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Monitoring arthropods fauna associated with sunflower (*Helianthus annuus* L.) Varieties used in cut flower trade industry in South Florida, USA

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Abstract
Sunflower (*Helianthus annuus* L.) is a profitable cash crop in the southern and eastern states of United States of America mainly for the production of edible oils, biodiesel as well as cut flower for ornamental purposes. Field experiment was conducted during spring season 2014 at Tropical Research and Education Centre (TREC) of The University of Florida at Homestead to monitor different arthropods fauna on four different sunflower cultivars i.e. Sunrich Lemon, Sunbright, Sunrich Orange and Russian Mammoth. Basic purpose of the study was to document different arthropods fauna associated with the crop. Among all four varieties of sunflower, three were cut flowers whereas Russian Mammoth was oilseed variety. While monitoring, no attempt was made to collect all the available individuals, only the representative species of each individual was collected since the basic purpose of the study was to report all the existing arthropod species on sunflower in the area. During the investigation, several pests, natural enemies and pollinators were identified. Several pests were identified during the course of experiment. The major pests were *Agalia nielsoni* and *Agalia albidula* (Ciacadidae), *Bemesia tabacii* (Aleyrodoidea), *Aphis* Spp. (Aphididae) and *Halictus brachtatus* (Miridae) blackbird (red-winged blackbird, *Agelaius phoeniceus* L.; common grackle, *Quiscalus quiscula* L. and certain blackbird species). Other pests included stem weevil (*Cylindrocopturus adspersus* LeConte) and head clipping weevil (*Haplorhynchites aeneus Boh*.). In addition to pest species, natural enemies were also reported which mostly comprised of ladybird beetle, green lacewing, praying mantis, syrphid flies, and some species of spider fauna.

Keywords: *Helianthus annuus*, arthropods, cut flower, South Florida, USA

Introduction
Sunflower (*Helianthus annuus* L.) belongs to the family Asteraceae, an ornamental plant that is grown largely all over the world (Groove and Summer, 2005) [15] was basically originated from North America (Knodel, 2010) [21]. Sunflower is a short season crop that can be easily identified by broad and dark yellow floral heads. Being an edible oil crop, sunflower has also gained much popularity as cut flowers and hence the endeavor of diversifying its benefits has been enhanced (FAO, 2004) [11]. Sunflower is usually grown in rain fed areas being a comparatively drought tolerant crop (Robinson, 1978; Lindstrom *et al*., 1982; Stone *et al*., 2002) [28, 22, 32-33] and have the capability of utilizing different soil nutrients competently (Connor and Hall, 1997; Valchovski, 2002) [10, 34] because of strong and extremely deep rooting (Jaafar *et al*., 1993; Nielsen, 1998; Angadi and Entz, 2002a, b; Stone *et al*., 2002) [17, 26, 1, 32-33].

Sunflower is among one of the four basic indigenous American profitable crops of worldwide importance and is mainly raised for edible oils, snacks, birdseeds and cut flowers. Sunflower plants have a high capacity for drought resistance, thrive well in full sunshine and can be sown on a wide range of soils both as annual and as perennial crop. Numerous sunflower cultivars are available in different colors, range from yellow to red, cream and bronze. Since many of the well-known old sunflower varieties are not suitable for ornamental purposes, new varieties are being introduced for cut flower use and bedding.

In Florida, sunflower growing season is comparatively long and restricted only by cold temperature. Most of the familiar cultivars grown for cut flower purpose include Sunrich Lemon, Sunbright, Sunrich Oramge, Moulin Rouge and Soraya, while Russian Mammoth is sown as oilseed crop, that sometimes attain a height up to ten feet (Zheljazkov *et al*., 2008) [35]. Presently in USA, sunflower is mainly cultivated in North Dakota, South Dakota, Colorado, Kansas, Minnesota, Nebraska, and Texas (Johnston *et al*., 2002; National Agricultural Statistics Service, 2006) [18, 24] and in Canada (Angadi and Entz, 2002a, b; Johnston *et al*., 2002) [1, 18].

Apart from oilseed crop, sunflower been proven to have a vital perception for biodiesel production and can be grown for bio seed production largely (National Sunflower Association, 2009) [25]. Consequently, farmers' community in the United States has been attracted in sunflower cultivation as a latent biodiesel crop. In Florida sunflower was assessed between 1970s and 1980s for biodiesel production (Green *et al*., 1980, 1981, 1982) [12-14]. Sunflower is such a crop that is associated with many ethnicities and uses. Major uses of the crop include food, cosmetics, therapeutic and many other ancient customs. Sunflower oil mainly accounts for more than 80% of the worth of the crop. Sunflower is a very proper module crop for crop rotation practices, as it is a short-term crop than many other crops, and can be sown later or harvested earlier. Ease and simplicity of cultivation is an additional advantage of the

crop. Sunflower can be raised in many types of soils provided they have constant and enough sources of water and sunlight. Plant population is mainly associated with crop yield. The more the plant density, the higher the anticipated outcome (Bertoria *et al.*, 1998) [6].

The major constraints to sunflower production are different insect pests. Many of these insect pests work as vector for carrying virus and other infectious diseases. For instance, Infestation of *Empoasca abrupta* may lead to leaf curling, chlorosis and pre mature senescence (Rogers, 1978) [29]. The pests attack sunflower crop are cutworms *(Agrotis Sp.),* aphids *(Aphis gossyipii),* thrips *(Thrips tabaci),* whitefly *(Bemisia tabaci),* grasshoppers and beetles have also been reported (Aslam, 2000) [3]. More than 50 insect pests have been recorded on sunflower crop *(H. annuus* L.) These insect species largely comprised of whitefly *(Bemesia tabaci),* leafhopper *(Amrasca biguttula),* thrips *(Thrips tabaci),* tobacco caterpillar *(Spodoptera litura),* maelybugs *(Phenacoccus solenopsis),* green semilooper *(Thysanoplusia orichalcea)* and capitulum or head borer *(Helicoverpa armigera).* All these insect pests cause heavy losses to the crop and greatly reduce the crop yield. Because of insect infestation, the total losses in crop yield ranges from 35.7 to 51.3 %. More than 50 % damages in the yield of sunflower have been reported due to infestation caused by capitulum borer (Basappa, 2008) [5]. Keeping in view the economic importance of sunflower *(H. annuus* L.*)* in cut trade industry of South Florida, the present investigation was therefore conducted with the objectives to monitor different insect pests and other arthropod species such as natural enemies as well as insect visitors associated with sunflower and to identify the most common and serious pests of the crop in Southern part of Miami Dade in Florida.

Materials and methods

The present investigation on monitoring of different fauna associated with ornamental as well as oilseed sunflower variety was carried out during the year 2014 at UF-Tropical Research & Education Center Homestead, Florida. During the course of experimentation three cut sunflower varieties i.e. Sunbright Supreme, Sunrich Lemon and Giant Sungold and one edible sunflower variety, Mammoth was raised as a test crop. Before planting of seeds, granular fertilizer was applied at the rate of 700 lb/ Acre with the band 2-12 inches to the side and 2-6 inches below the seed for row culture. Sunflower seeds were sown on ridges by placing three seeds in each hill up to a depth of 2 inches.

Soon after the sowing of seeds pre-emergence herbicide, Dual-II Magnum at the rate of 1.33 pts/ Acre were applied. After herbicide application, entry to the field was prohibited for a period of 24 hours. The field was irrigated one day after sowing of sunflower seed. After three weeks of the emergence of seedlings, thinning was done in order to maintain optimum population per plot. Ten days after thinning, fertilizer at the rate of 700 lb/ Acre was applied for the second time to all the plants. The field was irrigated twice a week while, and all the suggested agronomic as well as cultural practices applied equally to each treatment. The experimental area was kept free from any pesticide application during the course of experimentation. There were four plots and each plot was comprised of four rows that were 50 feet long. Row to row distance was maintained 3 feet with plant-to-plant distance of 18 inches respectively, whereas total number of plants in each row was 30 and thus ach plot consisted of 120 plants.

The following observations were recorded during the course of study.

Incidence of insect pests

After emergence of seedlings, incidence of different Insect pests was recorded on daily basis. Miscellaneous species of insects were collected from cultivated sunflower varieties during the course of experimentation. During collecting of insect species all standard entomological collecting practices were used to document host and habitat, etc., of collected insect pests and other arthropods. Representative specimens of unidentified species were sent to taxa specialists for identification. All the collected specimens of each species were then preserved in glass vials with 70 % alcohol and consequently deposited in the Entomology laboratory of University of Florida's Tropical Research and Education Centre, Homestead for proper cataloging and preservation.

Results and Discussion

Sunflowers have been known as basic niche for the nourishment of numerous species that not only attract a large number of pest fauna but also did play host to numerous pollinators particularly honey bee as well as other beneficial insects. In the current study we observed that all varieties of sunflower attracted a complex of pest species. Majority of the pests mentioned herein are not severe and major pests of economic importance, however the current catalogue may be served as orientation and with the help of which a more comprehensive study may be carried out in future. In order to facilitate discussion, all the reported species are described order wise. Different species of insect pests associated with sunflower were comprised of as many as 7 different orders.

Hemiptera

Among all the recorded group of pest species, the Hemipterans were well represented and among the most prevailing fauna of sunflower. Table 1. Indicates different species of Hemiptera that were recorded on sunflower during sunflower growing season Feb-May 2014. Hemiptera included *Agalia nielsoni* and *Agalia albidula* (Ciacadidae), *Bemesia tabacii* (Aleyrodoidea), *Aphis* Spp. (Aphidoidea) and *Halictus brachtatus* (Miridae) were found to be the most abundant and serious pests of the crop. In addition to these species other Hemipterans were also recorded on all varietal plots which mainly included Polymerus *testaceipes, Spanagonicus albofasciatus* and *Reuteroscopus ornatus* (Miridae), *Nysius raphanus* (Lygaeidae), and *Clastoptera xanthocephala* (Cercopidae). It was found that sucking pests such as aphid, whitefly and leaf hopper were the leading and most abundant group of pests observed on all varieties of the crop. Sunflower is such a crop that potentially attracts a complex of arthropods species, since as per report of Hilgendorf and Golden, (1981) more than 150 phytophagous species of different orders such as Coleoptera, Lepidoptera and Homoptera attack on sunflower. Sucking pests like whitefly and plant hopper not only severely damage the crop, but also serves as vector for viral infections and plays a vital role in the diseases transmission. Heavy losses by Hemiptera secies have been previously reported by Kataria and Kumar (2012).

Table 1: List of insect pests of order Hemiptera collected from sunflower cultivars in South Florida during 2014

S. No	Order	Family	Common Name	Scientific Name
1	Hemiptera	Ciacadidae	Leaf hoppers	*Agalia nielsoni*
2	Hemiptera	Miridae	Plant Bug	*Polymerus testaceipes*
3	Hemiptera	Miridae	Plant Bug	*Reuteroscopus ornatus*
4	Hemiptera	Lygaeidae	False chinch bug	*Nysius raphanus*
5	Hemiptera	Miridae	Plant Bug	*Spanagonicus albofasciatus*
6	Hemiptera	Miridae	Garden flea hopper	*Halictus brachtatus*
6	Hemiptera	Cercopidae	Spittle bug	*Clastoptera xanthocephala*
7	Hemiptera	Aleyrodoidea	Whitefly	*Bemesia tabacii*
8	Hemiptera	Aphidoidea	Aphids	*Aphis Spp.*
9	Hemiptera	Ciacadidae	Leaf hoppers	*Agalia albidula*
10	Hemiptera	Miridae	Plant/Leaf Bug	*Lygus lineolaris*
11	Hemiptera	Reduvidae	Assasin bug	*Sinea* Spp.

Coleoptera

Tables No. 2 shows the pest faun that were recorded on our cultivars of sunflower. Results on diversity of sunflower pests revealed that Coleopterans were recorded to be the second largest group of different pest species that found on sunflower crop. It was revealed that all cultivars of sunflower harbor three species of Curculionidae that is of prime importance to the sunflower production throughout the United States. Species of Curculionidae included Citrus Root Weevil, *Diaprepes abbreviates,* Blue Green Weevil, *Pachneus litus* and True weevil, *Conotrachelus tuberosus,* which frequently cause cost-effective losses to the crop. Species of Chrysomelidae such as Cucumber beetle, *Diabrotica balteata,* Pachybrachis stygicus and Leaf beetle, *Pachybrachis cephalicus* were also well represented among the pests' fauna associated with sunflower, among which the Leaf beetle, *Pachybrachis cephalicus* were potential pest of sunflower. As per report of Brewer and Charlet, (2004) [8] sunflower beetle is important pest of sunflower in North America. Sunflower beetles have been disseminated throughout the sunflower fields in United States which cause losses to the cultivated sunflower. Cucumber beetle, *Diabrotica balteata* was found one of the serious pest feeding on young and immature leaves of the crop, while *Euphoria* beetle or Flower Beetle efficiently fed on seed content of the flowers and made holes in the capitulum. Other Coleopterans included *Hippodamia* beetle, *Hippodamia convergens* (Coccinellidae) and Flower Beetle, *Euphoria* beetle (Scarabaeidae). As for as beetles and weevils were concerned, it was noticed that all the adult stages of Coleopterans rather than their immature is the stage that attack sunflower and were found nourishing on stem, florets, immature grains and even on roots of sunflower (Rogers, 1978) [29].

Table 2: List of insect pests of order Coleoptera collected from sunflower cultivars in South Florida during 2014

S. No	Order	Family	Common Name	Scientific Name
1	Coleoptera	Coccinellidae	Hippodamia beetle	*Hippodamia convergens*
2	Coleoptera	Curculionidae	Citrus Root Weevil	*Diaprepes abbreviates*
3	Coleoptera	Curculionidae	Blue Green Weevil	*Pachneus litus*
4	Coleoptera	Chrysomelidae	Cucumber beetle	*Diabrotica balteata*
5	Coleoptera	Scarabaeidae	Euphoria beetle	*Flower Beetle*
6	Coleoptera	Chrysomelidae	Leaf beetle	*Pachybrachis cephalicus*
7	Coleoptera	Chrysomelidae	--	Pachybrachis stygicus
8	Coleoptera	Curculionidae	True weevil	*Conotrachelus tuberosus*

Lepidoptera

It was observed that species of Lepidoptera competed Coleoptera while dominating pests associated with sunflower (Table No. 3). Lepidopterous pests are mostly polyphagous and are serious economic threats to several crops of economic crops including sunflower. Species of Lepidoptera contained numerous potential pests, which fed on different phonological stages of the cultivated sunflower. Leaf miners, Leaf Blotch miner, *Acrocercops brongniardella,* (Gracillariidae) and Army worms, *Spodoptera* Spp. (Noctuidae) were identified among serious pests of the crop. The Caribbean Armyworm Moth, *Spodoptera pulchella* and Garden Armyworm, *Spodoptera latifascia* (Noctuidae), Grass Tubeworm Moth, *Acrolophus arcanella* (Acrolophidae) and Omnivorous leafroller, *Platynota stultana* (Tortricidae) were also recorded on sunflower varieties, but all these pest species were not the potential feeders of the crop. Seedlings of sunflowers are highly vulnerable to the attack of cutworms as they cut off young plants below or above the soil level or sometimes leaves are also chieved. Immature larvae of cutworm cause injury normally at night and during day time hide under leaves, debris or cracks in the soil (Knodel and Charlet, 2007).

Table 3: List of insect pests of order Lepidoptera collected from sunflower cultivars in South Florida during 2014

S. No	Order	Family	Common Name	Scientific Name
1	Lepidoptera	Gracillariidae	Leaf miners	*Bedellia somnulentella*
2	Lepidoptera	Gracillariidae	Leaf Blotch miners	*Acrocercops brongniardella*
3	Lepidoptera	Noctuidae	Army worm	*Spodoptera* Spp.
4	Lepidoptera	Acrolophidae	Grass Tubeworm Moth	*Acrolophus arcanella*
5	Lepidoptera	Tortricidae	Omnivorous leaf roller	*Platynota stultana*

6	Lepidoptera	Noctuidae	The Caribbean Armyworm Moth	*Spodoptera pulchella*
7	Lepidoptera	Noctuidae	Garden Armyworm	*Spodoptera latifascia*
8	Lepidoptera	Noctuidae	Cutworm	*Agrotis* Spp.

Miscellaneous Orders

Many thrips (Thysanoptera) species such as Melon Thrips, *Thrips palmi, Thrips tabacii* and Black Thrips, *Franklinothrips vermiforms* of Thripidae and Aeolothripidae were collected from the floral parts of both edible as well as cut flower cultivars of sunflower (Table No. 4). Thrips were found the most common and serious inhabitants of the crop which not only suck the cell sap from the leaves but also play a vital role in transmission of diseases. Most probably, thrips encountered in the capitulum of sunflower were feeding on pollens. Numerous Tyhsanoptera species have been previously reported to be associated with sunflower which not only cause severe crop injury but also serve as disease carrying agents such as transmission of virus that cause sunflower necrosis (Chander, 2002) [9]. Crickets (Orthoptera) and some species of grasshopper (Acrididae) frequently noticed in the field that consumed seedling and immature parts such as leaves of sunflower. Field crickets and grasshopper are normally minor pests which feed on immature leaves, stem and seedlings. Crickets are mostly nocturnal pests. A complex of seedling and soil-dwelling pests including crickets and grasshoppers was reported by Simpson (1993) [31] and stated that these pests cause severe damage to sunflower seedlings during early days of its development.

Table 4: List of insect pests of order miscellaneous orders collected from sunflower cultivars in South Florida during 2014

S. No	Order	Family	Common Name	Scientific Name
1	Thysanoptera	Thripidae	Melon Thrips	*Thrips palmi*
2	Thysanoptera	Thripidae	Thrips	*Thrips tabacii*
3	Thysanoptera	Aeolothripidae	Black Thrips	*Franklinothrips vermiforms*
4	Orthoptera	Gryllidae	Cricket	*Teleogryllus* spp.
5	Orthoptera	Acrididea	Grasshopper	*Chrotogonus* spp.

Natural Enemies

The natural enemies of sunflower have previously been described and cataloged by many researchers. The listing given in Table 5 is an apprise form of the earlier work done by scientists. Ladybird beetle, green lacewing, praying mantis, syrphid flies, and certain species of spiders were the most important natural enemies that were recorded on sunflower. Honeybees (Hymenoptera) of different families were constantly associated with the inflorescences of cultivated sunflower. Parasitic Hymenoptera, *Opius Spp.* and *Cotesia marginiventris* were also found on the crop. Coccinellidae, Diptera and Mantoda species were among the principal insect fauna of sunflowers, since they are potential feeders of soft bodied insect pests such as aphid, leaf hoppers and whitefly. Larvae of Neuroptera are also excellent predators of soft-bodied pests whereas their adult are free living and mostly encountered on sunflower inflorescence and feeds on nectar content of floral parts. A list of natural enemies (*Coccinella septumpunctata* Linnaeus, *Mantis religiosa, C. carnea, Menochiles sexmaculata* Fabricius and *Brumus suturalis* Fabricius) as voracious predators of whitefly, aphids and jassids were presented by Pal and Katiyar, (2010) [27]. Our present results are further corroborated by the previous finding of Basappa, (2007) [4] that Coccinellidae, Chrysopid (*Chrysoperla carnea*), and different species of Araneae are active feeders of the nymphs of leafhoppers and other soft-bodies insect pests associated with sunflower.

Table 5: List of different natural enemies collected from sunflower cultivars in South Florida during 2014

S. No	Order	Family	Common Name	Scientific Name
1	Neuroptera	Chrysopidae	Green lacewing	*Chryspoha carnea*
2	Mantoda	Mantis	Praying mantis	*Mantis religiosa*
3	Hymenoptera	Braconidae	Parasitic wasp	*Opius Spp.*
4	Hymenoptera	Apidae	Honey bees	*Apis* Spp.
5	Hymenoptera	Braconidae	Wasp Parasitois	*Cotesia marginiventris*

Conclusions

Based on the present study, it is concluded that all four species of sunflower attracted large number of insect fauna. Sunflower, being an ornamental or cut flower has gained much importance in several counties in Florida States of USA. Hence keeping in view its economic importance in the trade of cut flower industry of South Florida, it is of great importance that entomologists may become acquainted with all these prevailing arthropods fauna and to develop ecologically and environmentally safe pest management techniques to deal with insect pests of both edible as well as cut flower cultivars of sunflower.

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