1.1	1.1
D(NKPS)	8.53	6.77	12.6	13.83	13.37	1.9	2.53	3.73	5.07	6.5	3.27	4.27	2.97	2.93	1.033	1.2
E1	1.5	0.6	0.9	0.9	0.3	0.1	0.8	0.9	2.4	1.3	3.3	1.7	0.7	1.2	0.8	0.5
E2	1.3	1	1	0.8	0	0	0.9	1.6	2.5	1.2	1	1.7	1.9	1.9	0.5	1.2
E3	1.1	0.4	0.5	0.3	0.4	0.5	0.5	0.6	2.3	2.4	1.8	1.5	1	1.4	0.2	1.9
E (SUM)	1.3	0.667	0.8	0.667	0.233	0.2	0.733	1.033	2.4	1.633	2.033	1.63	1.2	1.5	0.5	1.2

Table A11: Average number of adults/10leaves of *B. tabaci* at different days for each replication and for each treatment of tomato 1998

Date / Rep.	8.1	13.1	17.1	21.1	24.1	27.1	4.2	11.2	14.2	18.2	21.2	25.2	4.3	9.3	18.3
A1	0.0	2.0	0.0	0.0	2.0	7.0	22.0	2.0	2.0	2.0	5.0	4.0	9.0	11.0	3.0
A2	0.0	2.0	0.0	6.0	3.0	22.0	3.0	9.0	6.0	1.0	2.0	5.0	5.0	10.0	3.0
A3	6.0	0.0	0.0	2.0	2.0	11.0	9.0	3.0	4.0	0.0	0.0	15.0	9.0	0.0	2.0
A(C)	2.0	1.3	0.0	2.7	2.3	13.3	11.3	4.7	4.0	1.0	2.3	8.0	7.7	7.0	2.7
B1	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	3.0	1.0
B2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	3.0	1.0
B3	0.0	0.0	2.0	1.0	2.0	0.0	5.0	4.0	7.0	2.0	6.0	3.0	3.0	4.0	0.0
B (Naz)	0.0	0.0	0.7	0.3	0.7	0.7	1.7	1.3	2.3	0.7	2.0	1.7	1.7	3.3	0.7
C1	2.0	0.0	0.0	0.0	0.0	5.0	0.0	3.0	0.0	3.0	1.0	0.0	1.0	14.0	3.0
C2	0.0	0.0	0.0	0.0	0.0	5.0		3.0	7.0	0.0	2.0	11.0	8.0	11.0	4.0
C3	1.0	0.0	0.0	0.0	6.0	3.0	5.0	3.0	4.0	0.0	0.0	5.0	0.0	17.0	0.0
C(ANKE)	1.0	0.0	0.0	0.0	2.0	4.3	2.5	3.0	3.7	1.0	1.0	5.3	3.0	14.0	2.3
D1	0.0	0.0	0.0	0.0	0.0	7.0	31.0	9.0	22.0	4.0	6.0	2.0	2.0	22.0	3.0
D2	3.0	0.0	0.0	0.0	0.0	0.0		0.0	3.0	0.0	2.0	4.0	4.0	12.0	3.0
D3	0.0	0.0	0.0	3.0	0.0	4.0	3.0	6.0	4.0	0.0	0.0	13.0	1.0	13.0	3.0
D(NKPS)	1.0	0.0	0.0	1.0	0.0	3.7	17.0	5.0	9.7	1.3	2.7	6.3	2.3	15.7	3.0
E1	0.0	0.0	0.0	1.0	0.0	0.0	7.0	1.0	0.0	0.0	0.0	1.0	2.0	3.0	1.0
E2	0.0	3.0	0.0	0.0	0.0	0.0	2.0	2.0	0.0	0.0	10.0	2.0	6.0	9.0	1.0
E3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	0.0	7.0	0.0	1.0	1.0	2.0
E(SUM)	0.0	1.0	0.0	0.3	0.0	0.0	3.3	1.7	0.7	0.0	5.7	1.0	3.0	4.3	1.3

Table A12: Average yield (g) at different days for each treatment of tomato 1998

Treatment / Date	C	Naz	ANKE	NKPS	SUM
11.3	0.0	0.1	0.7	0.0	0.0
14.3	0.0	0.1	1.6	0.1	0.2
18.3	1.5	4.5	4.6	1.2	2.8
21.3	3.9	6.1	6.7	4.0	5.8
25.3	4.4	7.6	8.1	4.9	7.0
28.3	10.5	12.8	15.1	14.2	12.1
1.4	11.7	8.2	9.6	14.1	10.4
4.4	6.6	7.6	10.0	8.5	4.7
12.4	5.3	6.5	9.9	9.0	6.3
24.4	0.3	1.0	1.2	1.2	0.0

Table A13: Weather phenomenon 1997-1999

YEAR	1997		1998		1999	
MONTH	Rh.	M. TEMP.	Rh.	M. Temp.	Rh.	M. Temp.
JANUARY	31	26.7	25	20.8	30	23.7
FEBRUARY	22	21.3	21	23.0	30	28.4
MARCH	18	26.7	17	26.1	17	27.0
APRIL	16	30.8	15	31.7	14	31.2
MAY	22	32.7	18	34.1	29	35.2
JUNE	30	34.1	20	34.5	29	34.7
JULY	48	32.9	39	33.3	44	31.6
AUGUST	44	32.1	56	30.7	45	31.6
SEPTEMBER	33	33.6	52	31.3	47	30.3
OCTOBER	32	31.8	37	32.0	47	31.5
NOVENBER	24	27.4	25	28.9	26	31.1
DECEMBER	26	23.5	30	25.5	26	28.3

Table B1: The result of the statistical analysis of the effects of different treatments against *A. gossypii* on Okra 1998

treatment	Average	standard deviation
1	20,6	16,1
2	8,0	8,8
3	9,0	8,6
4	17,2	13,9
5	30	27,5
F value	8,2	
MQ	2,1	
p value	0,000	

Table B2: The result of the statistical analysis of the effects of different treatments against *A. gossypii* on Okra 1999

treatment	Average	standard deviation
1	420,4	308,6
2	127,5	107,1
3	273,3	224,0
4	478,1	251,5
F value	4,8	
MQ	,87	
p value	0,006	

Table B3: The result of the statistical analysis of the effects of different treatments against *E. vittella* on Okra 1998

treatment	Average	standard deviation
1	10,5	3,9
2	1,6	1,2
3	1,1	0,6
4	10,0	5,9
5	10,2	6,1
F value	61,3	
MQ	4,74	
p value	0,000	

Table B4: The result of the statistical analysis of the effects of different treatments against *P. puncticollis* on Okra 1998

treatment	average	standard deviation
1	4,5	0,6
2	1,4	0,5
3	0,4	O,3
4	1,9	0,8
5		
F value	29,6	
MQ	1,6	
p value	0,000	

Table B5: The results of the statistical analysis of the effects of different treatments against *B. tabaci* on Okra 1998.

Treatment	average	standard deviation
1	11,6	11,4
2	4,5	5,4
3	3,1	3,8
4	6,7	10,8
5	9,1	9,7
F value	2,3	
MQ	0,49	
p value	0,059	

Table B6: The result of the statistical analysis of the effects of different treatments on the yield (in kg)of Okra 1997.

Treatment	average	standard deviation
1	1	0,9
2	2,9	0,3
3	4,5	11,3
4	1,2	0,7
5	1,2	2,4
F value	65,1	
MQ	2,3	
p value	0,000	

Table B7: The result of the statistical analysis of the effects of different treatments on the yield (in kg) of Okra 1998

treatment	average	standard deviation
1	0,6	0,4
2	0,6	0,4
3	0,7	0,4
4	0,4	0,3
5	0,5	0,4
F value	1,4	
MQ	8,7	
p value	0,000	

Table B8: The result of the statistical analysis of the effects of different treatments on the yield (in kg) of Okra 1999

treatment	average	standard deviation
1	0,4	0,3
2	0,6	0,5
3	0,5	0,4
4	0,4	0,4
F value	0,3	
MQ	0,5	
p value	0,033	

Table B9: The result of the statistical analysis of the effects of different treatments against *A. gossypii* on Tomato 1998

treatment	average	standard deviation
1	10,1	11,8
2	8,6	12,3
3	5,9	7,9
4	10,5	11,8
5	4,1	7,3
F value	2,6	
MQ	1,0	
p value	0,037	

Table B10: The result of the statistical analysis of the effects of different treatments against *L. trifolii* on tomato 1998

treatment	average	standard deviation
1	3,3	2,2
2	1,8	1,1
3	1,3	0,9
4	3,1	1,9
5	1,1	0,7
F value	20,4	
MQ	1,8	
p value	0,000	

Table B11: The result of the statistical analysis of the effects of different treatments against *B. tabaci* on Tomato 1998

treatment	average	standard deviation
1	4,8	5,2
2	1,6	1,9
3	3,3	4,3
4	4,3	6,7
5	1,5	2,7
F value	4,9	
MQ	1,0	
p value	0,001	

Table B12: The result of the statistical analysis of the effects of different treatments on the yield of Tomato 1998

treatment	average	standard deviation
1	39,3	2,9
2	54,5	11,4
3	68,2	2,8
4	57,2	11,7
5	49,3	9,4
F value	4,5	
MQ	336,2	
p value	0,024	

Table B13: The result of the statistical analysis of the effects of different treatments against *T. tabaci* on Onion 1998

treatment	average	standard deviation
1	39,3	12,2
2	30,9	16,1
3	31,5	13,3
4	26,3	13,4
5	18,9	12,1
F value	3.0	
MQ	0,187	
p value	0,028	

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