



## Research Article

# Biodiversity of biocontrol agents in sunflower ecosystem

**H. BASAPPA**

Directorate of Oilseeds Research (ICAR), Rajendranagar, Hyderabad 500 030, Andhra Pradesh, India

E-mail : hbasappa@gmail.com; hbasappa@yahoo.com

**ABSTRACT:** Several species of both beneficial and harmful insects are associated with sunflower (*Helianthus annuus* L.). In sunflower ecosystem, 48 species of natural enemies are recorded comprising 7 parasitoids, 24 insect predators, 9 spiders and 8 predatory birds. Majority of the insect predators belong to Coleoptera, Hemiptera, Mantodea, Orthoptera, Odonata and Neuroptera whereas hymenopterans comprised both predators and parasitoids. Among the 48 species of natural enemies recorded in the sunflower ecosystem, the predominant species are *Trichogramma chilonis* Ishii (on eggs of *Helicoverpa armigera*), *Charops obtusus* Morley (on *Spilarctia obliqua* Walker), *Campoletis chlorideae* Uchida, *Rhogas percurrans* Lyle (on *H. armigera* larvae) and *Cotesia flavipes* (Cameron) (on *Spodoptera litura* larvae). Among predators, coccinellids, *Cheilomenes sexmaculata* (F.), *Brumoides suturalis* (Fab.), *Chilocorus nigritas* (F.), *Coccinella septempunctata* L. and *Scymnus* sp. keep a good check on eggs and early stage larvae of Lepidoptera and sucking pests. In addition, *Chrysoperla* (*carnea*-group), *Eocanthecona furcellata* (Wolff), *Rhynocoris kumarii* Ambrose and Livingstone, *Geocoris tricolor* F. and *Anthocoris* sp., mantids, *Eumantissa* sp., *Ceriagrion coromandelianum* (F.), *Ischnura* sp., *Dolichopus* sp., *Therevia* sp., microbial agents and predatory birds play a vital role in the suppression of insect pests in sunflower. Though the activity of major predators like coccinellids and spiders was noticed in all the cropping seasons, maximum population was found during September and January, coinciding with the maximum population of insect pests.

**KEY WORDS:** Sunflower, biocontrol agents, biodiversity.

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## INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the edible oilseed crops making rapid strides in the oilseeds scenario of India due to its wide adaptability, day neutral nature and responsiveness to better management practices. It is cultivated throughout the year as sole crop under irrigated conditions and in *kharif* and *rabi* seasons under rainfed conditions. Karnataka, Maharashtra and Andhra Pradesh are the major sunflower growing states. Tamil Nadu, Haryana, Punjab, Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal and Chattisgarh are the other sunflower producing states. Several species of both beneficial and harmful insects and non-insects are associated with sunflower crop. The species complexes of insect pests of sunflower and their natural enemies in temperate countries are different from those in tropical countries. In India, 67 species of insects, one species of mite and five species of vertebrate pests are reported to cause damage to sunflower crop (Basappa, 2008). Among them, cutworms (*Agrotis* spp.), sucking pests like leafhoppers (*Amrasca biguttula biguttula* Ishida, *Empoasca* sp.), thrips (*Scirtothrips dorsalis* Hood, *Frankliniella schultzei* (Tryb<sub>2</sub>) and *Thrips palmi* Karny), whitefly (*Bemisia tabaci*

(Gennadius)), mealybug (*Phenacoccus solenopsis* Tinsley), defoliators (*Spilarctia obliqua* (Walker), *Spodoptera litura* (Fabricius), *Spodoptera exigua* (Hubner), *Trichoplusia ni* (Hubner), *Condica illecta* (Walker) and *Thysanoplusia orichalcea* (Fab.)) and capitulum borer (*Helicoverpa armigera* (Hubner)) are major insect pests of economic importance. A wide array of biocontrol agents are reported to interfere in the succession of major insect pests of sunflower (Basappa, 2004; Basappa and Santha Lakshmi Prasad, 2005). Hence, it was felt essential to investigate the biodiversity of biocontrol agents of major insect pests in sunflower ecosystem.

## MATERIALS AND METHODS

Studies on the biodiversity of biocontrol agents associated with major insect pests of sunflower was carried out at the Directorate of Oilseeds Research (DOR), Rajendranagar, Hyderabad from 2003-04 to 2008-09. The experiment was conducted by raising the popular sunflower variety, Morden in an area of 150 m<sup>2</sup> by following the recommended package of practices (DOR, 2010) except plant protection. A total of 12 sowings were taken at two month intervals starting from June, 2003 till

May, 2005. From 2005-06 till 2008-09, observations were recorded every year during regular cropping seasons like *kharif*, *rabi* and summer seasons. Weekly observations on different biocontrol agents of major pests were recorded at different phenological stages of the crop from seedling stage till harvest and the specimens were preserved properly for identification. Eggs and larvae of lepidopteran pests were collected from sunflower fields regularly and maintained in the laboratory for parasitoid emergence. Apart from DOR Farm, biocontrol agents were also collected from sunflower fields from Akola, Latur, Savalvir of Maharashtra, Raichur and Bangalore of Karnataka and Coimbatore in Tamil Nadu at the time of AICRP sunflower monitoring programme during 2007 and 2009. Specimens were identified by comparing with CABI identified specimens at DOR, Hyderabad and UAS, Dharwad. Some of the specimens were identified by experts from the Department of Entomology, UAS, Bangalore, NBAII, Bangalore and Division of Entomology, IARI, New Delhi.

## RESULTS AND DISCUSSION

The natural enemy complex in sunflower ecosystem consisted of 48 species including seven parasitoids, 24 insect predators, nine spiders and eight insectivorous predatory birds apart from three nuclear polyhedrosis viruses (NPV) and 2 entomopathogenic fungi which were

recorded in Andhra Pradesh from 2003-2009 as well as in Karnataka, Maharashtra and Tamil Nadu during 2007 and 2009 as a part of AICRP sunflower monitoring programme (Table 1, 2 and 3).

### Parasitoids

Important egg and larval parasitoids recorded on major insect pests in sunflower ecosystem belonged to Hymenoptera and Diptera and their activity was maximum during *kharif* season. Among the parasitoids recorded in the sunflower ecosystem, the egg parasitoid *Trichogramma chilonis* Ishii (on eggs of *H. armigera*), larval parasitoids *Charops obtusus* Morley (on *S. obliqua*), *Campoletis chlorideae* Uchida, *Rhogas percurrans* Lyle (on *H. armigera* and *C. illecta* larvae), *Cotesia flavipes* (Cameron) (on *S. litura* and *C. illecta* larvae), *Exorista xanthaspis* Weiedemann (on *H. armigera*, *S. obliqua*, *T. ni*, *T. orichalcea* and *C. illecta* larvae) and *Peribaea* sp. (on *S. litura* and *S. exigua*) were predominant. Sometimes *Chelonus* spp. was also found to be egg-larval parasitoids of *S. litura*. *Aenasius bambawalei* Hayat was also recorded on mealybug infesting sunflower. Apart from these parasitoids occurring regularly on major insect pests, some of the parasitoids of minor importance included *Peribaea* sp., *Homolobus* sp. and *Aleiodes percurrans* Lyle on *C. illecta*.

**Table 1. Biodiversity of insect parasitoids and entomopathogenic microbial agents in sunflower ecosystem**

Organism Group	Name of the Biocontrol agent	Parasitoid on the insect pest	Sunflower growing states
<b>Insecta</b>			
Diptera: Tachinidae	<i>Exorista xanthaspis</i> Weiedemann	Larval parasitoid on <i>H. armigera</i>	1,2,3
Diptera: Tachinidae	<i>Peribaea</i> sp.	Larval parasitoid on <i>C. illecta</i> , <i>S. litura</i> and <i>S. exigua</i>	1,2,3
Hymenoptera: Trichogrammatidae	<i>Trichogramma chilonis</i> Ishii	Egg parasitoid on <i>H. armigera</i>	1
Hymenoptera: Ichneumonidae	<i>Campoletis chlorideae</i> Uchida	Larval parasitoid on <i>H. armigera</i>	1,2,3
Hymenoptera : Braconidae	<i>Rhogas percurrans</i> Lyle	Larval parasitoid on <i>H. armigera</i>	1,3
Hymenoptera: Ichneumonidae	<i>Charops obtusus</i> Morley	Larval parasitoid on <i>S. obliqua</i>	1,2,3
Hymenoptera: Braconidae	<i>Cotesia flavipes</i> (Cameron)	Larval parasitoid on <i>S. litura</i> larvae	1,3
<b>Microbial agents</b>			
Virales: Baculoviridae	HaNPV	Nuclear Polyhedrosis Virus on <i>H. armigera</i> larvae	1,3,4
Virales: Baculoviridae	SINPV	Nuclear Polyhedrosis Virus on <i>S. litura</i> larvae	1
Virales: Baculoviridae	ThorNPV	Nuclear Polyhedrosis Virus on <i>T. orichalcea</i>	1,3

1. Andhra Pradesh, 2. Karnataka, 3. Maharashtra, 4. Tamil Nadu

**Table 2. Biodiversity of insect predators of major insect pests in sunflower ecosystem**

Organism Group	Name of the Insect Predator	Name of the Prey/ insect pest	Sunflower growing states
<b>Arthropoda</b>			
<b>INSECTA</b>			
Coleoptera : Coccinellidae	<i>Cheilomenes sexmaculata</i> (F.)	Leafhopper, whitefly, mealy bugs, <i>H. armigera</i> , <i>T. ni</i> , <i>T. orichalcea</i> , <i>C. illecta</i> and <i>S. litura</i> larvae	1,2,3,4
Coleoptera : Coccinellidae	<i>Brumoides suturalis</i> (F.)	Mealybugs, leafhopper, whitefly and lepidopteran pests	1,2,3,4
Coleoptera : Coccinellidae	<i>Chilocorus nigrita</i> (F.)	Leafhopper, whitefly and thrips	1,3
Coleoptera : Coccinellidae	<i>Scymnus</i> sp.	<i>H. armigera</i> , leafhopper and whitefly	1,2,3,4
Coleoptera : Coccinellidae	<i>Hyperaspis maindroni</i> Sicard	Mealybugs, leafhopper and whitefly	1
Coleoptera : Coccinellidae	<i>Coccinella septempunctata</i> L.	Leafhopper, whitefly, mealybugs, <i>H. armigera</i> , <i>T. ni</i> , and <i>S. litura</i> larvae	1,2,3,4
Coleoptera : Coccinellidae	<i>Coccinella transversalis</i> F.	Mealybugs, leafhopper, whitefly and lepidopteran pests	1
Coleoptera : Coccinellidae	<i>Illeis cincta</i> (F.)	powdery mildew	1
Diptera: Syrphidae	<i>Ischiodon scutellaris</i> (F.)	Mealybugs, aphids, thrips and leafhoppers	1
Diptera: Dolichopodidae	<i>Dolichopus</i> sp.	Whitefly, thrips, <i>H. armigera</i> and <i>S. litura</i>	1,3
Hemiptera: Pentatomidae	<i>Eocanthecona furcellata</i> (Wolff)	<i>H. armigera</i> , <i>S. obliqua</i> , <i>T. ni</i> , <i>T. orichalcea</i> , <i>S. litura</i> and <i>C. illecta</i> larvae	1,2,3
Hemiptera: Reduviidae	<i>Rhynocoris kumarii</i> Ambrose and Livingstone	<i>H. armigera</i> , <i>S. obliqua</i> , <i>T. ni</i> , <i>T. orichalcea</i> and <i>S. litura</i>	1,2,3
Hemiptera: Lygaeidae	<i>Geocoris tricolor</i> F.	Leafhopper, whitefly, thrips, <i>H. armigera</i> , <i>S. exigua</i> , <i>T. orichalcea</i> and <i>S. litura</i>	1,2,3,4
Hemiptera: Anthocoridae	<i>Anthocoris</i> sp.	Thrips, leafhoppers and whitefly	1
Hemiptera: Anthocoridae	<i>Carayonocoris</i> sp.	Thrips, leafhoppers and whitefly	1
Hemiptera: Anthocoridae	<i>Orius</i> spp.	Thrips, leafhoppers and small caterpillars	1
Hymenoptera: Vespidae	<i>Polistes</i> sp.	<i>H. armigera</i> , <i>T. ni</i> and <i>S. litura</i> larvae	1
Hymenoptera: Sphecidae	Digger wasp, <i>Crabro</i> sp.	<i>H. armigera</i> , <i>T. orichalcea</i> and <i>S. litura</i> larvae.	1
Hymenoptera: Sphecidae	<i>Stizus vespiformis</i> (F.)	<i>H. armigera</i> , <i>T. orichalcea</i> , <i>S. litura</i> and <i>S. exigua</i> larvae	1
Mantodea: Mantidae	<i>Eumantissa</i> sp.	Leafhopper, whitefly, thrips, <i>H. armigera</i> , <i>C. illecta</i> , <i>T. orichalcea</i> , and <i>S. litura</i>	1
Odonata: Coenagrionidae	<i>Ceriagrion coromandelianum</i> (F)	Leafhopper, whitefly, thrips, <i>H. armigera</i> , <i>S. exigua</i> and <i>S. litura</i>	1
Odonata: Coenagrionidae	<i>Ischnura</i> sp.	Leafhopper, whitefly, thrips, <i>H. armigera</i> , <i>T. orichalcea</i> , and <i>S. litura</i>	1,2,3
Neuroptera: Chrysopidae	<i>Chrysoperla</i> sp.	<i>H. armigera</i> , <i>T. orichalcea</i> , <i>S. litura</i> and <i>S. exigua</i> eggs and larvae	1,2,3,4
Orthoptera: Gryllidae	<i>Ecanthus indicus</i>	Thrips, leafhoppers, whitefly	1

1. Andhra Pradesh, 2. Karnataka, 3. Maharashtra, 4. Tamil Nadu

**Table 3. Biodiversity of non-insect predators of major insect pests in sunflower ecosystem**

Organism Group	Name of the Biocontrol agent	Parasitoid on the insect pest	Sunflower growing states
<b>ARACHNIDA</b>			
Araneae: Araneidae	<i>Argiope pulchella</i> Thorell	Leaf hopper, whitefly, mealy bugs, <i>H. armigera</i> and <i>S. litura</i> larvae	1,2,3,4
Araneae: Clubionidae	<i>Clubiona drassodes</i> Cambridge	<i>H. armigera</i> , <i>T. ni</i> and <i>S. litura</i>	1,2,3
Araneae: Tetragnathidae	<i>Leucauge decorata</i> (Blackwall)	Leafhopper and whitefly	1,2,3
Araneae: Oxyopidae	<i>Oxyopes</i> sp.	Mealybugs, leafhopper, whitefly, thrips and <i>T. ni</i>	1,2,3,4
Araneae: Oxyopidae	<i>Peucetia viridana</i> (Stoliczka)	Leafhoppers and <i>H. armigera</i>	1,2,3,4
Araneae: Salticidae	<i>Rhene</i> sp.	<i>H. armigera</i> , leafhopper and whitefly	1,2,3
Araneae: Salticidae	<i>Salticus</i> sp.	<i>H. armigera</i> , leafhopper, whitefly and <i>S. litura</i>	1,2,3,4
Araneae: Theridiidae	<i>Theridion</i> sp.	<i>H. armigera</i> , <i>T. orichalcea</i> , leafhopper and whitefly	1,2,3
Araneae: Thomisidae	<i>Thomisus</i> sp.	<i>H. armigera</i> , <i>T. ni</i> , <i>S. litura</i> , leafhopper and whitefly	1,2
<b>AVES</b>			
<b>Insectivorous birds before sowing sunflower crop</b>			
Ciconiiformes: Ardeidae	Cattle egret, <i>Bubulcus ibis</i> (L.)	Actively preying on resting stages of insect pests and soil insects during summer ploughing and field operations	1
Passeriformes: Corvidae	House crow, <i>Corvus splendens</i> Vieillot		
Passeriformes: Dicruridae	Black drongo, <i>Dicrurus adsimilis</i> Bechstein		
Passeriformes: Sturnidae	Indian myna, <i>Acridotheres tristis</i> (L.)		
<b>Insectivorous birds after sowing sunflower crop</b>			
Passeriformes: Dicruridae	<i>D. adsimilis</i>	Predating on grown up larvae of lepidopterans like <i>H. armigera</i> , <i>T. orichalcea</i> , <i>T. ni</i> , <i>S. exigua</i>	1
Passeriformes: Sturnidae	<i>Acridotheres tristis</i>		
Cuculiformes : Centropopidae	Crow pheasant, <i>Centropus sinensis</i> L		
Passeriformes: Passeridae	Sparrow, <i>Passer domesticus</i> Linnaeus		
Passeriformes: Timaliidae	Large grey babbler, <i>Trudoides malcolmi</i> Sykes		
Coraciformes: Meropidae	Green bee eater, <i>Merops orientalis</i> Latham		

1. Andhra Pradesh, 2. Karnataka, 3. Maharashtra, 4. Tamil Nadu

*T. chilonis* is capable of parasitising eggs of *H. armigera* and in turn reducing larval population below economic threshold level (ETL 1/plant) in the sunflower ecosystem (Basappa *et al.*, 2005). Single pesticide spray did not affect the performance of *T. chilonis* on *H. armigera* indicating its importance as a natural regulatory factor in the sunflower ecosystem in Karnataka (Singh and Ballal, 1999). In Maharashtra, 38.95% of the larvae of *S. obliqua* were parasitised by *Charops* sp. (Shetgar *et al.*, 1990) while *Exorista xanthaspis* parasitized 24.54% of *H. armigera* larvae in Gujarat (Patel and Talati, 1987). *Peribaea* sp. is also recorded as a parasite of *S. litura* larvae attacking sunflower (AICRP, 1990). *Cotesia* sp. and *Euplectrus* sp. are also reported to parasitise *S. litura* in Maharashtra (AICRP, 1993). *Cotesia* sp. (*Apanteles* sp.) was recorded on defoliators damaging sunflower in Maharashtra (Akola) during *kharif* 2007 (AICRP, 2007).

### Microbial agents

In sunflower, *H. armigera*, *S. litura* and *T. orichalcea* larvae were infected with nuclear polyhedrosis viruses (NPV) which were isolated from dead larvae collected from Andhra Pradesh, Karnataka and Maharashtra. Entomopathogenic fungi, *Nomuraea rileyi* (Farlow) Samson and *Beauveria bassiana* (Balsamo) Vuillemin were found infecting *H. armigera*, *S. litura*, and *T. orichalcea* larvae immediately after heavy rains during August and September at Hyderabad. Similar observations were recorded by Basappa *et al.* (2005). HaNPV was found to be effective against *H. armigera* in the sunflower ecosystem (AICRP, 2011).

### Predators

A majority of the insect predators belonged to Coleoptera, Hemiptera, Mantodea, Orthoptera, Neuroptera, Hymenoptera and Diptera. Among the predators, coccinellids, (*Cheilomenes sexmaculata* (F.), *Brumoides suturalis* (Fab.), *Chilocorus nigrita* (F.), *Coccinella septempunctata* L., *Scymnus* sp. and *Hyperaspis maindroni* Sicard) and spiders keep a good check on eggs and early stage larvae of lepidopteran pests during *kharif* season and sucking pests in *rabi* season. Similar observations were made by Sandhu *et al.* (1973), Goel and Kumar (1990) and Basappa *et al.* (2005) as these bio agents play a vital role in the suppression of not only leafhopper populations but also other sucking and lepidopteran insect pests. In addition, *Chrysoperla* (*carnea*-group), *Eocanthecona furcellata* (Wolff), *Rhynocoris kumarii* Ambrose and Livingstone, *Geocoris tricolor* F., *Orius* sp., *Anthocoris* sp., *Eumantissa* sp., *Ceriagrion coromandelianum* (F.), *Ischnura* sp. and *Dolichopus* sp. play a vital role in the suppression of major insect pests. General predators belonging to Hymenoptera like

*Polistes* sp., sphecid digger wasps (*Crabro* sp. and *Stizus vespiformis* (Fabricius)) were also found predated on *H. armigera*, *T. orichalcea* and *S. litura* larvae. The activity of the gryllid, *Ecanthus indicus* was more during *rabi* season and it was found predated on sucking pests like leafhoppers, thrips and whiteflies (Table 2). Apart from these predators, several general predators like ground beetles and predatory ant species such as *Comptonotus compressus* (F.) and *C. sericius* (F.) were regular predators of major insect pests of sunflower. Fungivorous and predatory coccinellid, *Illeis cincta*, predatory pentatomid bugs, and syrphids were also recorded in the sunflower ecosystem in Karnataka, Maharashtra and Tamil Nadu (AICRP, 2007 and 2009). General predators like *Chrysoperla*, spiders, coccinellids and reduviid bugs were the predominant predators of major insect pests in Karnataka and Maharashtra (AICRP, 2011). The coccinellid predator, *C. sexmaculata*, predatory bugs, *Cyrtorhinus* spp. and *Geocoris* spp., *Chrysoperla* sp. and spiders were found feeding on leafhopper nymphs. The maximum population of *C. sexmaculata* was recorded during September and January whereas the populations of *I. cincta*, *Cyrtorhinus* spp. and *Geocoris* spp. were maximum during January. *Chrysoperla* sp. (*Carnea*-group) and spiders were maximum during September and January, respectively. Though the activity of major predators like coccinellids and spiders was noticed in all the cropping seasons, maximum population was found during September and January coinciding with the maximum population of major insect pests (Basappa, 2007).

Among non-insect predators of major insect pests of sunflower, spiders and insectivorous birds were important biocontrol agents (Table 3). Important spider species like *Argiope pulchella*, *Clubiona drassodes*, *Leucauge decorate*, *Oxyopes* sp., *Peucetia viridana*, *Rhene* sp., *Salticus* sp. *Theridion* sp. and *Thomisus* sp. were predated on different growth stages like eggs / larvae of major insect pests of sunflower. *Cheiracanthium* sp. and *Oxyopes* sp. have been recorded from Maharashtra feeding on leafhoppers (AICRP, 1991). Though spider population was observed throughout cropping season, maximum activity was noticed during September and January coinciding with the maximum population of major insect pests like *H. armigera*, *T. orichalcea*, *T. ni* and *S. litura* during *kharif* season and sucking pests during *rabi* season. Similar observations were made by Basappa (2007).

Among the predatory birds, cattle egret (*Bubulcus ibis* (L.)), House crow (*Corvus splendens* Vieillot), black drongo (*Dicrurus adsimilis* Bechstein) and Indian myna (*Acridotheres tristis* (L.)) were actively preying on resting stages of insect pests and soil insects during summer ploughing and field operations. Indian myna, black drongo, green bee eater (*Merops orientalis* Latham),

crow pheasant (*Centropus sinensis* L.) and large grey babbler (*Trudoides malcolmi* Sykes) were found predated on grown up larvae of lepidopteran insect pests (Table 3). Predatory birds including *D. adsimilis*, sparrow (*Passer domesticus*) and wrenwarbler (*Prinia subflava* Gmelin.) have been recorded as feeding on *T. ni* larvae (AICRP, 1991).

A wide array of natural enemies and pollinators are associated with sunflower ecosystem and hence conservation of these biocontrol agents and pollinators is essential. Sunflower is an excellent crop to attract beneficial insects. Sunflower crop can be grown throughout the year due to its wide adaptability, day neutral nature and responsiveness to better management practices. As the crop can be grown in different seasons in different regions, it is possible to grow this crop by adopting biointensive management tactics which protect the crop as well as the environment from pesticide toxic stress. Though several parasitoids, predators and microorganisms have been commercialized and several formulations are commercially available, their production and availability are limited. There is a lack of a systematic approach in the utilization of biocontrol agents in the biologically based pest management approach in sunflower, hence, in-depth knowledge of the biodiversity of biocontrol agents in sunflower ecosystem in different sunflower growing states is essential. Sustainable crop protection would involve an array of interactions among the herbivores, natural enemies and vegetation. An agroecosystem which is free from chemical pesticides harbours rich arthropod and vertebrate community, including different kinds of natural enemies and their abundance is sometimes greater than the pests. To achieve sustainability in sunflower production through integrated farming practices, we need to maintain and conserve biodiversity of biocontrol agents in the sunflower ecosystem by following eco-friendly biointensive integrated pest management (BIPM) approaches to keep major insect pest populations below economic threshold levels (ETL) for sustainable production of sunflower.

## References

- AICRP, 1990. *AICRP-Sunflower, Annual progress report of sunflower*. Directorate of Oilseeds Research, Hyderabad, 171 pp.
- AICRP, 1991. *AICRP-Sunflower, Annual progress report of Sunflower*. Directorate of Oilseeds Research, Hyderabad, 233 pp.
- AICRP, 1993. *AICRP-Sunflower, Annual Report, 2006-07*. Directorate of Oilseeds Research, Hyderabad, 222 pp.
- AICRP, 2007. *AICRP-Sunflower, Annual Report, 2006-07*. Directorate of Oilseeds Research, Hyderabad, 230 pp.
- AICRP, 2009. *AICRP-Sunflower, Annual Report, 2008-09*. Directorate of Oilseeds Research, Hyderabad, 233 pp.
- AICRP, 2011. *AICRP-Sunflower, Annual Report, 2010-11*. Directorate of Oilseeds Research, Hyderabad, 251 pp.
- Basappa, H. 2004. Integrated pest management in sunflower: An Indian scenario. Proceedings, 16<sup>th</sup> International Sunflower Conference, Fargo North Dakota, USA Aug. 29-Sept. 2, 2004, 2: 853-859.
- Basappa, H. 2007. Population of predators associated with leafhopper in sunflower. *Journal of Biological Control*, 21: (Special issue): 85–87.
- Basappa, H. 2008. Biodiversity of arthropods and vertebrates in sunflower ecosystem, Leslie Coleman memorial National Symposium on plant protection, UAS, Bangalore, Dec., 4–6, 2008.
- Basappa, H. and Santha Lakshmi Prasad, M. 2005. *Insect pests and diseases of sunflower and their management*. Directorate of Oilseeds Research, Hyderabad 500 030, India, 83 pp.
- Basappa, H., Vimala Devi, P. S., Prasad, R. D., Harvir Singh, Basu, M. S., Duhoon, S. S., Srivastava, R. L. Vijay Singh, Raoof, M. A., Lakshminarayana, M., Santha Lakshmi Prasad, M., Sharma, A. N. and Malik, Y. P. 2005. In: D. M. Hedge (ed.), *Biocontrol in Oilseed Crops*, Directorate of Oilseeds Research, Hyderabad, 24 pp.
- DOR, 2010, Sunflower: Package of Practices for increasing production. 5th revised edition. (Compiled by Babu S.N.S, Harvir Singh, Ranganatha, A.R.G, Basappa, H, Chander Rao, S and Edited by Hegde D.M), Directorate of Oilseeds Research, Hyderabad, 24 pp.
- Goel, S. C. and Kumar, A. 1990. Insect pests and predators associated to sunflower in winters of northern India. *Indian Journal of Entomology*, 52: 39–45.
- Patel, A. J. and Talati, G. M. 1987. Biology of *Heliothis armigera* Hubner as a pest of sunflower (*Helianthus annuus* Linn.). *Gujrat Agriculture University Research Journal*, 12: 54.
- Sandhu, G. S., Brar, K. S. and Bhalla, J. S. 1973. Pests of sunflower and other insects associated with sunflower crop. *Oilseeds Journal*, 3: 19–26.
- Shetgar, S. S., Bilapate, G. G., Patel, V. V. and Londhe, G. M. 1990. A note on the natural enemies of bihar hairy caterpillar, *Spilosoma obliqua* Walker. *Indian Journal of Entomology*, 52: 158.
- Singh, S. P. and Ballal, C. R. 1999. Role of Biocontrol in IPM, pp. 57–65. In: *Integrated Pest Management in Sunflower* Directorate of Oilseeds Research, Hyderabad, India. 93 pp.