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TEMPERATURE STRESS EFFECT ON THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* USING BIORATIONAL COMPOUNDS

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Abstract

Desert Locust, *Schistocerca gregaria* (Forskål), is one of the important insect pests worldwide. Chemical insecticides proved effective in controlling these locust, but with bad ecosystem impact. This study evaluated the temperature stress on biorational insecticides against *Schistocer ca gregaria*. Newly moulted 5th instar nymphs of the desert locust were feed on clover leaves treated with LC_{50} of Azadirachtin, Rotenone, Sabadilla and Limonene. Also, anti-hormonaleffects of Precocene II showed decrease in protein; carbohydrate and lipid of haemolymph contents after 24hrs treatment of 5th nymph instar with these biorational insecticides. The higher LC_{50} was 3.4 obtained after treating 5th nymphal instar with azadirachtin, lower LC_{50} was 4.2 caused by limonene with LC_{90} of 15.2 & 28.2% respectively. These biorational insecticides affected protein, lipid and carbohydrate of 5th nymphal ones, added by temperature marked stress. Supernumerary (extramoulted) nymph emerged after treating 5th nymph instar with Precocene II. Precocene II caused nymph malformations at high concentration (33.3%; 1000ppm) and at low concentration (14.2%; 50ppm), and blocked adult emergency with increased concentrations.

Keywords: *Schistocerca gregaria*, biorational insecticides, Temperature stress, Biochemical, morphogenic abnormality

Introduction

The desert locust, *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididiae) are conspicuous and unpredictable agricultural pests that disrupt local economies causing severe food shortages in subsistence farming systems (Uvarov, 1977).

The change its behavior and physiology in relation to the change in population density by forming swarms of adults or bands of wingless nymphs is called hoppers. Locust swarms may contain billions of individuals behaving in unison and can migrate over thousands of kilometers (Showler, 2002). The hot and high radiation climate in desert locust areas reduces the half-life of most compounds, compared to temperate regions and effect of the biorational. Besides, desert locust control carried out in a large number of ecosystems was extremely limited (Harris and Kinoshita 1977). Chemical control of must cover large infested areas in Africa, the Center East, and Asia (Ceccato *et al,* 2007).

A locust can consume about its weight in foliage daily (Lindsey, 2002). Extensive use of pesticides has risky drawbacks, such as resistance development, high costs, handling hazards, residues threating to man, animals and even plants (Pimentel *et al,* 2009), as well as environmental pollution (Garriga and Caballero, 2011). Generally speaking, all halogenated carbons and organic phosphorus insecticides cause health hazards to man and animals (El Bahnasawy *et al,* 2015). But, plant extracts, pathogenic bacteria, predateors, parasites, IGR's, fungus and animal venoms showed promising friendly agents both indoors and outdoors against pests of man, animals and plants (Weinzierl, 1988). Botanical control agents are generally pest specific and relatively harmless to non-target organisms and environmental safe (Rembold, 1994). Though, hundreds of plant natural products have established deleterious effects on insects only a handful of botanical insecticides were accepted for use in industrialized countries (Isman, 2006). Botanical pesticides are biodegradable and their use in

crop protection was a sustainable alternative and reduces environmental contamination and human health hazards (Nassar *et al*, 2018). The botanical pesticides were divided into two generations: 1st generation included Nicotine, Rotenone, Sabadilla, Ryania, Pyrthrum, and plant essential oils; while the 2nd included synthetic Pyrethroids and Azadirachtin, and new botanicals agents (Regnault-Roger, 2012).

Temperature stress scenario is a major factor determining insecticide efficacy. Two general trends either positive or negative occurred in efficacy of toxicity with temperature post application were recognized (Guthrie, 1950). Organophosphates tend to perform better under warm conditions as 30-32°C (Grafius, 1986), with mild or no dependence on temperature. Pyrethroids often manifest greater toxicity to arthropods at cooler ambient temperatures around 15-16°C (Hirano 1979). This depended on the target species, application method, and quantity of insecticide ingested or contacted (Sparks *et a1,* 1983). Schmidt and Robertson (1986) reported that permethrin cloth treated was more toxic to horn flies at higher temperatures, but topical application showed a negative temperature coefficient. Ewen *et a1.* (1984) treated migratory grasshoppers with a range of rates of cypermethrin, they found that at doses below a rate equivalent to field application of 12g (AI)/ha, toxicity increased with increasing temperature within the range 15-30°C. At higher doses, relative toxicity declined at temperatures >20°C. For grasshopper species, temperature was an important factor required under warm field conditions (25-35°C) on grassland or in cereal crops, and a negative temperature coefficient with pyrethroid. Decreased deltame--hrin toxicity to migratory grasshopper nymphs at temperatures >27°C was reported (Hinks, 1985).

The present study aimed to evaluate the toxicity, temperature stress and metabolic biochemical of haemolymph effect of the biorational ncompounds (Azadirachtin, Rotenone, Sabadella, and Limonene) against 5th nymphal instar, desert locust, *Schistocerca gregaria*, as well as anti-hormonal effects of Precocene II was evaluated

Materials and Methods

Insect colony: The used strain of desert locust, *Schistocerca gregaria* was kindly got from Locust Research Department, Ministry of Agriculture, Dokki. A stock colony was reared in cages 45x45x65cm. Except for the front side was made of glass; the other three sides were made of wood, with a small wire gauze window for ventilation. Each cage was supplied every morning with a suitable amount of fresh food, consisting of clover leaves and small petri-dish contained one spoon of yeast mixed with dry milk. The cages were provided with pots of moistened, sieved sand for oviposition. Daily the sand pots were checked for laid eggs, which were isolated into empty cages for hatching and the offspring were experimented with. Insect colony was reared (Hoste *et al,* 2002), with some modification. Locust culture and the experimental tests were kept in a light room, provided with a set of automated timer switch 60-watt electric bulbs hanged in front of the glass side. Temperature in cages was 25°C±2.4 and relative humidity between 50 and 60%.

Biorational insecticides: Molted 5th nymphal instars 12hrs old were feed on clover leaves treated with different concentrations of rotenone, sabadilla, limonene and azadirachtin (Aldrich and Sigma Chemical Co/).

Precocene II: Anti-juvenoid was diluted in acetone to 50, 125, 250, 500 & 1000ppm. Different concentrations were dropped on clover leaves given to 12hrs old 5th nymphal instars. Temperature stress action was evaluated on the nymphs post treated at 20, 25, 30 & 35°C.

Haemolymph biochemical evaluation: Haemolymph total proteins, total lipids & total carbohydrates were estimated after nymphal treated with biorational insecticides LC_{50}. Haemolymph was collected by a fine puncture in hind legmembrane and beneath dorsal

pronotal shield membrane (Metaweh *et al,* 2001). Control and treated samples were put under same conditions in 14:10 hours light: dark (Robert *et al*, 2002). Haemolymph was drawn into Eppendorff Pipetman containing few milligrams of phenoloxidase inhibitor (phenylthiourea) to prevent tanning or darkening thinned with a normal saline solution, and then centrifuged at 2000 rpm for 5 min. The supernatant fractions were frozen until needed. The main of three replicates of treated 5th nymphal instars was used to evaluate body metabolites. Total haemolymph protein content was evaluated (Doumas, 1975) by a kit of Bioadwic Company at Spectrophotometer of 500nm. Total carbohydrate (glycolgen) content was evaluated by enthrone reagent (Singh and Sinha, 1977) at 580nm and total lipid content of haemolymph was evaluated (Folch *et al,* 1957) at 530nm.

Bioassay: Limonene, sabadilla, rotenone & azadirachtin as 100% equal volume was added to same acetone volume as stock solution. Experimented with 5th instar nymphs were fed on clover leaves treated with concentrations (5, 10, 15, 20 & 25%) at 25ºC±2.3 and relative humidity fluctuated between 50 & 60% as LC_{50} of each biorational insecticide for 15 second and were left to evaporate solvent. Control nymphs were fed on clean clover leaves. All treated and control nymphs for each concentration kept in 50ml glass beaker to molting and adult emergence. Both experimented with and control nymphs were evaluated for heamolymph contents and toxicity under different temperature stress post treatment.

Statistical analysis: Data were analyzed by using software SPSS (Version10.0 for windows, SPSS Inc, Chicago (USA). Efficacy of biorational insecticides on nymphs' mortality was calculated by Abott's formula (1925).

Ethical approval in dealing with experimental with animals given by the Cairo faculty of Science, which went with in the Helsinki declarations (2008) was critically followed.

Results

Biorational insecticides against 5th nymphal stages showed toxicity and mortality was 100, 95, 84 & 78% after 72hrs post (25%) treatment with azadirachtin, rotenone, sabadilla and rotenone respectively, and 5% caused 65, 63, 62 & 55% mortalities. High LC_{50} toxicity was 3.4% by azadirachtin and lowest was 4.2% with limonene. LC_{90} was 15.2, 18.7, 26.3, & 28.1% of azadirachtin, rotenone, sabadilla, & limonene respectivvely. Lower and higher mortality by rotenone LC_{50} was 65.13 & 81.12 at 30ºC & 35ºC in 24 & 96hrs respectively and least one was by sabadilla 39.13 & 62.11% for same temperature and exposure times. Newly moulted 5th instar nymphs and emerging adult were affected.

Supernumerary after precocene II treatment increased side by side with concentrations. Adult emergency was blocked side by side with (33.3%) at highest concentration (1000ppm), but least (14.2%) at lowest one (50ppm), with deformities or adult morphogenesis. Precocene II seriously affected nymph's growth to nymph-adult intermediate at 13.2 concentrations (1000ppm). Treated nymphs showed growth inhibition increased side by side with concentration to metamorphosis extended duration. Adult deformities increased side by side with concentration. 52.2 & 41.1 showed high and low adult malformation at 1000 & 250ppm respectively. Adult emergence after nymphs' precocene II treatment varied between 34.7% (50ppm) and 11.3% (1000ppm), and short lived before mating with curled and twisted wings. Nymphs were exhausted, blackish-yellow-color and died with high morphometric ratios of adults developed from them.

Temperature stress affected haemolymph, protein, carbohydrate and lipid contents of nymphs after 24hr post LC_{50} limonene, rotenone, azadirachtin and sabadilla treatment.

Total carbohydrate levels in treated nymphs significantly differed from control. Higher decrease was 36.12mg/ml followed by sabadilla LC_{50} treated with at 35^{o}C, and shorting was 49.11mg/ml after treated with sabadilla at 30^{o}C. Carbohydrate levels didn't

decrease with LC_{50} of rotenone, limonene & azadirachtin at 20°C. The levels significantly deceased at 30°C & 35°C to 39.16, 40.14 & 41.12mg/ml by azadirachtin, rotenone and limonene compared to 47mg/ml control at 30°C, and 37.16, 37.13 & 38.21mg/ml compared to 48.36mg/ml at 35°C.

Total protein levels were significantly low in nymphs sabadilla treated to 64.04, 55.32, 54.22 & 48.12mg/ml at 20, 25, 30, & 35°C compared to control. Also, significantly decreased in azadirachtin treated ones at 25, 30, & 35°C to 61.36, 65.27 & 57.17mg/ml respectively compared to controls with 71.42, 68.23 & 65.12mg/ml stressed by temperatures. No significant decrease was in nymphs limonene treated with 78.16, 63.26 61.31 & 68.21mg/ml at 20, 25, 30 & 35°C compared to control, and increased after the bioratinal insecticidal treatment at 35°C to 8.22, 8.75, 8.66 &8.82mg/ml with compared to 9.12mg/ml controls.

Details were given in tables (1, 2, 3, 4 & 5) and figure (1)

Table 1: Temperature stress on mortality of one day old 5th nymphal instars treated with LC_{50} of different compounds.

Biorational materials	Temperature	Mortality% by temperature stress LC_{50} of bioinsecticides at different periods			
		24hrs	48hrs	72hrs	96hrs
Rotenone	30ºC	65.13 ± 3.2	62.11 ± 2.3	71.11 ± 2.2	72.19 ± 4.2
	35ºC	69.12 ± 2.5	73.14 ± 2.2	78.16 ± 1.8	81.12 ± 3.6
Limonene	30ºC	43.11 ± 2.3	47.13 ± 3.1	58.11 ± 2.2	66.1.7± 3.1
	35ºC	58.12 ± 3.1	63.14 ± 2.6	72.10 ± 2.7	76.23 ± 4.2
Azadirachtin	30ºC	54.11 ± 2.2	67.12 ± 2.1	66.13 ± 2.5	68.11 ± 2.3
	35ºC	64.15 ± 18	68.14 ± 2.7	67.12 ± 2.1	72.12 ± 2.2
Sabadilla	30ºC	39.13 ± 2.5	43.12 ± 3.2	55.12 ± 3.2	58.10 ± 3.2
	35ºC	43.12 ± 2.1	48.11 ± 4.2	57.11 ± 4.2	62.11 ± 2.2
Control	30ºC	00.00 ± 0.0	00.00 ± 0.0	00.00 ± 0.0	00.00 ± 0.0
	35ºC	00.00 ± 0.0	00.00 ± 0.0	00.00 ± 0.0	00.00 ± 0.0

Table 2: Moephogenic effect of precocenII on 5th instar nymphs of *Schi. gregaria*

PrecoceneII Conc.	Nymphs deformed	Nymph-adult intermediate	Adult emerging %	Adult deformation
1000.0 (ppm)	33.3	13.2	11.3	52.2
500.0	25.0	11.8	19.4	43.8
250.0	23.0	10.5	25.3	41.2
125.0	19.5	9.3	28.5	42.7
50.00	14.2	7.0	34.7	44.1
Control	00.0	00.0	100.0	00.0

Table 3: Temperature stress on heamolymph carbohydrate content on nymphs with LC_{50} of bioinecticides.

Bioinsecticides	Carbohydrate contentmg/ml of 5th Nymphal instar treated with LC_{50} of bioinsecticides at 4 temperature levels			
	Temp. of 20ºC	Temp. of 25ºC	Temp. of 30ºC	Temp. of 35ºC
Sabadilla	44.21^{b}±1.23	41.12^{b}±0.12	37.12^{c}±0.10	36.12^{c}±0.08
Azadirachtin	47.32^{a}±2.14	44.16^{b}± 3.12	39.16^{b}±0.13	37.16^{b}±2.07
Rotenone	48.11^{a}± 2.11	46.13^{b}± 2.13	40.14^{b}±0.12	37.13^{b} ±2.11
Limonine	49.11^{a}±0.12	49.11^{a}±0.11	41.12^{b}±0.14	38.21^{b} ± 2.09
Control	52.37^{a} ± 4.13	51.23^{a}± 3.22	48.36^{a}± 3.15	47.14^{a}± 2.16

Mean ± SD followed with the same letter (^{n}): is not significantly different (P>0.05)

Table 4: Temperature stress on heamolymph protein content on nymphs with LC_{50} of bioinecticides.

Bioinsecticides	Protein content mg/ml of nymphs treated with LC_{50} of four bioinsecticides at 2 temperatures			
	Temp. of 20ºC	Temp. of 25ºC	Temp. of 30ºC	Temp. of 35ºC
Sabadilla	64.04^{b} ± 2.31	55.32^{b} ± 2.10	54.22^{b} ±0.13	48.12^{b} ± 2.13
Azadirachtin	75.58^{a} ± 2.05	61.36^{b} ± 4.11	65.27^{b} ±0.12	57.17^{b} ± 3.12
Rotenone	72.21^{a} ± 3.23	58.34^{b} ± 4.12	68.24^{a} ±0.15	54.14^{b} ± 2.15
Limonine	78.16^{a} ± 3.04	63.26^{b} ± 3.13	61.31^{a} ±0.12	58.21^{a} ± 3.12
Control	80.33^{a} ± 5.11	71.42^{a} ± 2.24	68.22^{a} ±4.31	65.12^{a} ± 3.14

Table 5: Temperature stress on heamolymph lipid after treatment of 5th instar nymphs with LC_{50} of bioinecticides.

Bioinsecticides	Protein content/ml of nymphs treated with LC_{50} of different bioinsecticides at 2 temperature levels			
	Temp. of 25Cº	Temp. of 30Cº	Temp. of 25Cº	Temp. of 30Cº
Sabadill	7.56^{a} ± 0.13	8.87^{a}±0.14	8.15^{a}±0.12	8.22^{a}±0.08
Azadirachtin	7.86^{a}±0.12	8.77^{a}±0.09	7.62^{a}±0.07	8.75^{a} ±0.05
Rotenone	7.97^{a}±0.08	8.86^{a}±0.12	7.78^{a}±0.09	8.66^{a}±0.06
Limonene	8.12^{a}±0.07	7.21^{a}±0.08	8.13^{a}±0.06	8.82^{a}±0.06
Control	8.54^{a} ± 1.3	9.23^{a}±0.07	8.33^{a} ± 1.3	9.12^{a}±0.07

Discussion

Nassar and Ghazawy (2018) in Egypt safely used *Azadirachta indica* against *Sch. gregaria*. Also, Wilps *et al.* (1990), Schmutterer (1990) and Nasseh *et al.* (1993) used Neem extracts against on locusts. Al-Maroug *et al.* (2022) studied some biorational compounds against *Sch. gregaria*. Sharaby *et al.* (2012) reported that limonene has insecticidal, repellency, antimicrobial activity and essential oils phytotoxic against the insect-pests. This agreed with Nassar *et al.* (2000), they reported that locust mortality as all insect-pests depended on botanical extracts and application. Also, Abdel-Fattah and Ammar (2005) in field activities controlled locust nymphs. Soliman *et al*. (2019) obtained good results with chlorantraniliprole (Coragen®), spinosad (Tracer®) and fipronil (Coatch®) under laboratory conditions against *Sch. gregaria* nymphs and adults.

The present results showed that azadirachtin and rotenone were more potent than the other two. Many biorational insecticides activity was due to the bioactive components like saponin that affects cell membranes (Bogumil and Wieslaw, 2006) or reduced digestion and absorption (De Geyter *et al.,* 2012). Stark and Rangus (1994) reported that lethal and sublethal effects of the Neem extract acts slowly. Ghazawy *et al.* (2007) reported that LC_{50} within 24hrs on 2nd nymphs of *Sch. gregaria* and 4th, 5th & 6th of *Heteracris littoralis* instars was dose-dependent and died on ecdysis. Besides, some poisons lipid layers of membranes destroyed plasma membrane permeability by water loss and vacuoles appearance (Sharaby *et al,* 2012).

Sabadilla reduced the feeding behavior of *Diaprepes abbreviates* weevils and deterrence by its alkaloids similar to pyrethrins in acting on voltage-sensitive sodium channels (Stephen *et al,* 2010). Sabadilla caused a significant reduction in feeding behavior of *Sch. americana* caused by azadirachtin on different insects (Aerts and Mordue, 1997) especially Orthoptera (Capinera and Froeba 2007). Sabadilla triterpenoid toxicity blocked the neurons inputs by phagostimulatory compounds; as carbohydrates (Winstanley and Blaney, 1978).

Plants produce diverse chemicals known as allelochemicals making them suitable for utilization by phytophagous insects and other herbivores by imparting repellency, toxicity, biochemical and physiological functions (Baerson *et al,* 2005). This inhibited the JH-biosynthesis in the CA of females of the cricket *Gryllus maculates in vitro* (Muthukrishnan *et al*, 1999). Adfa *et al*. (2010, 2011) isolated the scopoletin from *Protium javanicum* (Burseraceae) and synthesized some derivatives similar to precocenes.

In the present study, elevated temperature was risky. This agreed with Hinks (1985), who found that at 23°C, 27°C, 31°C, mortalities didn't different but was twice as deltamethrin at 32.2°C differed from effectiveness at 31°C. Brown (1987) found that the LD_{50} of the tobacco budworm treated with fenvalerate, flucythrinate, & permethrin at 26°C was 27, 140, &13 times LD_{50} at 16°C.

In the present study, increasing exposure time increased biorational mortality. This agreed with Ewen *et al.* (1984), who reported that a field rate of 15g/ha cypermethrin caused effective mortality rates of 85, 90, 92, 95, & 97% after 1, 2, 3, 4, & 5days, respectively, But, pyrethroid insecticides showed poor efficacy of alphamethrin or deltamethrin on grasshoppers at high temperatures (Hinks 1985).

In the present study, different temperature levels stress determined different bioinsecticides toxicity. An insecticide with a positive temperature coefficient was more toxic with temperature increase, but those with a negative temperature coefficient were more toxic at low temperatures (Glunt *et al,* 2013). In the present study, increased toxicity was due to increase penetration of the biorational insecticides into the nymphs' body. At low temperatures stress, organophosphate toxicity decreased with decrease in biotransformation (Harwood *et al,* 2009). But, in the present study organophosphates, and pyre-

throids tested showed a negative association with temperature. This agreed with Li *et al.* (2006), who didn't find temperature impact on pyrethroid toxicity with some insect species. Temperature impact on toxicity of different insecticides was critical in implementing chemical-based management strategies controlled by environmental conditions (Bona *et al,* 2009). Locusts occur all year around with fluctuations depend on different climatic and environmental conditions, and insecticides rotation in summer and winter reduced insects selection pressure and de-layed insecticide resistance (Khan *et al,* 2014).

The current work showed biorational compounds risky effects on the body metabolites in nymphal instar by biorational compounds, which agreed with Walkowiak *et al.* (2015). The biorational insecticides received global attention as alternative to chemical ones due to shorter half-life and lower toxicity to non-target organisms (Gade and Goldsworthy, 2003), as friend agents (Tiryaki and Temur, 2010)

Chemical allatectomy can be performed by applying suitable chromenes (PrecoceneII) that selectively target and inactivate the nymphal corpora allata (Bowers *et al,* 1976). Precocenes undergo oxidative bioactivation in the target tissue (Pratt *et al,* 1980) caused in situ cellular necrosis preventing more JH production, truncating normal sequence of nymphs (Aboulafia-Baginsky *et al,* 1984), after molt resulted in precocious adultoids. Also, the precocene II compound inhibited the JH-biosynthesis in the CA of adult females of field cricket *Gryllus maculates in vitro* (Muthukrishnan *et al,* 1999). The present results went with these reported of precocious metamorphosis in several insects of by different IGR's compounds. Ghoneim and Ismail (1994) reported that *Sch. gregaria* subjected to five pyriproxyfen doses were died. Exposure of 5th instar nymphs of *Sch. gregaria* to Precocene II (15µg/cm^2) induced precocious adultoids (Salem *et al,* 1982).

In the present study, nymphs treated with PrecocenII led to hindered emergence of adults parallel to concentration level. Sehnal (1983) reported that juvenoids inhibited adult emergence not only due to function & growth of insect cells, but also prevented adult differentiation by IGRs in *Blatella germanica* (Kramer *et al,* 1989) by hydrpnene; *Anopheles farauti* (Suzuki *et al,* 1989), *Muscina stabulans* (Ghoneim *et al,* 1992); *Corcyra cephalonica* (Bhargava and Devrajurs, 1992). Morphogenic disorders were by PrecocenII in *Locusta migratoria* (Edwards *et al,* 1993) and *Sch. gregaria* (Ghoneim and Ismail, 1995). Rashwan (2013) found that rynaxypyr (Coragen) caused significant decrease on total lipids of *Spodoptera littoralis* 5th larvae after a day. Upadhyay *et al.* (2010) reported that fipronil caused a significant decrease in lipid levels after 8 & 4 hours of treatment with 40% & 80% of LD_{50}, on Indian white termite *Odontotermes obesus*.

Also, haemolymph contents in some bioinsecticides were affected. Rhodojaponin III, extracted from *camellia sinensis* affected proteins content in diamondback moth, *Plutella xyllostella* (Xiaolin *et al*, 2013). *Ricinus communis* extract caused a marked protein content decrease in *Spodoptera littoralis*larvae (Khatter and Abuldahb, 2010).

In the present study, protein decreased developmental stages. Shakoori and Salem (1991) reported that increased protein content or fat body of some insect species led to insecticide detoxification. Proteins synthesize microsomal were detoxified enzymes (Wilkinson, 1976). Proteins decrease caused enzymes decrease (Kyung and Kim, 1990).

In the present study, temperature tress inhibited the total protein in haemolymph, breakdown protein into amino acids, which agreed with Etebari and Matindoost (2004). This also agreed with Khatter and Abuldahb (2010), reported that increase carbohydrates in haemolymph and fat bodies of *Sp. Littoralis* larvae treated with *R. communis*, and *Brassica nigra* oils extracts.

The present haemolymph was reduced by metabolite mobilization and synthesis. Abo El-Ghar *et al*. (1995) found carbohydrate re-

duction in *Agrotis ipsilon* haemolymph. Shoukry and Hussein (1998) reported reduction in *Galleria mellonella* larvae by *Lantana camara* and *Vitexa gnuscastus* volatile oils. Chitra and Reddy (2000) found that *Sp. littoralis* was affected by *Ammi majus, Apium graveolens, Melia azedarach* and *Vinca rosea* extracts. Besides, Bakr *et al*. (2002) reported carbohydrate reduction in *Sp. littoralis* larvae treated with plant extracts

Conclusions

The Sabadilla, rotenone, azdirachtin and limonene (Biorational insecticides) caused *Schistocerca gregaria* mortality added by the temperature stress. The production or utilization of these metabolites, control by precocene II blocked Locusts' nymph and adult morphogenesis by temperature stress.

Recommendation

Biorational insecticides are recommended.

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Explanation of figure

Fig. 1 Effect of four biorational compounds on mortality of 5th nymphal instars of *Schistocerca gregaria*.