Industrial Crops and Products 63 (2015) 92–99

Contents lists available at ScienceDirect

Industrial Crops and Products

journal homepage: www.elsevier.com/locate/indcrop

Toxicity of essential plant oils, in comparison with conventional insecticides, against the desert locust, *Schistocerca gregaria* (Forskål)

Sameeh A. Mansour[a,*], Asmaa Z. El-Sharkawy[b], Neama A. Abdel-Hamid[b]

[a] Environmental Toxicology Research Unit (ETRU), Pesticide Chemistry Department, National Research Centre, Dokki, Cairo, Egypt
[b] Department of Entomology, Faculty of Science for Girls, Al-Azhar University, Cairo, Egypt

ARTICLE INFO

Article history:
Received 3 July 2014
Received in revised form 18 October 2014
Accepted 22 October 2014
Available online 11 November 2014

Keywords:
Essential plant oils
Insecticides
Toxicity
Joint action
Schistocerca gregaria
Topical application

ABSTRACT

Essential oils extracted from ten different plants belonging to five families were tested against the 3rd nymphal instars of the desert locust, *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae) by topical application technique. Also, the toxicity of four chemical insecticides, as well as the joint action resulted from mixing botanicals and insecticides were evaluated. Either at LD_{50} or LD_{90} values, the *Allium cepa*-oil proved to be the most toxic where the above mentioned values equaled to 1.11 and 1.42 ppm, respectively followed by the *Petroselinum sativum* (1.34 and 1.61 ppm, respectively). The LD_{50} and LD_{90} values for the oils of *Pelargonium radula*, *Cuminum cyminum*, *Ocimum basilicum*, *Origanum vulgare* and *Matricaria chamomilla* ranged between 1.54–1.59 ppm and between 1.84–1.91 ppm, respectively. GC/MS analyses revealed the presence of known biologically active compounds such as *p*-Cymene, Linalool, Thymol, Caryophyllene and Carvacrol in some of the analyzed oils. Fenitrothion was the most toxic (LD_{50} = 0.33 ppm), while fenvalerate was the least (LD_{50} = 1.48 ppm). The other 2 insecticides possessed intermediate and nearly equitoxic values (LD_{50} = 1.2 ppm). Surprisingly, the *A. cepa* oil was more toxic than methomyl, and the other plant oils possessed toxicity accounted to 74–80% and 83–98% of methomyl toxicity when comparisons were made at the LD_{50} and LD_{90} levels, respectively. Combining plant oils with insecticides resulted in different types of interaction (e.g., synergism, additive and antagonism). Such results may be considered as novel findings in the course of searching for potent botanical insecticides against the locust, *S. gregaria*, and magnify the industrial value of such plant oils in the era of biopesticides.

1. Introduction

The insect *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae), connoted as the desert locust, predominates in desert and scrub regions of northern Africa, the Sahel, the Arabian Peninsula and the southwest of Asia (Steedman, 1988). The locust populations during solitary phase are likely to present no obvious economic threat to the cultivated vegetations. When vegetation flushes occur in the locust breeding areas a rapid population build-ups accompanied by morphological, physiological, and behavioral transformation from solitary to gregarious phases on a regional scale (Uvarov, 1921; Roffey and Popov, 1968). Such phase transformation can build-up over two or three generations, then often collects in dense bands of flightless nymphs (or hoppers) and swarms of winged adults that may effectively destroy crop production at the local level (Showler, 2002). Thereafter, the insect's distribution can expand to include different areas in Africa, Asia and Southern Europe (Pedgley, 1981; Steedman, 1988).

According to Steedman (1988) a single swarm of locusts can be small, thousands of locusts over several hundred square meters, or large, billions, up to 80 million/km^2, infesting > 1000 km^2. A swarm of locusts can fly 100 km per day, and bands can march up to 1.5 km per day.

Based on the Ministry of Agriculture & Soil Reclamation of Egypt, the local news media reported the episode of locust invaded the Egyptian territory in 11 November (2004). Among a sum of 32 swarms of locusts, three of them were huge and each reached 70–80 km^2 (length), 6–10 km^2 (width), and a thickness of 4–6 km^2. Each swarm contained approximately 400 million locusts. Such locust invade was not occurred since 40 years ago, except in the north of Egypt at the year 1994, but with small swarms.

Before the late 1980s, longer residual compounds, such as dieldrin, were extensively applied on vegetation (Steedman, 1988). As a result of the banning of organochlorine compounds such

* Corresponding author. Tel.: +20 2 33371211; fax: +20 2 33370931.
E-mail address: samansour@hotmail.com (S.A. Mansour).

http://dx.doi.org/10.1016/j.indcrop.2014.10.038
0926-6690/

as dieldrin, current locust control operations are mainly based on organophosphorus pesticides (Lecoq, 2001). The insect tolerance against neurotoxic insecticides is expected to occur rapidly (Rembold, 1994), and insecticides of broad spectrum of action had substantial side-effects on the non-target fauna (Müller, 1988).

Botanical insecticides, known as plant secondary metabolites, are expected to be possible alternatives to the traditional chemical insecticides. They have broad-spectrum activity, relative specificity in their mode of action, and easy to process and use. They also tend to be safe for animals and the environment (Khater, 2011). The neem products were recommended by several researches as alternatives to the currently used harmful pesticides for the control of desert locust (Krall and Wilps, 1994). Among the plant families studied, the Meliaceae, Rutaceae, Asteraceae, Labiateae, Piperaceae and Annonaceae are perhaps the most promising (Schoonhoven, 1982; Jacobson, 1989; Isman, 1995).

In recent years, the plant essential oils (EOs) have received much attention as potentially bioactive compounds against a vast range of many pests including bacteria, fungi, protozoa, insects, plants, and viruses (Tassou et al., 1995; Keita et al., 2001; Lee et al., 2001; Tripathi et al., 2002; Esquenazi et al., 2002; Rosa et al., 2003; Khater, 2011). They have low toxicity to warm-blooded animals, high volatility, and most are nontoxic to birds, mammals and fish (Isman, 1999; Stroh et al., 1998). Some EOs used in processed food and beverages are exempted from registration in the United States (Quarles, 1996).

In addition to food uses, plant oils have found their way into industrial products such as plastics, polymers, surfactants, pharmaceuticals, inks, adhesives, coatings, biodiesel, pesticides and many other industries (Salimon et al., 2010). Many species of medicinal and aromatic plants (MAPs) are cultivated for such industrial uses (Lubbe and Verpoorte, 2011). The advantages of plant oil-derived industrial products can be illustrated by their role in the field of green chemistry (Schwartza et al., 2008).

The present study was undertaken to test efficacy of some EOs extracted from a variety of plants, compared with traditional commercial insecticides, as well as to assess the joint toxicity of their mixtures against the nymphal instar of *S. gregaria* under laboratory conditions. The work aimed to shed light to a group of plant oils that may magnify their industrial value in the era of biopesticides.

2. Materials and methods

2.1. Test insect

A colony of desert locust *S. gregaria* (Forsk.) was established in the laboratory according to Hoste et al. (2002). The rearing was performed in cages 60 cm × 60 cm × 60 cm provided with wire gauze sides and a glass top. The bottom was furnished with sterilized sand layer of 20 cm thickness for egg laying. These cages have small doors in the front side to facilitate daily routine feeding and cleaning. Fresh leaves of *Sesabania aegyptiaca* (Fabales: Fabaceae) were introduced daily as feeding materials, along with dry wheat bran fortified with 5% of yeast powder as a source of vitamin B. The cages were cleaned at regular intervals to keep locusts at outmost hygienic conditions and to avoid contamination. Furthermore, the cages were sterilized with an antiseptic agent every 4–6 weeks whenever terminating any experimental trial. The cages were kept under controlled conditions with light cycle of 12:12 h (light:dark) at temperature of 30 ± 2 °C and 50–60% relative humidity (RH). The culture was used to provide 3rd nymphal instars required for the present study.

Table 1
Plants investigated for biological activity against 3rd nymphal instar of *Schistocerca gregaria* (Forsk.).

Family	Scientific name	English name	Used part
Alliaceae	*Allium cepa* L.	Onion	Leaves
Asteraceae	*Matricaria chamomilla* L.	Chamomile Blue	Whole plant
Geraniaceae	*Pelargonium radula* Cav.	Geranium	Whole plant
Lamiaceae	*Origanum vulgare* L.	Marjoram	Whole plant
	Ocimum basilicum Linn.	Sweet Basil	Whole plant
	Thymus vulgaris L.	Thyme	Whole plant
	Thymus capitatus Hoffm.	Thyme	Whole plant
	Thymus bovei Benth.	Thyme	Whole plant
Umbeliferae	*Petroselinum sativum* L.	Parsley	Seeds
	Cuminum cyminum Linn.	Cumin	Seeds

2.2. Insecticides

Four commercial insecticides were used for studying their efficacy against 3rd nymphal instar of *S. gregaria.* These were:

a) Carbosulfan (a carbamate insecticide; 2,3-dihydro-2,2-dimethylbenzofuran-7-yl (diputylaminothio) – methylcarbamate) in a commercial formulation of Marshal® (25% WP).
b) Methomyl (a carbamate insecticide; S-methyl N-(methylcarbamoyloxy) thioacetatimide) in a commercial formulation of Lannate® (90% SP).
c) Fenitrothion (an organophosphorus insecticide; O,O-dimethyl O-4-nitro-m-tolyl phosphorothioate) in a commercial formulation of Sumithion® (50% EC).
d) Fenvalerate (a synthetic pyrethroid insecticide; (RS) α-cyano-3-phenoxybenzyl (RS)-2-(-4-chlorophenyl)-3-methylbutyrate) in a commercial formulation of Sumicidin® (25% EC).

The above mentioned insecticides were obtained from El-Nasr Company for Intermediate Chemicals, Cairo, Egypt.

2.3. Extraction of plant oils

Seeds of Parsley (*Petroselinum sativum* Linn.) and Cumin (*Cuminum cyminum* Linn.) were obtained from supermarkets, while the other plants were obtained from the National Research Centre's (NRC) farm at Giza. The plants were identified by the NRC Herbarium Unit and specimens were kept there. EOs from 10 plant species, belonging to five families (Alliaceae, Asteraceae, Geraniaceae, Lamiaceae and Umbeliferae), were extracted by hydrodistillation for 3–5 h in Clevenger apparatus according to Anderson et al. (1980). The obtained oils were dried over anhydrous sodium sulfate to remove any traces of water droplets, filtered, weighed and kept in a deep freezer (−18 °C) till used in the bioassay tests and phytochemical analyses. The scientific names of the 10 plants, extracted plant parts, family and English names are given in Table 1.

2.4. Analysis of plant oils

Each obtained oil was injected (1.5 μl) into Shimadzu GC/MS-QP model 5050A, equipped with class 5000 software and Wiley Mass spectral database. The MS scan parameters included electron impact ionization voltage of 70 eV, a mass range of 40–750 *m*/*z* and a scan interval of 0.5 s. The column was a stainless steel DB 1 of 25 m length × 0.53 mm I.D. and 1.5 μm film thickness (J&W Scientific). The oven temperature was programmed from 40 °C to 180 °C at 7.5 °C/min, then isothermally at 230 °C for 2 min. Detector and injector temperatures were 290 °C and 250 °C, respectively, and the carrier gas (Helium) flow rate was 40 mL min^{-1}. The oils