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Integrated Pest Management Strategies against safflower aphid, *Uroleucon compositae* (Theobald)

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Abstract
In the last 25 years, there has been a significant reduction in safflower area in India and else where. The growth rate is negative in India. In Karnataka state, the second largest producer of safflower, the area under safflower has reduced drastically from 2.5 lakh ha. in 1980's to 1.5 lakh ha in 2006. Among the different factors responsible for reduction in area of safflower, safflower pests are one among them. Safflower is vulnerable to biotic and abiotic stresses. The biotic stresses involve insect- pest and diseases. Out of a dozen insect-pests, the safflower aphid, *Uroleucon compositae* (Theobald) is a major pest which causes 30 to 80 per cent yield loss based upon the weather conditions. Therefore, integrated pest management approaches are very much essential for sustainable and profitable safflower production. The use of resistant varieties (A-1, Phule Kusume, NARI-H-15 and Bhima) is one of the important components in IPM in safflower. The other components include agronomic practices (summer ploughing, time of sowing, application of balanced fertilizer, intercultural operations, inter cropping, mixed cropping and clean cultivation), application of bioagents, bio-pesticides and chemical insecticides which have been discussed in detail in this paper.

Key words *Uroleucon compositae* - resistant varieties - Integrated Pest Management - inter cropping - mixed cropping - bio-pesticides - bio-agents.

Introduction

Safflower (*Carthamus tinctorius* L.) is an ancient crop that was used earlier for its value added products rather than oil. It was always a crop of small peasant, sown during adverse seasons to augment his personal needs of oil. The area under safflower crop across the world is 1.3 m ha. with India accounting for nearly 50 per cent of it and the rest, distributed in parts of Mexico, Australia, Mediterranean Europe, California valley, Canada, China and Africa. Among the several factors responsible for reduction in area of safflower, Safflower pests are one among them. Safflower is vulnerable to biotic and abiotic stresses. The biotic stresses involve insect pest and diseases. Although safflower is affected by a number of insect pests only few of them are of economically important in one or other part of the world. Out of a dozen insect pests, the safflower aphid, *Uroleucon compositae* (Theobold) is a major pest, which causes 30 to 80 per cent yield loss based upon the weather conditions. Since, safflower aphid cause economic damage to the crop, majority of growers seldom use control measures.

Severe crop losses have been reported at several places due to different insect species, which implies the need for planned strategic interventions to control the pests. The extent of yield decrease in relation to cost of protection is the major factor that affects the use of various management practices. Taking such factors into account control measures are quite essential for safflower aphid. Nevertheless, the pest management tactics like cultural practices, resistant varieties, use of bio-agent, botanical pesticides, chemical insecticides etc., have been found effective and profitable.

Among the insect pests that attack safflower, the aphid *U. Compositae* is considered as a major pest causing severe losses to the crop throughout the world. The various aspects of safflower aphid have been presented below.

Table1: Distribution and incidence status of aphid on safflower

Common Name	Scientific Name	Distribution	Incidence Status
Aphids	*Dactynotus carthami* (H.R.L.)	India	Severe
	Uroleucon compositae (Theobold)	India	Severe
	Dactynotus orientalis sp.	India	Moderate
	Dactyonotus jaceae (Linn.)	India	Moderate
	Macrosiphum sonchi (H.R.L.)	Middle East, Asia Minor, Asia	Moderate
	Macrosiphum sonchi (Linn.)	Middle East, Asia Minor,USSR	Moderate
	Macrosiphum compositae (Theobold)	India	Severe
	Macrosiphum spp.(jaceae)	Thiland, India	Severe
	Myzus persicae (Sulz)	U.S.A.,Middle East,U.S.S.R. and Africa	Severe
	Aphis fafia (Scop)	California	Severe
	Capitophorus eleagni (Del.Guer)	Queensland, Australia	Severe

(Mallapur *etal,*. 2002)

Mark of Identification and Nature of damage

The adult is black and shining. The body is spindle shaped to elongate pyriform measuring 1.5 to 2.0 mm in length. The antennae are shorter than the body length and six segmented. The legs are rather stout, long and covered with hairs, couda is prominent and elongated. Both alate and non-alate forms are found. The nymphs are reddish brown in colour.

Both nymphs and adults prefer to feed on tender parts like shoot apices, veins of young leaves. With the help of syringe like proboscis both nymphs and adults suck the cell sap due to which the plant growth is stunted. In case of sever attack of the aphid, the plants start showing drying symptoms from lower leaves and progress towards top of the plant resulting in premature death of plants. In addition, they also excrete honeydew, which falls on the upper surface of the leaves on which sooty mold develops hindering the photosynthetic activity.

Seasonal Incidence

Climatic conditions play a major role for the appearance of safflower aphid. It is highly adaptive to cool and cloudy conditions. According to Dubey and Thorat (1994) cool nights for 1-2 weeks in November are favorable for aphid attack on safflower. In Karnataka state of India, the aphid first appears during November first week and reaches a peak between end of December to end of January and disappeared by the end of March (Anon., 2006). Mallapur *et al*, 2005, reported that there was significantly positive correlation with relative humidity, minimum temperature and cloudy weather. Whereas the aphid population was negatively correlated with maximum temperature, heavy rainfall and as the crop age advances. The population buildup in Solapur region of Maharashtra started at the end of October and reached a peak by January first week when maximum and minimum temperature and morning and evening relative humidity were 31.1º C,12.9ºC and 67 and 39 per cent respectively (Akashe *et al.,* 1995). The authors also found that there existed a negative correlation between these weather parameters (including rainfall) and the pest population. However, at Delhi the aphid made its appearance in February and peaked during mid March (Goutam *et al.,* 1995).

Alternative host plants

Many alternative host plants have been recorded for the aphid at different places. In Karnataka state of India only few species of weeds and crop plants have been recorded as alternative hosts of safflower aphid. Mallapur (2000) and Anon (2006), recorded sunflower, niger, *Euphorbia geniculata*, *Calendula*, *Glyricidia maculate*, Ashwaghanda, *Lactus* sp. and *Parthenium hysterophorus* hosts of safflower aphid in Karnataka.

Biology and extent of damage

The safflower aphid passes through four nymphal instars occupying 3.22, 2.39 2.72 and 2.83 days, respectively. The total life cycle occupied 11-16 days. Up to 13 nymphs were laid on a

single day and a single female laid 6 to 56 nymphs. Adult survived upto 17 days and both apterous and alate forms were present throughout its period of activity, reported by Bindra and Rathor (1967) from India. Similarly, the studies conducted by Bhumannavar and Thontadarya (1983) in Karnataka revealed that only viviparous reproduction was observed. The nymphal stage consisting of four instars lasted for 9.34 days. Adult life span, pre reproductive and reproduction period occupied 14.9, 1.28 and 14.6 days, respectively. Each female produced on an average 89 off springs. One of the bottlenecks in successful growing of safflower in India is the infestation of aphid, which is causing severe losses in yield. The yield losses reported by various workers include 20-25 to 68 per cent, Basavanagoud (1979a), Bhumannavar and Thontadarya (1979a). The aphids not only reduce yields, of seed and oil content, but also attack petals lowering the quality of the value added product of this part of the plant (Kalpana Sastry, 1997).

Critical crop growth stage and Economic threshold level

Severe damage of aphid in safflower is observed at preflowering or flower stage. Based on the yield loses of the pest, it was suggested to take up plant protection measures soon after appearance of the aphid, which could be delayed at the most for one week (Anon., 1985). The economic threshold level (ETL) for *U. compositae* was determined at 48.78 aphids/5 cm apical twig/plant on Bhima variety of safflower, with exposure periods of about 2-3 weeks from first aphid incidence (Akashe *et al.,* 1997). However, on Annigeri-1 variety of safflower, the ETL was estimated at 38.5 aphids/5 cm apical twig/plant with exposure periods of 2 to 3 weeks from first aphid appearance Kamat *et al.,* 1999)

Integrated Pest Management Strategies

Host Plant Resistance

Safflower is a crop of small and marginal farmers which is mainly grown under rainfed conditions the safflower may not receive any plant protection measures. The economic status of majority of the farmers is such that they are not in a position to afford monetary inputs for protecting the crop even against the noxious pest like safflower aphid. The only possible way is to develop lines with durable and stable resistance to aphid. Scientist working on search for aphid resistant /tolerant lines from germplasm collection and from early and advanced generation breeding material is in progress at various AICRPO (Safflower) centres throught India. Although several entries have already been identified as stable, aphid tolerant sources, unfortunately, resistant source has not been identified even in wild varieties.

Many studies on plant resistance in safflower to *U. compositae* have been made by Dhoble (1984), Akashe *et al*., (1994), Mallapur *et al*., (1997a), Balikai (1999a and 1999b), Hanumantharaya *et al*., (2007c) and Anon. (2007). According to these studies, none of the varieties was found immune or absolutely resistant but show varied degree of tolerance. The varieties with hardy stem, spiny nature, light green colour leaves with waxy coating on the stem, and early maturity types were most tolerant while, soft stem, non spiny, dark green colored leaves and delayed maturity were susceptible / highly susceptible to safflower aphid. The list of safflower entries or varieties or hybrids which are tolerant to aphid are listed in table-2.

Table2: List of tolerant to moderately tolerant safflower genotypes against safflower aphid over the years

Year	Tolerant to moderately tolerant safflower entries
2002-03	98-67, 98-74, JSI-106, A-1, Bhima
2003-04	A-1, 98-74, JSI-6, Bhima, 98-67, 98-64 and Phule Kusum
2004-05	PBNS-33, 98-64-2, 8-17-2, 98-29, A-1, SSF-646 and 98-66-12
2005-06	11-17-2, GMU-579, 6-9-3, A-1, Bhima and PBNS-58, MRSA-521, DSH-129, GMU-2518
2006-07	GMU-579,11-17-2, 6-9-3, PBNS-59, SSF-659, SSF-679, Bhima, A-1, NARI-H-15

Source: Annual Progress Report of Safflower (2002-03 to 2006-07) All India Co-coordinated Research project on Oilseeds, Directorate of Oil seeds Research, Rajendranagar, Hyderabad.

Even though many entries have been identified as tolerant to aphid, their utilization in breeding programme is very much limited. But, efforts are now being going at various AICRPO (Safflower) centers throughout India to incorporate the resistant trait in the high yielding safflower varieties.

Time of Sowing

The loss caused by safflower aphid can be reduced by manipulating the sowing time. Several workers from different parts of the country reported that early sowing escapes the peak pest incidence (Rathore and Pathak, 1982; Ghule *et al.,* 1987 and Anon., 2006). In Karnataka, October and November sown crop harbored maximum aphid infestation while, the September sown crop experienced less damage (Bhumannavar and Thontadarya, 1979a). Whereas, mid September was better for sowing safflower to minimize the aphid damage in Maharashtra (Mhase *et al.,* 1986 and Ghule *et al.,* 1987). Singh *et.al.,* (1996) reported that the aphid population is positive correlated with date of sowing and age of the crop. Early sowing up to the first week of October and spraying with melthy parathian @ 0.05 % during bud formation and 50 % flowering are recommended for the control of *U. compositae* and *Helicoverpa armigera* (Hub.) (Ghorpade *et al.,* 1994). The highest mean intensity of aphid on safflower was in the December sowing and lowest in the October sowing (Shantanu Jha, 1998).

Fertilizer Application

Application of balanced fertilizer is also one of the components in the Integrated pest management. Higher the nitrogenous fertilizer more will be the aphid infestation and *vice-versa*. According to UAS, Dharwad package of practice (2006), the recommended dosage of fertilizer for safflower crop is 40:40:20 kgs of NPK /ha.

Intercultural Operations

Intercultural operations like, harrowing, hoeing can reduces the weeds, which are consider as a alternative host plants for safflower aphid example, *Parthenium hysterophorus*. On the other hand clean cultivations better for safflower protection against aphid.

Intercropping and mixed cropping

Cropping pattern and cropping systems also influence the aphid incidence in safflower. Safflower intercropped with sorghum, coriander and wheat reduces the pest population (Hanumantharaya *et al*., 2007a). Whereas, safflower intercropped with Niger harbors the aphid population on safflower. Safflower mixed cropping with coriander also reduces the aphid population on safflower and increases the predatory population (Hanumantharaya *et al*., 2008).

Natural Enemies

Many natural enemies (Parasitoids and predators) have been recorded on *U. compositae*. In Karnataka state of India, the dipteran, *Pseudendaphis* sp. is known to cause up to 10 percent parasitization of the aphid during first week of January (Anon, 2005). The lady bird beetles (coccinellids) and the chrysopids are the major predators of safflower aphid in Karnataka. Mallapur *et al*., (1997) and Balikai (2000) reported *Chrysoperla* sp., coccinellids and syrphids prying on aphids. Investigations made by Badgujar *et al.* (2000) in Nagpur, India have reported that the larval releases of *Chrysoperla carnea* (Stephens) @ 2 or 3 larvae/plant reduced the population level of 40 to 50 per cent. Egg releases of *C.carnea* larvae did not help in satisfactory reduction in aphid population. Hemagirish *et al.,*(2001) and Kamath *et al.,*(2001) reported *C. carnea* @ 1.75 lakhs/ha reduced the aphid population to the maximum (23%) and also recorded yield of 3.52 q/ha increase over control. But, the benefit cost ratio was quite discouraging in *C. carnea* released treatment. *Chrysoperla carnea* is a potential predatory biological control agent that can be used in augmentation programmes for sustainable crop pest suppression (Goutam and Testaye, 2002).

Biopesticides

Earlier, the safflower aphid was controlled by botanical insecticides like nicotine Sulphate (0.05%) spray (Singh and Sidhu, 1959 and Narayanan, 1961). Later, on owing to several advantages with chemical insecticides, the botanicals were replaced by insecticides until

1980's. However, due to indiscriminate use of insecticides, the problems like resistance, resurgence, minor pests become major ones, adverse effects on non target organisms, residues and environmental pollution etc., were created. Considering these problems, once again the ecofriendly plant products came into existence and several botanicals have been found promising in managing this notorious pest on safflower.

Many of the plant products have been found effective against *U. compositae* under laboratory and field conditions (Patil *et al.,* 1997 and Ravikumar *et al.,* 1999). The list of effective plant products recorded against safflower aphid is given in Table 3.

Table 3: Promising botanicals against safflower aphid under field condition:

Sl. No.	Botanicals	Efficacy	Authors
1.	Neem oil emulsion (0.25 %)	85.4 –95.4 % mortality	Mani *et al*. (1990)
2.	*V. rosea* (2%)	Effective as Dimethoate spray	Patil *et al.,* (1997)
3.	NSKE (7 & 5 %) and custard seed extract (7%)	Effective	Akashe & Showale (1997)
4.	*V. rosea* leaf (2%), Neem oil, *V. nigundo*, *Derris indica* leaf extracts (5%)	Effective	Ravikumar *et al.,* (1999)
5.	NSKE (5%) Neem cake extracts (5 %), *L. camara* (5%) *Derris indica* 5 %	Effective	Mallapur *et al.,* (2001a)

A number of plant products have been evaluated by many scientists for the management of safflower aphid and almost all the botanicals were quite effective against the aphid (Table 3).

Azadiractin was found to be highly toxic to *U. compositae* (Devkumar *et al*., 1986). Extracts of *Azadirachta indica*, *Pongamia glabra*, *Ipomoea carnea* and *Nictiona tabacum* were compared with endosulfan and phosphamidon. Among the botanicals leaf extract (2%) *N. tabacum* and *I. carnea* were equally effective as the insecticides (Kulat *et al.,* 1998; Kulat *et al*., 2000). NSKE 5 % and NSK powder 3 % were found to be most economic treatments with higher IBC/ BC ratio next to dimethoate for management of safflower aphids. Oil content did not vary with imposition of different treatments for aphid management.

Experiments conducted at different locations (Annigeri, Solapur, Indore and Hyderabad) in India the result shows that, NSKE-5% and NSK powder 3% were found to be most effective and economic treatments with higher IBC/BC ratio next to Dimethoate for the management of safflower aphid reported by Anon., (2004), Hanumantharaya *et al*., (2005) and Vijay Singh (2005).

Table 4: Management of safflower aphid with botanical insecticides at different locations in India

Tr. No.	Treatments	Avg. aphids/ 5 cm apical twig (AS) at			Predators/pl.(C.c & C)			Yield.			IBC/BC ratio		
		Ann igeri	Hyd erabad	Sol apur	Ann igeri	Hyd erabad	Sol apur	Ann igeri (q/ha)	Hyd erabad (kgs/ha)	Sol apur (kgs /ha)	Ann igeri	Hyd erabad	Sol apur
T1	NSKE 5 %	31.00 (5.56)	47.0	29.0	2.16	6.0	_	15.01	535	484	3.10	7.6	1.56
T2	NSK Pow der (3 %)	30.20 (5.49)	64.0	27.0	2.20	5.0	_	14.90	515	489	3.11	7.3	1.14
T3	Neem oil 1 %	44.66 (6.68)	110.0	29.0	2.00	4.0	_	13.23	368	515	2.64	2.8	1.56
T4	Neem cake 5 %(soaked over night)	30.13 (5.48)	78.0	36.0	2.16	3.0	_	15.23	480	410	3.16	5.2	1.32
T5	Neemark 5 ml /l	32.06 (5.66)	87.0	31.0	2.06	3.0	_	14.22	383	471	2.46	2.6	1.35
T6	Dimethoate 0.03%	6.56 (2.56)	0.0	10.0	0.60	1.0	_	15.93	632	615	3.39	8.5	2.13
T7	Dimethoate 0.05%	5.73 (2.39)	0.0	9.0	0.50	1.0	_	16.02	685	681	3.32	9.1	2.35
T8	Water Spray	81.60 (9.03)	170.0	38.0	3.53	5.0	_	12.22	197	250	2.68	_	0.91
T9	Absolute control	87.00 (9.32)	179.0	43.0	3.66	5.0	_	11.93	151	280	2.75	_	0.81
SEm+/-		0.06	2.0	1.1	0.04		_	0.03	5.0	37.0	-	_	_
C D (P=0.05)		0.18	7.0	3.9	0.13		_	0.10	14.0	110.0	-	_	_

C.c= *Chrysoperla carnea* and coccinellids
AS=After Spray, Figures in the parentheses are square root transformed values

Chemical control

Since, chemical insecticides are one of the inevitable component in the integrated pest management, need based application is must for the management of the safflower aphid. Several workers have been worked out the relative toxicity of insecticides against the aphid in India and elsewhere.

Among several insecticides tested on safflower aphid endosulfan at 1.12 kg/ha and meviphos @ 0.25 kg/ha (Carlson, 1972) were significantly superior to other insecticides tested. Among the dust formulations, the overall efficacy in increasing the net profit per hectare was in the order of quinalphos > phosalone> carbaryl > BHC (Puri and Garshin, 1978). Bhumannavar and Thontadarya (1979b) have reported that phosphamidon (0.25 kg a.i/ha) or dicrotophos (0.5 kg a.i/ha) applied twice at 20 days interval starting from 60 days after sowing gave effective control of aphid and, increased the seed yield considerably. Basavanagoud *et al.,* (1980) reported that pirimicarb 50 DP as spray and quinalphos (1.5%) as dust were highly effective in controlling the aphid by recording maximum seed yield in Karnataka. Further, the authors also mentioned that the residues of malathion (5% dust), endosulfan (4% dust), quinalphos (1.5% dust), phosalone (4 % dust) phosphamidon (100 % SC), vamidothion (40% EC), ethiofencarb (50% EC) and pirimicarb (50 DP) were below the tolerance limits in safflower seed (Basavanagoud *et al*., 1981). Several authors proved the effectiveness of quinalphos, endosulfan, dimethoate, phosphomidon etc., against the pest (Chaudhary *et al*., 1983, Vora *et al*., 1984 and Jagdale *et al*., 1985). Ramanagoud *et al*., (1982) indicated that the dust formulations didn't retain their effectiveness for a longtime and hence, they were ineffective. However, sprays of carbaryl,

fenitrothion, endosulfan and phosalone (at 0.05%) were highly effective in reducing the aphid menace. Dusting with quinalphos (1.5%), malathion (4%), carbaryl (5%) or endosulfan (4%) @ 20 kg/ha twice at fifteen days interval kept the pest under control (Dhoble, 1985). Pawar *et al*., (1985) recorded carbaryl (0.15%) monocrotophos (0.07%), mecarbam (0.08%) and methomyl (0.07%) as effective insecticides against the aphid. When they used methomyl at 0.03 per cent concentration, no residues could be detected in safflower seed.

Sprays of dimethoate (0.05%) was recommended at 15 days interval starting from 15 days of first aphid appearance (Anon., 1987), whereas Ghule *et al*., (1987) found two sprays of phosphamidon (0.05%) given at 15 days interval gave better mortality of aphid. According to Singh *et al*., (1988) two sprays of endosulfan at 800 ml/ha. or dimethoate at 750 ml/ha fortnightly intervals gave the most effective control against safflower aphid. Chandrakar and Gupta (1989) reported that, methyl demeton at 100ml/ha followed by phosphamidon at 300ml/ha, monocrotophos at 750 ml/ha and dimethoate at 625 m/ha were highly effective against safflower aphid and these treatments also recorded significantly higher yield and cost benefit ratio then compared with no treatment. Spraying of methyl demeton and dimethoate was the most effective in reducing aphid populations and increasing grain yield over no treatment (Singh and Dwived, 1989; Upadhyay *et al*., 1990 and Shetgar *et al*., 1993). Narangalkar and Shivapuje (1990) reported that under laboratory pirimphos methyl proved to the most toxic and butocarboxim the least toxic against the 4th instar nymphs of safflower aphid, *U. sonchi*. The author also reported that, spraying of dimethoate (0.03 %) at 10 days intervals beginning 30 days after sowing to control the *U. sonchi* gave significant higher yield than no treatment.

Ghorpade *et al.,* (1994) reported that application of 0.05 % methyl parathion at 500ml/ha or 20kg/ha of dust formulation of 2 % methyl parathion, when applied 60 days after sowing were better than 15 other insecticide formulations tested for control of aphids on Bhima variety of safflower. Among the different insecticides evaluated against the safflower aphid, carboryl (0.1 %) and phosphamidon treated plots given good control of safflower aphid and recorded highest grain yield.

Considering the efficacy in controlling the aphid, conserving its predator and the seed yield, the insecticides like dimethoate (0.03%) methyl -o- demetan (0.03%) and combinations of neemcake (0.15%) with phosphamidon (0.02%), monocrotophos (0.02%) and endosulfan (0.25%) are most promising (Kadam and Bade 1993). Ghorpade *et al*., (1994) reported that single application at 60 days after sowing with methyl parathion (0.05%) spray or 2% dust) gave the best protection against the aphid resulting in higher benefit cost ratio. There was no significant difference between ultra low volume and high volume sprayers in controlling safflower aphid. Foliar application of dimethoate (0.05%) or malathion dust (5%) @ 20 kg/ha applied alternatively at 60 days after sowing gave best protection against aphid and registered the highest benefit cost ratio (Balikai 2001).

The seed dressing insecticides like carbofuran 50 SP benfarocarb 50 SP carbofuran 35 STD and 25 STD, bromophos methyl 25 SP and UC 54229 –100 S effectively suppressed aphid population up to six weeks after germination when used @ 60 g/kg seeds. Besides their high effectivness, there was no adverse effect on germination. Morever, there was significant increase in the plant height and number of leaves per plant (Naik *et al.,* 1987). Among several seed dressers evaluated, carbosulfan 25 DS @ 20 g/kg of seed proved to check the initial build up and, the later population was effectively managed by peripheral application (1.8 m all around the field) with NSKE (5%) or dimethoate (0.05%) (Mallapur and Patil 2001 and Mallapur *et al*., 2001).

Experiment conducted at different locations (Annigeri, Solapur and Indore) in India the result shows that, among the newer molecules of insecticides tested against safflower aphid, Thiamethoxam, acetampirid followed by imidacloprid were found more effective and economic as against dimethoate. These insecticides registered more than 97 % kill of aphids (Anon., 2006 and Hanumantharaya *et al*., 2007).

Table 5: Management of Safflower aphid with newer insecticides (Pooled data of 2004-05 & 2005-06)

Sl. No./ Treatments	Average aphid population/ 5 cm twig	*Helicoverpa armigera*/pl.	Natural Enemies/ pl.(C&C)	Yield (q/ha)	Oil Content	B: C ratio
T1-Imidacloprid (Confidor)17.8 % @0.0045%	3.51 (1.94)	0.5 (0.99)	1.00	13.23	25.57	2.70
T2-Acetamiprid (Pride) 20 SP @ 0.004%	3.56 (1.90)	0.50 (0.99)	1.30	13.45	25.50	2.63
T3-Thiamethoxam (Actara) 25 WG @0.005%	1.30 (1.22)	0.45 (0.97)	1.61	13.66	25.63	2.74
T4-Fipronil (Regent) 5 SL @ 0.01%	10.0 (3.16)	0.5 (0.99)	1.20	12.48	25.19	2.24
T5-Profenophos (Curacron) @ 0.05%	2.63 (1.66)	0.20 (0.81)	0.90	13.64	25.27	2.73
T6-Abamectin (Vertimec) 1.8 EC 0.0009%	15.2 (3.71)	0.55 (1.01)	1.75	12.97	25.45	1.60
T7-Dimethoate (Rogar) 30 EC 0.03%	7.10 (2.68)	0.55 (1.01)	0.90	13.16	25.54	2.90
T8-Absolute control	71.88 (8.46)	1.10 (1.20)	3.0	9.66	25.51	-
SEm ±	0.24	0.034	0.14	0.34	-	-
CD @5%	0.70	0.10	0.41	1.02	NS	-

Figures in the parentheses are √ x+0.5 values used for statistical analysis
C&C= *Chrysoperla* & Coccinellids.

(Hanumantharaya *et al.*2007b)

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