

Entomology Abstracts

Conference Lecture: Insect pests management in Sudan, current status, challenges and future prospective

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Abstract

Insects count for *ca.* one million species i.e., 80% of the animal world. They constitute the major impediments to successful crop production. The objectives of this review were to point up the current status of insect pests management in the field, vegetable and fruit crops, national and store pests, and to state the challenges and future prospective. The impacts of tolerant varieties, cultural practices, optimum sowing date, certified seeds, plant density, and nutrients as first defensive mechanism that curb seasonal abundance, distribution and population buildup of insect pests were revealed. The review also tackled in details the traditional insect pests and optional control measures practiced at present; the newly introduced, invasive, resurged and upraising insect pests, losses causing factors by insects in stores, the motivating, constraining and challenges hindering the integrated crop and pests management and imperative of the economic threshold levels.

The review had also explored challenges confronting agricultural development, recommended research, extension and technology transfer efforts to face the newly appeared insect pests, the misuse of pesticides, developed resistance, lack of knowledge and awareness on pesticides among framers and retailers, negligence of legislative and field hygiene measures, imperfection in adoption the recommended cultural practices, insufficient field management in the national irrigated schemes, inadequate extension and poor training of farmers and meager funding of the research.

The explored future prospective includes development of resistant varieties, introduction and implementation of genomics, incorporation of *Bt* genes into local cultivars, development of applied biological control and economic thresholds and perfection of chemical measure. More emphasis is to focus on rainfed crop protection, implementation of organic farming, adherence and revision of regulations governing introduction and pesticide testing. Conduction of back-up research on biology, ecology, host range, distribution, economic importance and IPM components to suppress the newly appeared insect pests and training of scientists, technicians, farmers and retailers.

Keywords: ICM, IPM, field, vegetable, fruit crops and national insect pests.

1.1.1 *Trichogramma* rearing technique in Sudan and effects of cold storage of host eggs on parasitism and of preimaginal parasitoids on adults' emergence

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This study constitutes part of the *Trichogramma* Mass Rearing Project, being conducted at the Entomology Program, Crop Protection Research Centre, Agricultural Research Corporation, since January 2009. The objectives of the study were: (i) to provide detailed guides of Sudan technique on *Trichogramma* mass rearing (ii) to report results of the effect of cold storage of host eggs (at 2 ± 1 °C for 0 – 10 days prior to introduction to the parasitoid, on efficiency of parasitism and (iii) to report the effects of cold storage of preimaginal parasitoids, at 10 ± 2 °C and complete darkness for 0 – 10 weeks on adults' emergence. The guides covered the rearing technique, the required conditions, equipments, and diet for the host *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae), and the parasitoid *Trichogramma principium* (Sugonyaev et Sorokina) (Hymenoptera: Trichogrammatidae). The percentage of parasitism ranged between 68.7% and 100% with an average of $88.8\pm 7\%$ on fresh eggs and between 29.6% and 69.7% with an average of $50.7\pm 10.1\%$ on cold stored eggs. This markedly indicated preference of the parasitoid females to lay egg inside fresh, rather than cold stored eggs. The percentage of emerged adults out of the preimaginals, cold stored for 0 to 10 weeks was 91.6%, 67.3%, 68.5%, 65.2%, 64.4%, 49.2%, 42.4%, 38.4, 28.6%, 23.3% and 17.8%, respectively. These results clearly explained the advantage of releasing non cooled preimaginal parasitoids directly in the fields, rather than those subjected to cold storage. In case of production of the parasitoid during non-release season, cold storage should not exceed four weeks, after which a drastic decrease in emergence would occur.

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Keywords: *Trichogramma* rearing technique, Cold storage of host eggs and preimaginal

1.1.2 Establishment and parasitism efficiency of *Trichogramma principium* (*Sogonyaev et Sorokinia*) (Hymenoptera: Trichogrammatidae) on *Helicoverpa armigera* (Hb.) infesting cotton in Gezira. Sudan

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This study was conducted at the Gezira Research Station (GRS) Farm during 2010/11 season to verify establishment and parasitism efficiency of *Trichogramma principium* (*sugonyaev et Sorokina*) (Hymenoptera: Trichogrammatidae) in eggs of the African bollworm, *Helicoverpa armigera* (Hb.), (Lepidoptera: Noctuidae) infesting the Sudanese cotton cultivars “Barac 67B”, “Hamid”, “Burhan” and “Abdin”. *Trichogramma* was acquired from the Rearing Unit, Agricultural Research Corporation (ARC), at preimaginal (prepupal) stage, in eggs of the rice moth *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae). Depending on numbers of *H. armigera* eggs/100 plants, one release was done on each of Barac and Hamid and two on each of Abdin and Burhan. The release rate was 24,000 parasitoids/fed, at 7x7m distance between release points and 14 day intervals. Evaluation was done between treated plots with *Trichogramma* versus untreated. Observations consisted of the percentage of emerged parasitism and the numbers of the African bollworm larvae/100 plants. At the first release, the percentage of emerged parasitoids ranged between 71% in Barac and 86.4% in Hamid; the cultivars average ranged between 60.5% and 94.8% and the overall average was 79.2. The percentage of parasitized *H. armigera* eggs ranged between 22.2% and 77.7%. The high level of parasitoid emergence declared a good viability of the release material, tolerance of the parasitoid to the local weather conditions and acceptance of the crop. The levels of parasitoid reported were quite acceptable for this introductory release and first occurrence of the parasitoid in this new cotton agroecosystem. A positive signal of migration from treated to untreated plots was observed through parasitized *H. armigera* eggs detected in the later plots. The numbers of *H. armigera* larvae were negligible in both treatments. Accordingly, for proving potential capacity of establishment and parasitism efficiency against *H. armigera*, *T. principium* is strongly recommended for use on Sudanese cotton cultivars.

**Keywords: *Trichogramma principium*, Cotton, *Helicoverpa armigera*
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1.1.3 Sterile insect technique: successes, challenges and constraints on an area wide basis

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The sterile Insect Technique (SIT), used for suppression or eradication of insect pest was tested through the last 50 years against many pests. Its application depends on many factors such as the biology and ecology of the pest and agronomic and bionomic considerations. The mostly used strategies at present are suppression, eradication, containment and prevention. These strategies have resulted in successes in some cases and failures in others. However, the successful application of SIT program, on an area wide basis, depends on several parameters among which are the population level of the pest ,target area and the socio- economic context. A feasibility study must be done before establishment of any SIT program to ensure successes of its all components. The manuscript and presentation illustrate the SIT exploited in Tunisia, its progress, successes, challenges, constraints, and economic and social impacts.

Keywords: SIT, Area wide, Strategies, Constraints, Perspectives.

1.1.4 Development of fungal based-product for the control of Western flower thrips *Frankliniella occidentalis* (Pergande)(Thysanoptera:Thripidae)

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The Western flower thrips *Frankliniella occidentalis* is an important economic pest of crops throughout the world. Entomopathogenic fungi are the most promising alternative to chemical insecticides. Ten isolates of *Mearhizium anisopliae* and eight of *Beauveria bassiana* were screened for virulence against second-instar larvae of *F. occidentalis*. Molecular polymorphism was also investigated to understand the differences in virulence, and later on assessed the compatibility of the most virulent isolate with agrochemicals used in French

bean production and possibility of the use in autoinoculation system alongwith the commercial kairomonal attractant LUREM-TR.

The *Metarhizium* isolate ICIPE 69 showed high virulence on larval stages of *F. occidentals* and produced significantly more conidia. Although chitinase sequence analysis did not reveal major differences, its sequence comparison indicated the presence of a restriction site Sfol on ICIPE69, which could be due to the difference in geographical origin.

Among 12 agrochemicals commonly used in Kenya, ICIPE69 was compatible with abamectin, imidacloprid and thiamethoxam, whereas Neem and L-cyhalothrin, spiromesifen, carbendazim,probineb, copper-hydroxide were toxic to the fungus.

In autoinoculation experiment, thrips acquired more conidia in the fungus-treated semiochemical. However, conidial viability was considerably reduced in the device with semiochemical. Thrips density per plant was significantly reduced in both treatments as compared to the control.

ICIPE 69 was shown to be the most virulent isolate on larval stages of thrips. Its compatibility with imidacloprid or thiamethoxam suggests its suitability as candidate for fungal biopesticide for thrips management. Results in autoinoculation system using semiochemical demonstrated, gave promising strategies for thrips management and their vectored diseases.

Keywords: Biopesticides, Thrips, Metarhizium anisopliae, Agrochemicals, Autoinoculation

1.1.5 Parsimonious management of the Desert Locust, *Schistocerca gregaria*, (Orthoptera: Acrididae (Forsk.) nymphs by the use of gregarious adult pheromone phenylacetonitrile (PAN)

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This presentation is an outcome of research conducted by 2 PhD and 4 MSc. The semi-field and field trials were conducted at the Northern, Central and Southern part of the Red Sea State. This is because these areas evidence two breeding seasons and sometimes a third season every year. The studies included the use of adult gregarization pheromone phenylacetonitril (PAN) alone and

combined fractional doses of the fungus *Metarhizium acridum* (biocontrol, agent (GM) and one conventional insecticide (Marshal 200UL) used in the control of the of desert locust. PAN alone caused high frequency of predation and cannibalism among the treated band. Fragmentation of the bands was also evident from the low value of the two gregarization indices. PAN also enhanced the efficacy of both *Metarhizim* and Marshal. Fractional dosages of both were similarly effective as the recommended dose of each. The application rate of 10ml of PAN per ha combined with 12.5 gm of GM gave 96.42 ± 23.50 mortality compared with 97.73 ± 1.34 when the recommended dose (500 ml/ha) of Marshal was used. These findings will lead to a reduction of up to quarter the cost per ha. PAN alone costs 20 cents/ha. Marshal and the biopesticide GM cost \$12/ha, \$ 20/ha, respectively.

In both cases the cost of control tactics as well as the environmental risks and externalities characteristics of conventional pesticides are avoided.

Keyword: Desert Locust, *Schistocerca gregaria*, Adult pheromone, Phenylacetone nitrile, *Metarhizium arcidum*, Marshal

1.1.6 Prospects of Biological Control of Date Palm Green Pit Scale Insect *Asterolecanium phoenicis* Rao (Homoptera: Asterolecaniidae) in Sudan

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The Northern and River Nile States are the main areas for date production in Sudan. In 2008, one million trees out of five million trees grown in the two states were infested by green pit scale insect *Asterolecanium phoenicis* Rao (Homoptera: Asterolecaniidae). A survey was carried out during August 2008 - July 2009 at Artigasha island, Eburgag, Elgaba, Elgolid, Old Dongola (Elgadar area) and Urbi to find out natural enemies of this pest and assess their role in natural regulation of its population. Another study was conducted at Elgolid to determine the seasonal abundance of the green pit scale and associated natural enemies. Predators found in all surveyed areas were Nitidulidae beetle *Cypocephalus dudichi* L., the ladybird *Pharoscyrnus numidicus* Pic., and a

Chrysoperla sp. These predators were observed attacking the first stages and young females. The Nitidulidae beetle and the ladybird were relatively the most abundant predators (4.8/leaf). The percentage of scales with signs of predation was 13% recorded in some areas. The parasitoid, *Metaphycus* sp. was found in association with the pest and the percentage of scales with exit hole; the sign of parasitism was 16% in some areas. The highest infestation level by green pit scale insect was recorded in Artigasha Island (209 scales/ sample) and the lowest was in Elburgag scheme (96 scales/ sample). The pest was found throughout the year and its population increased from October to January and decreased in August which can be attributed to climatic conditions. Parasitism with the *Metaphycus* sp was relatively high in October to February while the seasonal abundance of the predators was relatively low from December to March.

Key Words: Biological Control, Date Palm, *Asterolecanium phoenicis*, Sudan

2.1.1 Biology of three Trichogramma species and their effectiveness as biological control agents against *Helicoverpa armigera* Hub. (Lepidoptera: Noctuidae and other insect pests in Sudan

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The African bollworm is considered as one of the most serious insect pest in Sudan. *Trichogramma piceum* MD, *T. nerudai* PT and *T. bourarachae* EG (Hymenoptera: Tchicopgramma) were tested for their effectiveness against *H. armigera*. Biological parameters at 25 and 30 °C were studied on laboratory on eggs of *H. armigera*. Also ability of dispersing on the cotton plants in greenhouse and open field was studied. The parasitism potential of three *Trichogramma* against native Lepidopterous host in laboratory was study. The highest parasitism levels were at 25 °C for *T. piceum* and *T. nerudai*, but *T. bourarachae* showed the highest at 30 °C emergence rate at both temperatures was for *T. nerudai* and *T. picum* while *T. bourarachae* showed an increase in their emergence rate. From 25 °C to 30 °C percentage female decreased when

the temperatures change from 25 °C to 30 °C in case of *T. piceum* and *T. bourarachae* EG. While in *T. nerudai* showed same trend. Under greenhouse and in open field all tested *Trichogramma* species showed good dispersal behavior. *T. bourarachae* showed good ability to distribute within cotton plants, followed by *T. nerudai*, while *T. piceum* showed promising ability. Parasitism potential of *T. piceum* were higher on *Spodopera* and *Sitortoga* eggs, but *T. nerudai* and *T. bourarachae* showed high parasitism potential on *Sitotroga* and *Corcyra* eggs. The three *Trichogramma* species showed emergence rate more than one adult per parasitized egg and sex ratio was 50% females or above.

Keywords: Biological control, *Helicoverpa armigera*, *Trichogramma* spp. Biological Parameters, Dispersal behavior, Negative ,Lepidopterous

2.1.2 Response of *Trichogramma oleae* (Hymenoptera: Trichogrammatidae), to the host pheromones, frass and scales Extracts

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Semiochemicals help natural enemies locate and recognize their hosts. Therefore, knowledge of the nature of these chemicals and their functional roles is important in design of programmes that use parasitoids as biological control agents, *Trichogramma oleae* has been found to parasitise egg masses of lepidopterous olive pest. The present study was aiming to develop an IPM for lepidopterous olive insect pests, based on natural enemies and pheromones. The study investigated the kairomonal effect of *prays oleae*, and *Palpita* and *Palpitauniondalis* sex pheromone components, frass and scale extracts. Petri dishes were used for the choice test. A filter paper (PS-Whatman 9 cm) was placed at the bottom of the petri dish. The filter was separated to quadrant. Egg masses of *Sitotroga* eggs were glued in each quadrant. Testing chemicals were applied to each of the two opposite quadrants at appropriate rate; pure solvent was applied to each of the two remaining quadrants. Five wasps, 3 days old, were introduced into the centre of Petri dish. Wasp movements to the treated and control quadrants were observed at regular time intervals. The number of black (parasitized) eggs was recorded after 5 days. The results indicated in general a deterrent action of some Pheromones, especially unsaturated

aldehydes,. Experiments investigating the influence extracts of peals and frass indicated, in general, a neutral and or attractive action. However the results showed that the effect were dose and persistence dependent.

2.1.3 Ecotoxicological studies on the gregarious Deseret Locust pheromone Phenylacetonitrile (PAN) used alone and combine with green muscle, *Metarchizium acridum* (GM)

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Phenylacetonitrile 98% (PAN) manufactured by Sigma-Alrich constitutes the main component of gregarious Desert Locust (DL) pheromone, Two types of ecotoxicology tests were conducted. First tier (topical application) and second tier tests (treated soil exposure, direct exposure, feeding tests and field tests on dung beetles). Pan was used alone and combined with low dosages of GM. Carbamate (carbosulfan) as Marshal 200UL was tested as a reference conventional. First tier tests of PAN and diesel were conducted on *Adesmia antique* and *Trachyderma hispida* (Coleoptera; Tenebrionidae) which are predators of the desert locust and grasshopper eggs. The following doses were tested: 1, 3, 5, 7, 10, 15 and 20 microlitres per individual using a Hamilton® micro syringe applicator. The designated dose was applied on the pronotum of the tested individual. The treated and control insects were monitored daily for 10 days.

Mortality due to diesel and Pan on *A. antique* were not significantly different from each other. The mean mortality was high particularly in the first day when high dosages (10 microliters per individual and above) were administered. The LD₅₀ value for PAN was at 15 microlitres while for diesel was 10 microlitres. After treatment, some individuals became lame, and they had an extruded ovipositor, However, at low doses recovery was recorded in few individuals.

Mortality due to diesel and PAN on *T. hispida* was not significantly different. The LD₅₀ value was not significantly different for PAN (8.5 microlitres) and diesel (10 microlitres). In the second tier tests, soil treatments, PAN, GM and Marshal had no negative effect on ant lions and Tenebrionids. In feeding assays, only

Marshal caused significant mortality in ant lions fed on treated ants and the Tenebrionids fed on a treated meal of beans and bread. When the treatments were applied to camel and goat droppings and to sugar coated cardboard sheet to test their effects on dung beetles and termites,. This was evident by the reduced sheeting and areas on the treated cardboards. Also high dosages of GM combined with PAN curtailed the activity of termite but with less effect compared to the effect of Marshal.

Keywords :Ecotoxicology,Phenylacetone nitrile,Tenebrionids,Ant lions,Dung

2.1.4 Effects of *Metarhizium acridium* (Metch) and the desert locust, *Schistocerca gregaria* (Forsk)(Orthoptera: Acrididae) adult aggregation pheromone phenylacetone nitrile (PAN) on the feeding rates of the nymphs

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The effects of infection by the entomopathogen fungus, *Metarhizium anisopliae*, var/ *acridium* (Metch) and exposure to the adult aggregation nymphs of the Desert Locust, *Schistocerca gregaria* (Forskasl), was investigated in cages in the laboratory. A significant reduction in feeding, as indicated by food concentration per day, was recorded after inoculation with different spore concentrations (1.3×10^6 , 1.3×10^7 and 1.3×10^8 spores/ml and PAN alone or combined with the pathogen. Individual in all the treatments died by day six. In day four the treated nymphs consumed less food compared with the ones in both controls. The reduction in feeding, expressed as accumulated mean measured in milligrams dry weight in day four was 39.1, 24.4 and 15.3 for the doses rates 1.3×10^6 , 1.3×10^7 and 1.3×10^8 spores/ml respectively. In the untreated control the value was (38.1 mg/day). The reduction is substantial contribution to the overall effect of the slow acting pathogen. Furthermore, the rapid reduction in feeding indicated that the effect was not simply due to the invasion of host tissues by the pathogen or production of secondary metabolites. The mechanism behind such reduction is unclear. In the late stages of infection process, it can be attributed to mechanical damage of host tissue. It is also possible that reduction in feeding is associated with lethal behavioral changes due to infection.

Keywords; Entomopathogen, Metarhizium, Pathogen, Adult aggregation pheromone

2.1.5 The role of taxonomy in integrated pest management: A case study of Psyllids (Hemiptera: Pyslloidea) in Cameroon

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Local faunal and floral inventories are an important base for reaching the goals defined in the conventions Biological Diversity in 1992, i.e. the conservation and sustainable use of biodiversity. For large groups such as insects with over one and half million described species, a major problem constitutes the large proportion of undescribed taxa. This situation has been termed the “taxonomic impediment”. Psyllids are, in this respect, no exception as less than half of the existing species is described up to date. Jumping plant-lice or psyllids (Hemiptera, psylloidea) form a small group of plant-sap sucking insects. Currently, there are some 3800 species described worldwide with an estimated further 5000 undescribed ones. They are particularly species rich in the tropics where the fauna is generally poorly known. Like other insects, psyllids may become serious pests on cultivated plants. In Cameroon several species of economically important crops and commercial timber species are attacked by psyllids that are responsible for big losses in orchards and plantations. Psyllids damage their hosts in various ways: distortion of leaves, necrotic leaf damage by sucking, and induction of various types of galls on the leaves, stems or flowers. In some cases psyllids action can cause death of the plant, more often the tree growth is slowed down causing economical loss. In nurseries psyllids can destroy young plants. Some psyllids act as vector of bacterial and viral diseases. A sound taxonomic base is also essential for the control of pests. This base, however, lacks almost completely in the tropics. Recent field work in Cameroon focused on biodiversity, taxonomy and biology of psyllids. This presentation reports on the importance of taxonomy in Integrate Pest Management of psyllids, pest of cultivated plant and forest timbers in Cameroon.

Keywords: Psyllids, Taxonomy, Pest Control, Cameroon

2.1.6 Susceptibility of some varieties and breeding lines of tomato to leafminer, *Liriomyza* spp (order: family) infestation in Central Sudan

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Tomato crop in the central Sudan is liable to heavy infestation by the leaf miners *Liriomyza* spp. Field experiments indicated significant differences between susceptibility of varieties and breeding lines of tomato to the damage in terms of infestation caused by *Liriomyza* spp. The variety Flora Dade and the breeding lines Omdurman, UG Fireset A3 36L and UG Fireset A6 30R were the most infested (susceptible) by the leafminer. The breeding line Trop G9-18 and the varieties, Alfa, Peto 86 and Strain B were the least infested (tolerant). Moderate susceptibility was exhibited by the breeding lines, Hillo, UG 46 and UG Fireset A4 20R and the variety Fed Star.

The laboratory test revealed that Flora Dade was more susceptible to *Liriomyza sativae* than Trop-G, whereas the latter was absolutely resistant to *L. trifolii*. The mean number of larvae/leaf and the larval period were taken as parameters to evaluate the susceptibility of two breeding lines and two varieties. No differences were found in larval duration of varieties and Omdurman breeding line. Resistance is attributed to anti-feedants and associated with glandular trichomes on the leaves.

Keywords: Infestation, Leafminer, Breeding Line

3.1.1 Evaluation of some onion (*Allium cepa*) varieties against thrips, *Thrips tabaci* (Thysanoptera :Thripidae) and onion yellow dwarf virus infestation in Khartoum State, Sudan

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A comparative study on seven onion (*Allium cepa* L.) varieties (Saggai Red Improved, Kamleen Yellow, Abuferaiwa, Baftaim Red, Baftaim Yellow, Rouge and Texas Grano) was conducted against onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) and onion Yellow Dwarf Virus (OYDV) during seasons, 2009-2010 and 2010-2011 in Khartoum State, Sudan. These varieties were treated with lambda-cyhalothrin 5% EC and compared with untreated plots to study the effect of thrips and OYDV on growth parameters and bulbs and seeds yields. The results revealed that all the varieties were infested by thrips and OYDV at various degrees in the untreated plots and showed significant growth parameters and yield reduction compared with treated plots. Local varieties, Kamleen Yellow, Saggai Red Improved and Abuferaiwa were the most susceptible to thrips infestation in the untreated plots while Baftaim yellow, Rouge and Texas Yellow Grano were the least infested. Moreover, Saggai Red Improved, Abuferaiwa were most susceptible and seriously affected by OYDV in both bulbs and seeds production and followed by Kamleen Yellow. The introduced varieties, Baftaim Red, Baftaim Yellow, Rouge and Texas Yellow Grano were less infected with OYDV.

Keywords: Onion, Thrips, Onion Yellow Dwarf Virus, OYDV, Varieties

3.1.2 The use of *Bacillus thuringiensis* and neem alternation on *Plutella xylostella* (Lepidoptera: plutellidae) and the effects on natural enemies in cabbage production

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The diamondback moth (DBM), *Plutella xylostella* (L) is a major pest of cabbage in Senegal. Chemical control is the most commonly used method despite its environmental and health issues. *Bacillus thuringiensis* (Bt) and Neem-based products are considered as relevant alternatives to synthetic chemical insecticides. The aim of this study was to assess the effects of the alternation of Bt, and Neem (*Azadirachta indica*) on *P. xylostella* and the effects on parasitoids compared to sole applications of Bt, Neem and Dimethoate. Plants treated with Dimethoate recorded three times more *P. xylostella* compared to application of Bt, Bt/Neem and Neem. Results showed that although there were no significant differences between Bt, Bt/Neem, Neen population of *P. xylostella* were considerably reduced in these treatments as compared to Dimethoate and control. Four parasitoid species were recorded two of these species were important both in abundance and level of parasitism. These include *Oomyzus sokolowskill* and *Apanteles litae*. The parasitism rate was higher in the Neem treatment. A correlation between abundance of *P. xylostella* and parasitism rate was observed in all the treatments except that on Dimethoate and was stronger in Bt/Neem and Neem. The results demonstrated that in the absence of chemical insecticides, the impact of parasitoid was significant. This study suggests that the use of four alternated applications of Bt and Neem is as effective as sole treatments in the control of *P. xylostella* and is more cost effective to farmers.

Keywords: Parasitism, Cabbage, Azadirachtin, Diamondback moth, Bacillus thuringiensis

3.1.3 Efficacy of mixing *Metarhizium* and Neem against the tree locust, *Anacridium melanorhodon melanorhodon* (Orthoptera: Acrididae)

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Gum Arabic is produced mainly from *Acacia Senegal*, (hashab tree and is considered as one of the most export product of the Sudan. Production of Gum Arabic is constraint by the tree locust, *Anacridium melanorhodon melanorhodon* (Orthoptera: Acrididae). Therefore, biological control is considered as a panacea for having a blemish free produce. The current study was conducted in Hashab plantations of Acacia Company south east Elobeid to evaluate the efficacy of *Metarhizium* whether tested alone or in mixture with Neem seed oil seed against the tree locust. Relatively high dose of Neem seed oil (1.5%) has been tested in one *Metarhizium acridum* strain IMI 330189, in comparison with *Metarhizium* alone. An area of 18 ha of hashab plantation infested with *Anacridium* nymphs was divided into 18 plots and then treated with the recommended dose of *Metarhizium* and its mixture with (1.5%) Neem seed oil using car mounted UL sprayers, some untreated plots were saved as control. One day after application. tree locust samples from treated area were taken placed in cages (50x50x50cm) and observed for mortality rate. Locusts' density in the treated plots was estimated before and after application. Results indicated that mixture of *Metarhizium*/Neem scoring more than 95% mortality out numbering the average mortality given by *Metarhizium* and control treatments. The study concluded that: the use of *Metarhizium*/Neem as mixture increases the efficacy and boosts the killing speed comparing to *Metarhizium* alone.

Keywords: Acacia Senegal, Tree Locust, Metarhizium, Neem, Sudan

3.1.4 Relative resistance of some maize genotypes (*Zea mays L.*) against stem borers, *Chilo partellus* and *Sesamia cretica* (Lepidoptera: Pyraidae) in central Sudan

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In the Sudan maize in the field subjected mainly by two Lepidopteran stem borers, *Chilo partellus* and *Sesamia cretica* damage and consequently damage yield loss. The experiment was conducted at Gezira Research Station Farm, during two consecutive winter seasons 2011 – 2012 and 2012 – 2013 in an attempt of identify relative resistance of thirteen genotypes tested against stem borers' plants. In addition, the existing obtained natural enemies were recorded. The results obtained showed that the infestation of plants and dead hearts by stem borers were higher at season 2011 – 2012 with Hudiba-2 recorded the highest percentage infestation (96%). While in season 2011 – 2012 TZBRID-4YCI recorded the highest dead heart (40%) and the highest plant infestation (47%) was recorded by TZBR COMP2-Y. The TZBR COMPID-Y recorded the highest dead heart (19%). However, the average temperature and % RH almost the same (24.7 °C, 31.31.7% RH) for 2011 – 2012 and (25.7 °C, 32.2% RH for season 2012 – 2013. This variation in the infestation level may be due to the plant population density. The natural enemies observed in the field and in laboratory were combination of predators.

The best performance against the two pests was followed by TZBRID-Y-CWI and BR9922 DMRSR. The genotypes were tall and late with a comparable yield of 1000.9, 675.1, 675.1 and 838.8 kg/ha, respectively. Moreover, highest leaf damage was reported by short and early genotypes (Handeiboz).

Keywords; Stem Borers Dead heart, Resistance

3.1.5 Evaluation of some maize varieties for resistance to *Chillo partellus*, (Lepidoptera:Pyralidae (Swinhoe) in New Halfa

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A field experiment was conducted at New Halfa Research Station Farm (Eastern Sudan) for three consecutive winter seasons 2010/2011, 2011/2012 and 2012 / 2013 in a randomized complete block design (RCBD), with three

replications. Twelve maize (*Zea mays* L.) genotypes were introduced from IITA (International Institute of Tropical Agriculture, Nigeria), namely, TZBR Eld-3C5, TZBR Ed- WCI, ZB E-4YCI, BR9922-DM RSR, BR9928-DM , BR9943-DM RSR, BTZL O4DMRERm Ama TZ BRm WC3, TZBR Comp2-W, TZBR Comp 1-Y, TZBR Comp2-Y), in addition to two local checks (Hudeiba-2 and Var 113) were assessed for stem borer incidence. The objective of this study was to evaluate genotypes for resistance and tolerance to stem borer infestation. Data were recorded on days to 50% silking, plant height, ear height, grain yield% dead-heart, % infested plants, % damaged leaves, % stems tunneling and number of exit holes/meter long. Simple correlation analysis was carried out among grain yield and the stem borer infestation parameters. The results showed significant differences as to plant infestation. High infestation was recorded by genotype BR9922-MD RSR 47.2% followed by TZBR ComI-Y 46.1% TZBR Com2-Y, 46.3% TZBR CompI-W 45.8, TZBR Eld-4-WC5 43.3%, BR9943 28-DM RSR 41.1 AmaTZBR- WC3 39.8% YZBR Eld4-WCI 39.4%, while moderate infestation were recorded by BZTZL Comp-4 DMRSR 38.6%, Hudeiba-2 38.% and TZBR Comp2-W 38.2%. The lowest infestation was recorded by genotypes BR 9928-DM RSB 32.7%, TABR Com ELD-4YCI 30.0% and Var-11329.9%. The high yielding genotypes were TZBR Comp1-y (3605) ELd 3C5 (3576), TZBR Comp2-Y 3185), BRZL Comp04 DMRSRLd-3C5(, TZBRComp1-W (3165). Hudeuba-2(2911) 3182) BR99343 –DNRSR (3181), TZBR Comp2-Y(2858), (1972kg/ha) respectively, can be described as susceptible to stem borer parameters. Dead heart, stem tunneling, leaves damage , days to 50% tasseling and days to 50% silking had high significant positive correlation with % infestation that ranged from (0.40 to 0.77) while plant height, ear height and grain yield had high significant negative correlation. Based on the result obtained from this study we selected the superior genotypes'' resistant or tolerant to stem borer and used as sources of resistance for the development o f new stem borer resistant varieties in maize breeding program .

Keywodrs: Maize, Genotypes, ITTA, Tasseling, Infestation

3.1.6 Control of cucurbits fruit fly using entomopathogenic fungi, *Beauveria bassiana* (Bals.) and *Metarhizium anisopliae* (Met.) and the botanical insecticide, Neem Azal

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Fruit flies *Dacus ciliatus* Loew, *Dacus vertebratus* Bez and *Bactorcera cucurbitae* (Coquillett) (Diptera: Tephritidae) are considered of the most important pests of cucurbits in Sudan and worldwide. The objectives of the present study was the control of cucurbits fruit flies using the entomopathogenic fungi *Beauveria bassiana* (als) and *Metarhizium anisopliae* (Met.) and the botanical insecticide Neem Azal. *B. bassiana* 6.5×10^{10} conidia/ml, *M. anisopliae* 4.3×10^8 conidia/ml and Neem Azal were used. Mortality of larvae of snake cucumber fruit flies caused by *B. bassiana*, *M. anisopliae* and Neem Azal were; 62-69%, 72-81% and 74%, respectively. When Neem Azal was mixed with *B. bassiana* and *M. anisopliae* the mortality was 73-76% and 74-81% respectively. Mortality of pupae of fruit flies treated by *B. Bassiana*, *M. anisopliae* ranged between 65-74%, 51-68%, 51-10, respectively. When Neem Azal was mixed with *B. bassiana* the mortality in the pupae of fruit flies snake cucumber were 55-62% and 56-70%, respectively. Generally *B. bassiana*, *M. anisopliae* and Neem Azal gave high level of mortality of larvae and pupae of snake cucumber fruit flies in the green house as single or mixed products. The bio pesticides *B. bassiana* at concentration of 6.5×10^{10} conidia/ml and *M. anisopliae* at concentration of 4.3×10^8 conidia/ml in the form of powder, water formulation or water + oil formulation can be effective in control adults, pupae and larvae of *D. ciliatus*, *D. vertebrates* and *B. cucurbita* fruit files. Also, Neem Azal 1% can be used at 15 ppm and 20 ppm for control of all of the fruit fly species on the snake cucumber.

Keywords: Fruit fly, Entomopathogenic, Bio-insecticide, Neem Azal

4.1.1 Evaluation of neem seed kernel and water extract for the control of spotted stem borers, *Chilo partellus* Swinhoce,(Lepidoptera:Pyralidae) in sorghum at New Halfa, Sudan

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A field experiment was conducted to study the effects of Neem seed kernel (NSK) and Neem leaf (NL) water extracts on the incidence and damage of stem borer in sorghum during 2011/2012 – 2012/2013 seasons at New Halfa Research Station Farm. Sorghum variety Tabat was used and laid in randomized complete block design with four replicates. The seven treatments evaluated were: NSK powder at one kg/30 and 40 litres of water, NL powder at kg/15 and 20 litres and one kg at 20, 21 litres of water, Furadan 10% at 15kg/feddan and Malathion 57% EC at 2 litres/feddan as standard and the untreated control . A liquid soap was added to Neem treatments as an emulsifying agent. Three sprayings were applied using knapsack sprayer starting 2 weeks after emergence with 10 days interval . However, Furadan 10% as a granule was applied into the whorl of sorghum plants one time. Data on percent dead heart, leaf damage of plants, percent stem tunneling, number of borer holes per plant and grain yield were recorded. Results indicated that, all treatments significantly reduced stem borer damage compared to the untreated one. NSK powder at 1.0 kg/40 litres of water was the best in reducing the stem borer infestation and increasing crop yield. This result was comparable to the standard treatment, Furadan 10% at 15kg/F.

Keywords: Neem extracts, Stem borer, Dead heart, Borer holes

4.1.2 Field response of Tephritid fruit flies (Diptera: Tephritidae) to water extract of some botanicals

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Fruit flies belonging to the family Tephritidae are the most notorious insect pests that attack various fruits and vegetables, causing severe economic losses. Guava orchard at Elfaki Hashim and Elsayagi Elgenobia were selected to assess the response of some tephritids to water extracts (WEs) of mango, guava, apple, cucumber, and ready-made juice of mango (Crystal[®]; crystal industrial Co. Ltd, Araak, Group; crystal@araak.com) against *Torula* yeast (a standard attractant) and water (control) baited in locally made traps. The trial was performed as randomized complete block design (RCBD) replicated 3 times for 5 consecutive weeks at each site, Highly significant differences were recorded between attractants and the interaction between attractants and times (weeks) on trapping different species of *B. cucurbitae*, *cosyra* and *quinaria*, were found to respond positively to all material at both sites. Few numbers of *Dacus ciliatus* and *D. vertebratus* were found lured to SEs of cucumber and mango. The greatest number of *C.capitata* flies was caught by traps equipped with ready-made Crystal[®] mango juice at the Elfaki Hashim site. The mean number of *B. invadens* attracted to the Wes of mango and guava at the Elsayagi Elgenobia was statistically similar to that species lured to *Torula* yeast, 83.7, 70.3 and 111.5 flies/trap/week, respectively. Attractants extracted from botanicals are cost- free and easily prepared by farmers and can be used for mass trapping of fruit flies. More studies regarding active ingredients, doses, and the number of traps utilized per area should be considered.

Keywords: Tephritidae, Orchard, Attractant, Fruit fly

4.1.3 Evaluation of *Jatropha curcas*,(L) seed extract against, *Aphis gossypii* (Homoptera: Aphrididae)in Sudan

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In the Sudan there is growing tendency to inject the use of insecticide of plant origin in pest control strategies. Among the different plant species need to be evaluated, the physic nut, *Jatropha curcas* L. Malpighiales (Malpighiales Z; Euphorbiaceae) which is widely grown in the Sudan. The present investigation was planned to identify the efficacy of *curcas* seed ethanol extract and its fractions against aphids under laboratory condition, determination of LC50 and LC90 of *J.curcas* seed ethanol extracts against aphids and the side effects of *curcas* seed ethanol extract on natural enemies of aphids. The biological activity of the solution of *J. curcas* seed extract ethanol against *A. gossypii*, showed that the whole seed extract was more effective than the fractionated compounds of the extract. This suggests synergistic effect of the compounds when they are combined together. The ingestion toxicity was highly effective (100% mortality) than contact toxicity (26% mortality) after 24 hrs, also, *J. curcas* ethanol seed extract showed no efficiency (zero mortality) against the natural enemies (*Chrysoperla* spp(lacewing)and *Coccinella septempunctata*) at all doses used (10%, 5, and 1% and absolute ethanol as control). Also, the LC50 and LC90 of *J. curcas* seed ethanol extract against aphids were determined as 0.331 and 1.052 , respectively.

Keywords: *Jatropha curcas* ,Ethanol Aphids ,*Chrysoperla*, Toxicity

4.1.4 Effects of Aqueous extracts of 4.1 ,*Ocimum basilicum* L.,Sodom's apple ,*Calotropis procera* Ait and Coriander, *Coriandrum sativum* L. on flea beetle, *Podagrica spp* (Coleoptera: Haticidae) in okra crop

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An experiment was conducted at the University of Gezira Experimental Farm to evaluate the effects of 10% aqueous leaf and fruit extract of Basil, (*Ocimum basilium* L), leaf extracts of Sodom' apple (*Calotropis procera* Ait) and fruit extract of Coriander, (*Coriandrum sativum* L.) on flea beetle, *Podagrica spp*, on okra. The experiment comprised of 16 plots assigned to 4 treatments replicated 4 times , arranged in completely randomized block design. The treatments consisted of spraying okra plants with Basil, Sodom's apple and coriander 10% aqueous extract or distilled water (control). The efficacy of the extract was assessed in terms of shot holes in okra leaves and flea beetles nymphs and adults alive and feeding . The results indicated that the three aqueous extracts significantly ($P>0.05$) reduced the infestation level by the flea beetle on okra leaves. Coriander extract resulted in the lowest infestation level by the pest (mean number of shot holes = 630m, followed by Rehan (mean number of shot holes -722) and Usher and while the control treatment scored 1327 shot holes.

Keywords; Insecticides, Resistance, Okra,Efficacy

4.1.5 Biological and ecological studies of the mealybug *Planococcus citri* Risso (Homptera: Psedococcidae) on citrus in the Gezira State, Sudan

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This study was conducted at the Gezira State (Hilat Hassan and Elsenat District, Sudan during 2004-2005, to study the biology, ecology, damage, natural enemies' and host range of the mealybug, *planococcus citri* (Risso) (Homoptera:Psedococcidae) on citrus. The results showed that a single female formed only one ovisack during its life time, whicht contained 30-639 eggs. The pest has three nymphal instars. The incubation period was 9.3 days, and nymgal

instars duration as 1th and 2rd took 10.2, 9.2 days 8.5 days, respectively. The pre-oviposition, oviposition and post oviposition period took 3.9, 8.1 and 3.4 days respectively. The life time of the female was 52.6 days . *P. citri* attacked citrus leaves causing them wilt, get distorted and yellowed. New fruits setting stopped growing and dropped to the ground and advanced aged fruits showed discoloration and splitting, *P. citri* secretes honeydew, on which sooty moulds developed and caused physical and physiological damages. The ecological studies, showed that the incidence of *P. citri* much dependent on the minimum temperature during winter season. The rainfall and relative humidity affects *P. citri* population negatively. The high numbers of adult females were reported during September-January and coincided with high numbers of ovisacks and nymphs. The natural enemies commonly found were; the parasitoid *Leptomastix phenacocci* Compere (Hymenoptera: Encyrtidae) and the predator *Cybocephalus sp.* (Coleoptera: Nitidulidae). The only alternative host plant found recorded was the parasitic weed *Loranthus* (Santalales: loranthaceae)

Keywords: Mealybug, Ovisack, Nymph, Adult

4.1.6 Identification, damage, host range, seasonal abundance and chemical control of mango on fruit fly species (Diptera: Tephritidae) in Sennar State, Sudan

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Mango exports have decreased by 7x mainly due to fruit flies (FFs) (Diptera: Tephritidae). Integrated FF control program requires accurate data about taxonomy, distribution, seasonality and incidence of the members of Tephritidae. Surveys and collections were carried out in Sennar State from January 2006-2008. Traps (Yellow sticky and Dome) and infested fruits were used for adult collection. A number of laboratory experiments, i.e. rearing and bioassay were conducted at University of Gezira Laboratories Molecular Analysis (DNA barcoding) of specimens was conducted in the Royal Belgian Institute for Natural Science to obtain quick and accurate identification of FF specimens.

Monthly counts of *B. invadens* trapped using Dome traps showed the presence of the species throughout of the year in Sennar State. The population is much

higher in Singa (mean = 3.163 fly/trap/month) than in Sinnar (157 fly/trap/month); this is attributed to the large population of guava trees in Singa area.

Bactrocera. invadens, *Ceratitits. cosyra* and *B. invadens* trapped using yellow sticky traps hanged on mango and guava trees. The populations of the later two species were very low. The highest population was observed during July, November and December, March and April showed the lowest population, due to higher temperature and low Reative Humidity.FF populations gave negative co-relation with temperature and R.H.

FF infestation on Baladi was 10-20% during March to April. From June to August, the only cultivar available is Abu Samaka, which is subject to a heavy infestation. The % infestation on Abu Samaka reached 30% in June and 50% in July. From October to December, the FFs attack guava *ca*, 80% in November and December, and 90% in October).Sunce 2001 *C. cosyra* (Walker) was known to be the dominant species that attack mango and guava in the Sudan. Mango fruit grown in Singa area were infested by *B. invadens* (Drew, *T.suruta* and White (80%) and *C. cosyra* (19.8%) and *Dacus longistylust* (Wiedemann) 0.2% of total emerged adults. This is the first record for the later species in a host other than *Callotropis procera* (Apocynaceae). Guava fruits were infested by *B. invadens* (84.5%), *C. cosyra* (15.3%), and *C. quinaria* (Bezzi) and replace the indigenous species. Ripe and cracked banana fruits were infested by the pest. Cucurbit fruits hosted *D. ciliatus* (Leow) only. The wild magad fruits (cucurbit) hosted *B. invadens*, and during December hosted *B. cucurbitae* (Coquiller).

Morphologically, *B.invadens*, *B. cueurbitae*, *C. cosyra*, *C. quinaria*, *D. ciliatus* and *D. longistylus* were identified. The morphological characterization results matched the molecular analysis. *B. invadens* specimens appeared with same or with a little variation (0.7%) in DNA sequences. *D. ciliatus* and *B. cucurbiae* appeared in two culsters, with no variation among sequences of their specimens. *Bactrocera*, *Ceratitits* and *Dacus* exhibited low inter-specific variation compared with that between (inter) species.

The bioassay results of chlorpyrifos, imidacloprid and neem seed powder (NSP) on adult emergence of *B. invadens*, when exposed as late third instars (L3) treated sand were determined under laboratory conditions. The three tested chemicals proved to be effective in inhibiting the emergence of adults.

Keywords: Mango, Fruit fly, Yellow Efficacy, DNA Bar-coding, Bioassay

4.1.7 Field surveys, host specificity, and life cycle of the mesquite seed feeding *Bruchid*, *Algarobius prosopis* (LeConte), (Coleoptera:Bruchidae)

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Algrabius prosopis is a seed feeding bruchid imported from Southwestern United States into South Africa and latter into Australian as biocontrol agent against *Prosopis* spp. The beetles were established and the evaluation of its effects in retarding the spread of mesquite was positive.

The species was found infesting mesquite pods at the Red Sea State as well as other parts of the Sudan.

Survey carried out during August and October 2004 revealed that *Algarobius prosopis* is prevalent in most mesquite invasion areas. Samples of more than 200 pods collected randomly from each area changing that the percentage damage was 7.4%, 9.6%, 24.03%,7.31% and 90.19% for kassala, Khartoum (Kafouri), Khartoum (Soba), Northern State and Toker, respectively. The age of the pods in the first 4 localities ranges from 25 to 40 days. However, the samples from Toker are 7-8 months old. No old pods were found in the first 4 localities due to prompt utilization by herbivore animals. The

5.1.1 Effects of sowing date on incidence of spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) in two sorghum cultivars (*Sorghum bicolor* (L) Moench) at New Halfa, Sudan

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The study was carried out at New Halfa Research Station Farm during 2011-2013 seasons to determine the optimum sowing date of sorghum for management of the spotted stem borer *Chilo partellus* under New Halfa conditions. Tabat and Butana sorghum varieties were tested. Five sowing dates were effected; 15,30 June, 15,30 July and 15 August. Data on percent dead heart, percent leaf damage, percent stem tunneling, and number of borer holes per plant and grain yield were recorded. Results obtained of combined analysis for two seasons revealed that a highly significantly difference between sowing dates and cultivars for all mentioned parameters were established. The optimum sowing date (15 July) was less infested by the spotted stem borer and resulted in a high grain yield, compared to the other sowing dates. On the other hand variety Butana was superior to Tabat for grain yield under infestation conditions throughout all sowing dates.

Keywords: Infestation level, Stem boring, Borer holes, Butana, Tabat

5.1.2 Studies on the bio-ecology of the Senegalese grasshopper, *Oedaleus senegalensis* (Orthoptera:Acrididae)in Kordofan Region

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Senegalese grasshopper, *Oedaleus senegalensis* (Krauss, 1877) (Orthoptera: Acrididae) is a serious pest of cereal crops and grassy pastures in Sudan. Field surveys were conducted over three-years period to study its relative abundance, density and population structure/dynamics. Observations were made twice a week, between April and November each year (2006-2009) in two sites in Kordofan. Light traps were installed in three selected areas to study nocturnal activity and migration every night between April to November for two seasons (2007-2009). The density was assessed by visual counts of the nymph instars in 100m² and adults in 1000m². The data obtained were analyzed using descriptive statistics. Results revealed that the Senegalese grasshopper is dominant over the grasshopper species and the adults and nymphal instars appeared on two morphs: green and brown, according to prevailing environmental conditions. Mean population density was 1037±351 adult/ha and 3464±1379 adult/ha in Kuik and Gellabiya sites ,respectively; for nymphal instars, 2145±1138 nymph/ha and nymphal and 5500±2047 nymph/ha in the same above mentioned sites, respectively. The results showed that this species produce two generations a year and each generation takes sixty days on average. These results help in the development of descriptive ecological model that may help in monitoring and surveying this pest in the future. Moreover, the outcome of this study may contribute to the ecologically sound management of the pest in the near future.

Keywords: *Oedaleus Senegalensis*, Kordofan, Grasshoppers, Density

5.1.3 Geographical distribution, host range and seasonal abundance of fruit fly species (Diptera: Tephritidae) in the Blue Nile State, Sudan

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This work was conducted at Blue Nile State, for two consecutive seasons 2009-2010 and 2010-2011 to study geographical distribution, host range and seasonal abundance of the fruit flies species in the area. Five localities in the Blue Nile

State (Damazin, Rosaries, Baw, Kurmuk and Geissan) were selected and (GPS) was used to mark the coordinates of the sites. Two orchards of mango and guava located at Damazin and Rosaries were selected for seasonal abundance studies. Rearing of infested fruits and trapping with methyl eugenol were used to monitor and detect the fruit fly species. *Bactrocera invadens* was found in the five localities and it was dominant among the fruit fly species recorded.

B. invadens, *Ceratitis cosyra*, *B. cucurbitae*, *Dacus ciliates* and *D. longistylus*, were found in fruits of mango (*Mangifera indica*), guava (*Psidium guajava*), grape fruit (*Citrus paradise*), banana (*Musa spp.*), papaya (*Carica papaya*), tepish (*Cucumis melo*), brazilia (*Terminalia braziliensis*), Usher (*Calotropis procera*) and wild strawberry (*Fragaria vesca*). *B. invadens* was hosted on mango, guava, grapefruit, banana, papaya, tepish, brazilia and wild strawberry, while *Ceratitis cosyra* was found on mango fruits in Geissan locality. Wild strawberry was found as host plant for *B. invadens*, *B. cucurbitae*, *D. ciliatus* and *D. longistylus*. Usher was detected as host plant for *D. longistylus*.

B. invadens showed a low population level during April – May and peaks appeared in July, December and January depending on the temperature and rainfall.

Keywords: Blue Nile Fruit fly, GPS, Methyl Eugenol

5.1.4 Studies on the bio-ecology of the Tree Locust, *Anacridium melanorhodon melanorhodon*, (Orthoptera: Acrididae) on gum Arabic tree (*Acacia Senegal* L. Wild.) in Kordofan

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This study was conducted in Acacia Company, 35km south east of Elobeid city, North Kordofan State, during 2008 -2009. The main objective was to investigate the bio-ecology of the tree locust, *Anacridium melanorhodon melanorhodon*. Walker, (Orthoptera: Acrididae) a serious pest that constitute a real constraint to successful gum-Arabic production. Density of the adult locust and nymphs was worked out and the locust biotype was surveyed. Observation was taken on weekly basis. Results revealed that the eggs were laid in damp soil in rainy season in mid-July and had an average incubation period about 40 days. Moreover, eggs hatched to nymph stage in August and developed in early September and adults emerged late September - early October at the end of the

rainy season . The correlation of adults and hoppers density showed that, there were variations on density of nymphs and adults on the trees at different growth levels with means of 4.71 ± 1.257 and 8.205 ± 0.034) and 0.054 ± 3.36 and 0.308 ± 0.107), respectively. The means of population structures were started from 0.00 to 14.0783 in 2008, whereas, in 2009 started from 0.00 to 4.8867. The correlation between the insect adults and nymphs with rainfall, adults showed negative relationship, whereas, nymphs was positively correlated during the period of the study. These finding may be of value in monitoring or early detection of tree locust and thus avoiding the economical losses caused by the insect in the future.

Keyword: Tree Locust, Bio-ecology, Acacia, Gum Arabic, Kordofan

5.1.5 Seasonal abundance of the fruitfly, *Bactrocera invadens* (Diptera: Tephritidae) in mango and guava orchards in three states of Central Sudan

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A survey was carried out during the period 2009-2011 in many orchard distributed at three States: Khartoum, Gezira and Sinnar. The study aimed to investigate the seasonal abundance of the invasive fruit fly, *Bactrocera invadens* (Drew, Tsuruta, and White) (Diptera: Tephritidae) during the main mango production season. The survey was conducted using homemade traps with plywood blocks soaked in Methyl Eugenol (ME). The results of the study revealed that, *B. invadens* is present in all the study sites during the main mango production seasons. The population of *B. invadens* differed among orchards according to location, orchard management, type and number of fruit trees. However, the invasive fruit fly had one population peak through the mango production season in March.

Keyword: *Bactrocera invadens*, Methyl Eugenol

5.1.6 Biology and host preference of the melon worm, *Diaphania hyalinata* L (Lepidoptera: Pyralidae) on cucurbits in Gezira State, Sudan

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The melon worm, *Diaphania hyalinata* considered an important insect pest of cucurbits. In spite of its importance yet ,it has not received adequate study. This study was conducted at the Experimental Farm of the Gezira University in two winter seasons, to determine level of damage on leaves and fruits on six types of cucurbits namely: snake cucumber, squash, pumpkin, sweet melon, water melon and tibish by the melon worm ,*D.hyalinata*

The study revealed that leaves of snake cucumber were the most damaged by the insect (24.92%), while leaves of pumpkin recorded the least damage (4.5). Moreover, no damage was recorded in water melon. Snake cucumber was found to harbor most of the arvae while pumkin was the least. The average duration of the developmental stages i.e. egg. larvae and pupa were 2.5 ± 0.25 , 11.4 ± 0.13 and 7 ± 0.15 days, respectively. The fecundity was 90.4 ± 7.60 and 73.6 ± 3.63 per female, respectively. The life cycle was completed in 20-23 days, with a mean of 21.37 ± 0.22 when the insect was fed on snake cucumber. The sex ratio was 1:0.8 male: female. The morphology of the different developmental stages were described. The results revealed the effects of food type on larval, pupal period and total life cycle. It was found that a clear impact on the life cycle was observed when insects were fed on leaves of snake cucumber, squash, pumpkin, sweet melon, water m, respectively. Moreover, total life cycle when fed on fruits were; 23.25, 23.5, 23.6, 23.9, 24.5 and 24.25 days, respectively. It was found that snake cucumber and sweet melon were the most preferred by female compared with other cucurbits. None of the tested cultivars was immune.

Keywords :Melon worm ,Cucurbits, Biology, Sex ratio

5.1.7 Distribution of date palm dust mite *Oligonychus afrasiaticus* Meg., (Acarida: Tetranychidae) in Northern State of Sudan and its impact on productivity of dates` fruits

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A survey was conducted to quantify dust mite *Oligonychus afrasiaticus* Meg. (Acarida: Tetranychidae) infestation on date palm varieties “Wad Khatib”, “Wad laggi”, “Gaw”, Gundala, “Garguda” and “Barakawi” in high terrace and Nile River bank plantations of date palm, in Arnati, Say, Sauarda, Nalwati islands, Atab, Elborgaig, Dongola, Elgolid, Elgaba and Marawi in the Northern State of Sudan. The population of the dust mite, their effects on fruit growth, development and productivity of trees were assessed during the fruiting period March - August 2013, from three Barakawi trees. The results assured burgeoning of the dust mite on date palm trees grown in high terrace lands more than those grown in islands and Nile River bank lands. Infestation showed area and variety dependence. Barakawi, Wad laggi, Wad khatib and Gaw in the Nile bank lands at Elgaba and Merawi sites were free of infestation. The Barakawi grown at the high terrace lands at the same sites recorded 76-79% infested plants, Wad laggi 69% at Elgaba, Wad khatib 83% at Merawi, and Gaw 81% at Elgaba. Gundala and Garguda recorded 0-7% and 0-3% at Sauarda and Arnati Island, respectively. Mites began to attack fruits in Hababok stage at first week of April, reached the peak (93 adults + 46 nymphs/ fruit) at the first week of May and were not observed on the fruits at the first week of June. They reduced length, width and weight of fruits, where Barakawi infested fruits scored 2.7cm, 1.3cm and 2.8g, respectively, versus 5.2cm, 2.2cm and 14.2g, respectively, for un-infested ones. The infested fruits became stunted, distorted, blemished and covered with nymph moult skins and dust. At the end of Kamri stage, the loss of fruits was estimated as 96.6% of the potential tree productivity.

Key Words: Dust Mite, Economic Importance, Distribution, Northern State, Sudan.

**6.1.1 Resurgence of the cotton stemborer , *Sphenoptera gossypii* ,
(Coleoptea:Buprestidae conte) as serious insect pest in the irrigated
schemes in the Sudan**

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During October 2012 farmers from New Halfa Agricultural Corporation, Gezira, Rahad and El-Suki Schemes complained of drying, wilting and death of cotton plants in their fields; the incidence was especially higher in the introduced genetically modified Bt cotton variety (CN-CO2 than on the local variety “Hamid”. Season 2012-2013 ranked first for commercial planting of the Bt cotton in Sudan. Thus, the Bt cotton was blamed as a causative of the incident. The CN-CO2 seeds were obtained from the Chinese Research Centre in El Fau and from China. In response, a survey, was organized starting from 16 October 2012 to clarify the case. The symptoms appeared at the fields were drying and death of the young plants, wilting and stunted growth of the older ones, ring cuts at the bottom of stems. The longitudinal sections made, showed long yellowish-white worms; whitish, open and shiny pupae, and coleopteran beetles, inside the stems. From these symptoms, damage and morphological characteristics, the insect was identified as the cotton stem borer, *Sphenoptera gossypii* (Conte) (Coleoptera : Buprestidae), and later was confirmed by the counterpart specimens from the ARC Taxonomy Unit. The article revealed the history of the pest in Sudan, showed its biological and habitat characteristics and quantified its damage to the Bt cotton variety.

Keywords: Cotton stemborer ,Resurgence, Irrigated Schemes, Sudan

6.1.2 First record of the sorghum chafer, *Pachnoda interrupta* Olivier, (Coleoptera:Cetoniidae) outbreak on sorghum, pearl millet and sunflower in Sudan

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During the autumn season of 2011, an outbreak of the sorghum chafer, *Pachnoda interrupta* Olivier (Coleoptera: Cetoniidae) occurred for the first time in Sudan on four genotypes of sorghum (*Sorghum bicolor*), four of pearl millet (*Pennisetum glaucum*) and eight of sunflower (*Helianthus annuus*) in the Gezira Research Station Farm. The objective of this study was to quantify the damage caused by the sorghum chafer to these crops. The percentage of infested panicles (PIP), infested disc, (PPD) panicle damage (PPD), disc damage (PDD) and number of beetles per panicle/disc were determined. Two sorghum genotypes (Jimbo and Pannar) showed tolerance to the beetle, as they scored the lowest PIP and PPD. Whereas the other two (Kambal and Sugar graze) were highly susceptible. All pearl millet genotypes showed high susceptibility scoring a range of 92.9-94.2 PIP and 98.8 PPD. Alexandra sunflower genotypes showed high tolerance, securing "Zero" PID and PDD; pac 361,7033, pan 7351 and hysun 33 genotypes showed tolerance; Sirena and ARC 310 had comparatively high disc attraction and grains sensitivity and Pac 317 showed the highest disc attraction and seed sensitivity to the beetle. The study concluded that *P.interrupta* has become a new potential serious pest of sorghum, pearl millet and sunflower in Sudan. Infestation was found variety/hybrid dependent with sorghum and sunflower and all tested pearl millet genotypes were highly sensitive to the beetle.

Keyword: *Pachnoda interrupta*; Sorghum, Pearl millet, Sunflower, First outbreak, Sudan

6.1.3 Tomato russet mite *Aculops lycopersici* (Masse) (Acari: Eriophyidae): A new serious insect pest of tomato

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In the winter season of 2005-2006, farmers from the irrigated Gezira and banks of the Blue Nile and Rahad River (Sudan) complained of Sudden wilting, drying and shedding of tomato leaves and death of whole plants in their fields. The phenomenon, name by the farmers as “Asala Nashsfa”, seems to have been widely spread at these areas and the given name was stemmed from their beliefs that the incidence looks a lot like aphids damage, but without honeydew formation. In response , surveys on 11 tomato fields (sites) were immediately organized during March 2006; three sites at Um Sunut, two at each of Fadasi El-Halimab and El-gregrib and one at each of the Rahad River, Taiba, Fadasi El-amrab and Gezira Research Farm. The objectives of this survey were to determine the causal agent of the phenomenon and its host range, to quantify the severity and extent of damage and the control attempts taken by the famers. The symptoms observed at the field were purplish yellow rusty color of the tomato leaves, silvering of the undersurface of the lower ones, curling longitudinally inward of their upper surface, wilting, desiccating and eventually death of the whole plant. The damage starts at the base of the plant and spreads upward over stems and tomato leaves. Branches turned bronze or rusty and cracked in longitudinal direction. Fruit became bronzed and their thin skin turned coarse, some were cracked longitudinally and their size were severely reduced. Loss of foliage resulted in exposing the tomato fruits to sunburn. The samples of tomato plants taken to the laboratory showed large number of eggs and active tomato russet mite (tomato rust mite), *Aculops lycopersici* (massee) (Acari: Eriophyidae). The article revealed quantitative damage of the pest, cause of appearance, control measures practiced by the farmers and suggested fundamental procedures for its control.

Keywords: *Aculops lycopersici*, First appearance , Sudan,Damage and control

6.1.4 Insect pest complex and natural enemies associated with cowpea (*Vigna unguiculata*(L.) Walp.) in a subtropical agro-ecosystem, South Africa

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Insect pests and their potential natural enemies were montioered on cowpea during the cropping season in the Transkei area of South Africa. A total of 5953 insects belonging to 21 species, in 12 families and 5 orders (Coleopter, Hemiptera, Orthoptera, Homoptera and Lepidoptera) were counted from 18 observations on cowpea from seedling to maturity. Aphids, Lepidoteran larvae, blister beetles and pod-sucking bugs were designated as “major” pests of cowpea in this study area on account of their high levels of population density ,infestation, persistence and overall damage inflicted on the crop. Potential natural enemies recorded during the study were; ladybird beetles, ants, wasps, assassin bug and spiders. Insect pest activity was much concentrated between eight and thirteen weeks after sowing (WAS) corresponding to flower budding and pod formation stages of cowpea phenology, respectively. Results from this study have significant implications for the integrated control of the insect pest complex of cowpea in sub-tropical agro-ecosystems.

Keywords: Cowpea, *Vigna unguiculata*, Insect pests, Natural Enemies, Transkei

6.1.5 Towards better understanding and management of the African bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera :Noctuidae): Economic target or Academic Challenge

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The recent development and perceived changes in the behavior and economic importance of the African bollworm, *Helicoverpa armigera*(Hubner)., (Lepidoptera: Noctuidae) are investigated, reviewed and quantified,. Some recent research focused on understanding, management explaining the changes,

analyzing the magnitude and extent of damage, risk assessments and economic feasibility is presented.

Currently, advances in genomics demonstrating powerful new approaches related to bollworm are reviewed. The prospects for more rational,, practical involvement of natural bio-control elements in the environment and integrated control based on this research are considered. Future investigation as to diffusion of the pest in various susceptible crops required future thorough examination and exploitation.

Keywords: African Bollworm, Management, Bio-control ,Genomics

6.2.1 Biological performance of the African bollworm , *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) fed on cotton cultivars containing gossypol

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Gossypol, a yellow pigment polyphenolic compound is contained in the sub-epidermal glands of cotton leaves, and fruiting points i.e. buds, flowers, bolls and seeds. Gossypol has long been recognized as having an adverse effect on some cotton pests such as bollworms. Gossypol was extracted (by the method used by Smith ,1960) from cotton parts of four cotton cultivars currently grown in the Sudan, namely, Nour, Barakat 90, Barac 67(B) and Shambat. The amount of gossypol extracted from the cotton parts of these cultivars was determined and was found higher in seeds followed by bolls, flower leaves and least in bud. The effect of gossypol on development till pupation and adult emergence larval mortality, adult longevity and female fecundity of the African bollworm, *Helicoverpa armigera* were all studied by conducting two experiments: in the firstst to 5th instar larvae were reared on green parts of cotton and in the second, same instars were reared on semi-artificial diet (devised by Gadu and Khafagi, 1997) (unpublished) mixed with three concentrations (.5, 1.0, and 1.5%) of pure gossypol extracted from seeds of Nour cotton cultivar. The control was a diet free -gossypol. The results obtained in both experiments showed that gossypol extended the larval to adult emergence developmental period, increase the percentages of larval mortality and deformed moths, reduced pupal weight, adult longevity and female fecundity. The adverse effects were more severe when remained on the diet containing pure gossypol compared to those reared on green cotton parts. The results of this work may be used by biotechnologists to transfer high gossypol producing genes to gossypol

low cotton cultivars in order to increase their resistance to the African bollworm.

Keywords: Gossypol, Bollworm, Mortality ,Fecundity

6.2.2 Studies on the ecology and management of the fruit flies, *Ceratitis spp.*, (Diptera; Tephritidae) on guava at Sennar State

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The investigations on the ecology and management of the fruit flies (*Ceratitis spp.*) were carried out during seasons 2006 – 2007 and 2007 – 2008 at Sennar State. The performance of some insect attractants and the extent of pest damage in guava were evaluated in the field at 4 different sites in the State. Moreover, the results indicated that *Ceratitis capitata* was the dominant species in the area scoring a mean number of 12.8 and 35.0 fruit fly insects during 2006 – 007 and 2007 – 2008. respectively. The seasonal distribution studies disclosed that Elsuki and Singa sites were the most preferred area for the development of both species .The dominance of *C. capitata* in Singa was clearly observed particularly during 2006 – 2007 and 2007 – 2008 seasons and the cumulative means recorded were 9.0 and 36.0 compared to 12.0 and 42.0 insects in Elsuki during the same seasons, respectively. Both sites were found more attractive than the other 2 locations, where the mean catch per trap of *quinaria* species reported was 3.0 and 12.0 in Singa and 4.5 and 14.5 in Elsuki during 2006 – 2008 seasons, respectively. This indicated that Elsuki was considered as a hot spot of the fly, especially, *capitata* and *quinaria* species in the all experimental sites throughout the experimental seasons. Once again, the highest record of 181, 130 flies per traps were obtained with *Capitata species* in season 2006 – 2007 and 2007 – 2008 in the same location. The assessment of attractant studies projected the conclusion that this approach could significantly effectively assist implementation of integrated tactics for the control of the pest particularly when it was supplied with a lethal product. The extent and degree of damaged fruits was positively lower compared with sound fruit yield i.e the highest the yield the lower the percentage damaged fruit. The highest fruit yields of 70 and 62 kg/tree was recorded at Sennar Sugar Factory site whereas, the lowest record of 25 and 28kg/tree was reported at Morafa and Singa during 2006 – 2007 and 2007–2008, respectively. Moreover, it was remarkably observed that a consistently lower yield was obtained whenever the Chemosterilant gel was used. The integration of the improved cultural practices such as in Sennar Sugar

Factory alongwith other sites the attractants could assist in the design and implementation of efficient control strategy particularly with the edible fruits and fruits for export.

Keywords: Fruit, Fruit fly, Insect pest, Nulure attractant.

6.2.3 Use of solar energy for disinfesting stored dates.

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A solar heat exposure or solarization trial was carried out during November 2007 at Shambat Research Station, Sudan. The Objective of the study was to control the date moth *Ephestia calidella* (Guen.) and the saw-toothed grain beetle *Oryzaephilus surinamensis* (L.) in stored dates. Black iron and polyethylene solar heat collectors were constructed and exposed to the sun. The results showed considerable variation in the mean temperature between the iron heat collector, polyethylene heat collector and control treatments; they were 41.5°C, 53.7 °C and 57.4 °C, respectively, while the ambient mean temperature and relative humidity were 33°C and 52.9%. Six and 12 hours were enough to control *E. calidella* in the iron heat and polyethylene heat collectors, respectively, and 18 and 24 hours to control *O. surinamensis*. Exposing the ripened dates to a mean temperature of 57.4 °C for 24 hours did not lead to high significant change in the chemical composition, except that some sucrose was inverted to reducing sugars.

6.2.4 Determination of developmental time of *Encarsia lutea* (Masi), (Hymenoptera: Aphelinidae) at different temperatures

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Encarsia lutea(Masi) (Hymenoptera: Aphelinidae) is a solitary internal parasitoid of the whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)). It is a heterononymous aphelinid and considered as one of the most important biological control agents against whitefly worldwide. Its biology refers to as autoparasitic. The constant temperatures: 20, 25 and 30 0C at 60% R.H .were investigated in the laboratory in Adnana. Turkey, to show their effects on the developmental time of *E. lutea*. Six pots planted with cotton (*Gossypium hirsutum* L. cv. SG -125), after cotton seedlings reached the 4- leaf stages are exposed to *B. tabaci* adults to oviposit in a close limited area of 4 cm in diameter by using a small clipped cage with holes. Whitefly adults removed

after 19h and the plants maintained in cages in greenhouse at temperature of 25-28 °C. The 2nd and 3rd nymph stages in mentioned plants' leaves subjected to mate *E. lutea* females for 24h after the plants; leaves insert inside a plastic cylinder. The female parasitoids removed and each 2 pots kept in 3 different incubators with different temperatures. Temperature found to be an important factor in determining the developmental time of *E. lutea* developed in the nymphs of *B. tabaci*. Although the percent parasitism between 35-42%, but few dead parasitized larvae and pupae were observed. The mean developmental time of mated *E. lutea* female deposited in 20, 25, and 30°C were found to be 17.9, 17.4, 13.3 days, respectively. Therefore, 30°C gave significantly less developmental period but further studies are needed to verify if it is the optimal temperature or not.

Keywords: *Encarsia lutea*; *Bemisia tabaci*, Cotton, Temperature, Development

6.2.5 Cultural practices: the hidden role on management of Tephritid fruit flies (Diptera :Tephritidae)

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Fruit flies of the family Tephritidae are the major insect pests that attack horticultural crops reducing economically their production . In Sudan, the fruit flies problem exaggerated to the extent that they were upgraded and added to the list of

the notorious national pests of Sudan since 2007. The role of cultural practices as part of integrated pest management to control fruit flies was investigated for three consecutive seasons on mango. Three orchards within the study area were chosen and subjected to a package of cultural practices-included hoeing, flooding, orchard cleaning and early harvesting of fruits before ripening. Results showed a highly significant difference in the percentage and degree of infestation for the different mango varieties grown on the study areas. The reduction percentage ranged from (49-73%, 57.3-99%), (44.9-72%, 64.6-83.4)

and (29-55%, 49.6-75.4)for the three parameters, respectively for the two seasons. This result was in accordance with the number of trapped fruit flies per month. High performance of cultural practices on lessening infestation levels of fruit flies give it the priority to be applied as an effective method in management of fruit flies to avoid overlapping of generations and to reduce the growth rate of insects population.

Keywords: Fruit flies, Sudan Management, Cultural Practices