J. Biol. Control, 21(Special Issue): 65-71, 2007

Coccinellids and chrysopids as native predators of sucking pests in relation to rainfed cotton production system

S. VENNILA, V. K. BIRADAR and P. R. PANCHBHAI
Central Institute for Cotton Research, P. B. No. 2, Shankar Nagar P. O.
Nagpur - 440 010, Maharashtra, India
E-mail: s_vennila@rediffmail.com

ABSTRACT: Status and dynamics of sucking pests (jassids and aphids) and their native predators (coccinellids and chrysopids) were studied for five consecutive years (2001-05) in rainfed cotton production system. The effect of cultivars, cropping pattern, fertility levels and pest management options on the activity of predators was also inferred from the observations taken from different agronomic and plant protection field experiments. The range of jassid incidence, aphid infestation, activity of coccinellids and chrysopids was 2.4 to 7.5 nymphs per three leaves, 15.0 to 38.9 percent, 0.1 to 0.4 and 0.52 to 1.87 per plant, respectively. Dynamics of the predators indicated perpetuating population of chrysopid over coccinellids with their association positive (r=0.058) but non-significant. Higher incidences of jassids and aphids and their predators were observed on the hybrids than the varieties. Long-term soil fertility changes did not have any direct influence on the predators. Significantly higher chrysopids and coccinellids (1.83 and 0.99 per plant) observed on cotton sole crop reduced the aphid infestation (19.2 %) compared to the soybean-intercropped cotton (24.2 %). While the occurrence of coccinellids on cotton under protected and unprotected situations was discontinuous, chrysopids continued to occur between August and November months. Recolonisation of both predators was observed under insecticidal spray situations. The paper discusses the role of coccinellids and chrysopids in the context of sucking pest management and emphasizes the need for designing cotton ecosystems favourable for higher predation by these native predators.

KEY WORDS: Aphids, chrysopid, coccinellids, cotton, dynamics, jassids, native predators, sucking pests

INTRODUCTION

Sucking pests, also referred to as "sap feeders", limit the realization of potential productivity of cotton. Among sucking pests, jassids - *Amrasca devastans* Distant; aphids- *Aphis gossypii* Glover; thrips -*Thrips tabaci* Lindeman; whiteflies - *Bemisia tabaci* (Gennadius) and mirids -*Ragmus* spp., are of importance deserving their management by cotton farmers as they are deleterious to the cotton plant growth and development by being assimilate sappers, stand reducers and light stealers. Depending upon the local source of infestation, the spectrum of natural enemies and crop production practices such as variety, sowing date, fertilizer and pesticide regime, irrigation pattern, and the weather conditions, the dominant species of sucking pests is determined in a given season. Nevertheless, jassids and aphids deserve importance due to their regularity in occurrence during the early season.

A number of naturally occurring native predators such as aphidophagous coccinellids (*Coccinella septempunctata* L., *Cheilomenes sexmaculata* and *Scymnus* spp.) and syrphids, besides the generalist chrysopid, *Chrysoperla carnea* (Stephens), offer significant control of aphids and jassids. The degree of control by these predators has been more often quoted to be significant than determined because such an objective did not deserve more attention in research programs. In India, there have been faunistic and taxonomic surveys during the earlier part of the last century (Sankaran, 1976; Agarwala & Ghosh, 1988) and scattered biological and ecological studies including their laboratory mass production here and there and now and then, of these predatory groups. This paper reports on the status and dynamics of select species, *viz., Coccinella septempunctata, Cheilomenes sexmaculata* and *Scymnus* sp. and *C. carnea* of cotton production system predatory on jassids and aphids, and the interaction of some production and protection practices.

MATERIAL AND METHODS

Status and dynamics

The study on the dynamics of insect pests and natural enemies of cotton carried out for five consecutive years (2001-2005) at the Central Institute for Cotton Research (CICR), Nagpur as a part of the project aiming to evolve protection technologies *vis-à-vis* production practices based on the interactions of crop, pests and entomophages of rainfed cotton ecosystem was utilized to assess the status and the dynamics of aphidophagous coccinellids (*C. septempunctata, C. sexmaculata* and *Scymnus* sp.) and the generalist chrysopid, *C. carnea*. During each year, larger fields with a minimum area of 0.6 hectare grown with variety LRA-5166 were scouted for the sucking pests and the predators on weekly basis. Random sampling of 20 plants per 0.4 hectare was adopted for the observations on jassids and the predators. While observations on the number of nymphs from three leaves at each positions of top, middle and bottom of a plant constituted scouting procedure for jassids, the proportion of aphid infested plants (>50/ plant) based on the examination of 10 plants in a row at 10 randomly selected places per 0.4 hectare was the measurement procedure for aphids. The predatory grubs of coccinellids across species and eggs of *C. carnea* were counted on plant basis as a measure of predatory activity. The seasonal mean incidence of the pest and predatory stages sampled was used to infer the status of these predators over years. The dynamics of the two groups of predators was looked into for the individual years and their association was tested through correlation (Snedecor and Cochran, 1967) considering the common periods of occurrence of both predators over years.

Influence of cotton cultivars

Experiments conducted to assess the performance of seven hybrids (*viz.*, PKVHy-2, PKVHy-3, NHH-44, H-6, H-8, Kirti and JKHy-1) and an equal number of varieties (AKH-4, Arogya, CNH-36, PKV-081, AKH-8401, AKH-84635 and Anjali) of cotton were utilized for the study on the predatory activity in relation to cultivars. Observations on the incidence of jassids and aphids and predatory activity of coccinellids and chrysopid were recorded on each of the cotton cultivars raised in randomly allotted unreplicated 800 sq.m. plots. A minimum of three metre buffer space separated the cultivars in all directions. Each plot was divided into five sampling units as replicates and five plants per replication were randomly selected for the population counts of jassids and predators on three leaves and plant basis, respectively. For aphids, the percent infestation based on the number of aphid-infested plants out of the 10 randomly selected plants per plot was worked out. Sampling period was between 20 days after planting and flowering stage. Mean incidence of jassids, coccinellid grubs, chrysopid eggs and infestation by aphids pooled over the sampling period for varieties and hybrids separately were subjected to non-parametric Mann-Whitney's 'U' test (Siegel, 1956).

Observations of coccinellids and chrysopids taken on conventional and Bt cotton hybrids grown across ten farms each with a minimum area of 0.4 hectare in IPM villages of the institute over two crop seasons (2004 and 2005) were also used to assess the effect of conventional versus transgenic cotton hybrids on the sucking pest and predatory activity. The sampling procedure, size and interval were similar to that described above in the study on the status and dynamics. The seasonal means of the sucking pests and predators were compared between the two types of hybrids using two sample t-test with known variances (Snedecor and Cochran, 1967).

Influence of soil fertility and cropping pattern

This study utilized the long term agronomic experiment carried out for gaining insights into the soil fertility and crop productivity changes as influenced by cotton based systems in vertisols, under rainfed conditions. The experiment was during its fourth year and laid out in a strip plot design having three replications. The main strips had two-fertilizer treatments, *viz.*, i. recommended doses of synthetic fertilisers (60:30:30 NPK kg/ ha) with organic manuring (farm yard manure @ 10 t/ ha) and ii. only recommended dose of synthetic fertilisers. Sub-strips had monocrops of cotton (LRA-5166), sorghum (CSH-9) soybean (Monetta) and redgram (C-11), sequential crop of cotton and soybean besides intercrop of soybean with cotton, redgram and sorghum. Plots involving cotton alone were considered for the observations on the entomofauna. A total of 18 plots (two fertilizer levels and three cropping patterns in three replicates) associated with cotton were used for observations. Population counts of jassids, coccinellids, chrysopids and per cent infestation by aphids were recorded from seedling emergence to 60 days of crop growth at weekly interval on two plants per replicate. Data pooled over the sampling period for the fertility changes and cropping pattern were analysed using non-parametric Mann Whitney's 'U' statistics (Siegel, 1956).

Influence of pest management options

Field experiments conducted at the CICR, Nagpur to quantify the efficacy of different IPM components during 2004 and 2005 seasons, on cotton hybrid NHH-44 were utilized to investigate the influence of pest management options on the predatory activity. Only the treatments of complete protection involving need based insecticidal sprays and no protection that served as untreated check were considered in this paper. Crop under protection had a total of six and seven insecticidal sprays apart from seed treatment during 2004 and 2005, respectively. Neither seed treatment nor any insecticidal spray was given to the crop under no protection. There were five replicates under each treatment and five plants per plot were scouted for jassids and the predators on three leaves and plant basis, respectively. The means of jassids, coccinellid grubs and chrysopid ovipositions were compared between protected and unprotected situations for the individual years using two-sample 't-test' (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Status and dynamics

There has been declining levels of injury due to jassids (Fig.1) and aphids (Fig.2) in the 21st century. However, the activity of coccinellids (Fig. 3) and chrysopids (Fig.4) indicated fluctuating trends. The range of jassid incidence, aphid infestation, activity of coccinellids and chrysopids was 2.4 to 7.5 nymphs per three leaves, 15.0 to 38.9 per cent, 0.1 to 0.4 and 0.52 to 1.87 per plant, respectively. While the overall decreasing levels of jassids and aphids could be attributed to the larger use of neonicotinoids as seed treatment with the dawn of the present century, their occurrence till late in the season and their resurgence led by the continued use of insecticides for the management of sucking pests *per se* or bollworm management (Regupathy and Ayyaswamy, 2004). The trends of seasonal means of predatory activity measured in terms of grubs for coccinellids and oviposition for chrysopids did not indicate a direct density relation with either jassids or aphids. The population dynamics of coccinellids for different years revealed low density during most part of the crop season and their activity ceased from September but for the year 2002 (Fig. 5). On the other hand, chrysopids continued to occur between August and November months during all the years. Higher initial cum early occurrence of chrysopids was observed during 2003 (Fig. 6), the year that had highest mean abundance (1.87 per plant) too. Inter-specific association between coccinellids and chrysopids had been non-significant (r=0.058). Coccinellids are highly aphidophagous and their colonization on the crop is aphid-dependent.

On the other hand, chrysopids, as generalists, had numerical response to various insect life stages such as jassid nymphs, thrips, eggs and small larvae on cotton bollworms in cotton ecosystem. That is the reason the coccinellids failed to sustain in the cotton production

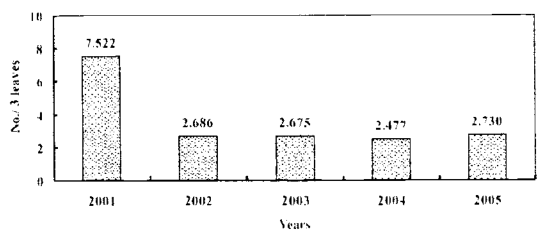

Fig.1. Seasonal mean of jassid nymphs

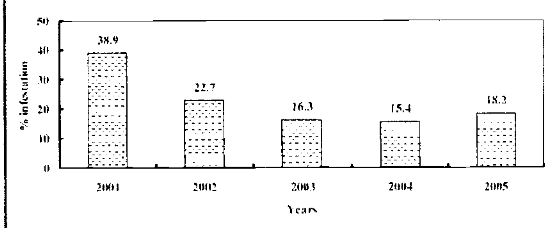

Fig.2. Seasonal mean of aphid infestation

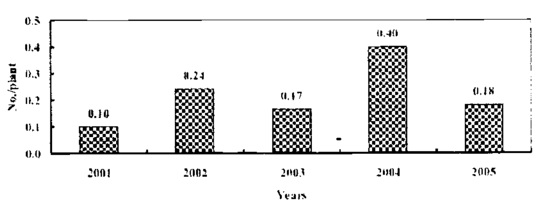

Fig.3. Seasonal mean of coccinellid grubs

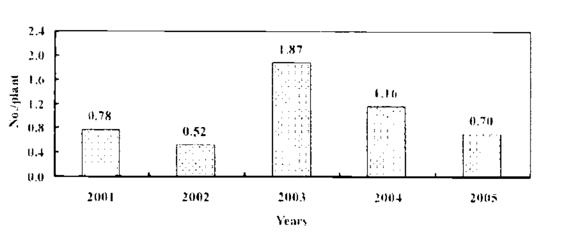

Fig.4. Seasonal mean of chrysopid oviposition

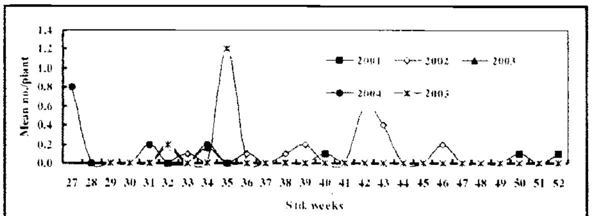

Fig.5. Seasonal dynamics of coccinellid grubs

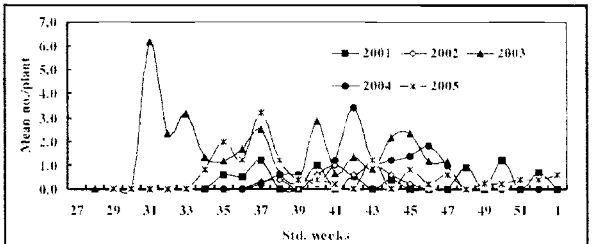

Fig.6. Seasonal dynamics of chrysopid oviposition

system. Nevertheless, the perpetuation of the chrysopids in the system signified their relatively greater role in natural regulation of insect pests including sucking pests and bollworms of cotton. Under these circumstances an early season inoculative release can be expected to supplement the native population.

Effect of cotton cultivars

Significantly higher incidences of jassids and aphids (3.23 per three leaves and 42.3 %) and their predators were observed on the hybrids than the varieties (2.34 per three leaves and 31.1 %) (Table 1). This indicated the density dependent nature of predators playing a major role in the suppression of sucking pests. Between conventional and transgenic cotton hybrids, despite higher nymphal population of jassids on transgenic hybrids (1.56 per three leaves) during 2004, the differences for both predators were non-significant (Table 2). This implied factors other than prey density on the activity of the predators. Available literature provides evidence of coccinellid grubs experiencing reduced walking speed on hairy leaves (Elsey, 1974) and plant canopies with overlapping leaves associated with increased rates of their dispersal (Kareiva and Perry, 1989). Our earlier studies also indicated the differential reaction of cotton cultivars to aphids and jassids, besides varying nature of associations of jassids and aphids to their predators (Vennila, 1998). So the aspect of natural enemy abundance in relation to cultivars gains importance in developing integrated pest management utilizing native natural enemies.

Effect of fertility levels and cropping pattern

Fertility changes in terms of recommended dose of synthetic fertilisers without organic manuring, and recommended dose of synthetic fertilizers with organic manuring did not differ for levels of jassids, aphids, coccinellids and chrysopids. Significantly higher population of jassids (2.84 per three leaves) in sole crop of cotton was observed over the soybean-intercropped cotton (2.39 per three leaves). Conversely, aphid infestation was heavier (24.2 %) on cotton intercropped with soybean than sole crop of cotton (19.2 %) (Table 3). Significantly higher population of chrysopids (1.83 per plant) observed on cotton sole crop reduced the aphid infestation compared to the soybean-intercropped cotton. Soybean could not have any positive impact upon the predators, as it had not supported effective population of jassids or aphids. Seshadri and Natarajan (1989) had shown significant reduction in growth and yield of cotton intercropped with soybean. Cowpea as an intercrop harboured aphids by itself and facilitated increased predation on aphids of cotton (Natarajan and Seshadri, 1988; Balasubramanian *et al.*, 1998). Therefore, any intercrop to have a positive impact on cotton production system through enhancement of natural enemy efficiency, should be an alternate host for any of the cotton pests (Vennila, 2001). The present study also revealed that the sucking pests and predators are significantly influenced by current cropping pattern than the current and/or inherent fertility status of the soil, the later gaining importance through its influence on cotton plant growth and development. It is thus the crop centered factors and their influence on pests that play a significant role over the direct effect of production practices on the activity of predators. Hence, formulation of favourable and remunerative cropping systems can enhance the role of native natural enemies.

Effect of pest management options

The seasonal mean incidence of jassids, coccinellids and chrysopids did not differ between

Table 1. Influence of cotton cultivars: hybrids *versus* varieties

Pests / Natural Enemies	Cotton		Significance of 'U' statistic (n_1=7, n_2=7)
	Hybrids	Varieties	
Jassid nymphs*	3.23	2.34	18[S]
Aphids**	42.35	31.11	27[S]
Coccinellid grubs ***	2.01	0.89	14[S]
Chrysopid oviposition***	0.08	0.03	12[S]

*: Mean no./3 leaves; ** : Per cent infestation; ***: Mean no./plant; [S]:Significant at P<0.01

Table 2. Influence of cotton cultivars: Conventional *versus* transgenic hybrids

Particulars	2004			2005		
	Conventional	Transgenic	Significance of 't-test'	Conventional	Transgenic	Significance of 't-test'
Jassid nymphs*	0.57	1.56	***	0.58	0.96	NS
Coccinellid grubs**	0.68	0.06	NS	0.09	0.09	NS
Chrysopid oviposition**	0.11	0.30	NS	0.36	0.35	NS

*: Mean no./3 leaves; **: Mean no./plant; ***: Significant at P<0.05 with one tailed t-value; NS: Non-significant

Table 3. Influence of soil fertility and cropping pattern on sucking pests and predators

Particulars	Soil fertility levels			Cropping pattern		
	Organic manure + synthetic fertilizers	Synthetic fertilizers alone	Mann Whitney's 'U' statistic (n_1=6, n_2=6)	Cotton + soybean	Sole crop of cotton	Mann Whitney's 'U' statistic (n_1=9, n_2=9)
Jassid nymphs*	2.78	2.69	NS	2.39	2.84	16[S]
Aphids**	18.34	17.86	NS	24.22	19.16	24[S]
Coccinellid grubs***	0.46	0.51	NS	0.38	0.99	26[S]
Chrysopid oviposition**	1.02	1.09	NS	0.83	1.83	24[S]

*: Mean no./3 leaves; **: Percent infestation; ***: Mean no./plant; [S]: Significant at P<0.01; NS: Non-significant

treatments although the former had six to seven insecticidal interventions for management of sucking pests and bollworms (Table 4). However, a look into the dynamics of coccinellid grubs revealed a differing and similar dynamics of very low population during 2004 (Fig. 7) and 2005 (Fig. 8), respectively under protected and unprotected treatments. Chrysopid oviposition was earlier at least by a week during both years (Fig. 9 and 10) on the crop under protection. The early occurrence of the chrysopids on the protected crop could be due to the resurgence of thrips arising out of seed treatment.

The non-significant differences for predators that had occurred on the cotton crop at the end of season indicated their recolonisation under insecticidal spray conditions also. It is well known in cotton that population densities of insect pests are enhanced by use or misuse of insecticides. Higher attack by thrips following seed

Table 4. Effect of pest management options on sucking pests and predators

Particulars	2004-05			2005-06		
	Protected	Unprotected	Significance of 't-test'	Protected	Unprotected	Significance of 't-test'
Jassid nymphs*	1.66	2.48	NS	2.03	2.62	NS
Coccinellid grubs**	0.04	0.13	NS	0.80	0.28	NS
Chrysopid eggs**	1.00	1.07	NS	0.85	0.67	NS

*: Mean no./3 leaves; **: Mean no./plant: NS: Non-significant

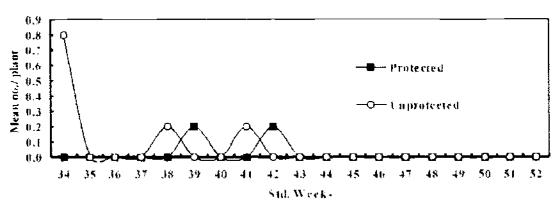

Fig.7. Seasonal dynamics of coccinellid grubs (2004-05)

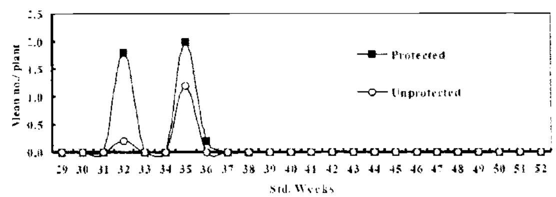

Fig.8. Seasonal dynamics of coccinellid grubs (2005-06)

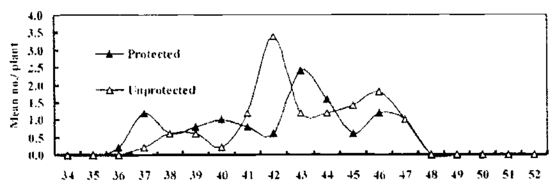

Fig.9. Seasonal dynamics of chrysopid oviposition (2004-06)

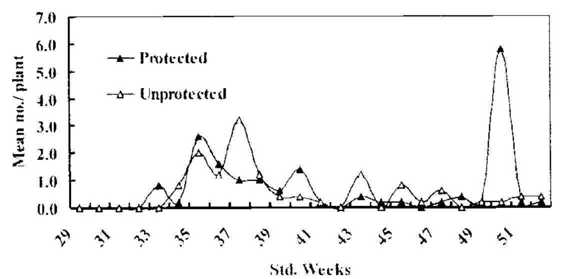

Fig.10. Seasonal dynamics of chrysopid oviposition (2005-06)

treatment (Rajendran. 2004). aphid and whitefly resurgence following pyrethroid usage (Natarajan *et al.*, 1987). and higher *Helicoverpa armigera* oviposition and survival on the seed treated and/or systemic insecticide sprayed crop (Vennila and Banerjee, 2001) are well documented. These studies provide evidences towards explaining the differences in dynamics of predatory activity between protected and unprotected situations. The ability of these predators to rebuild on the crop with the availability of prey sources on the insecticidal treated crop is an advantageous feature. Such an attribute along with host plant resistance traits for sucking pests can aid in development of robust IPM systems.

The featured pests and predators of the present study are only a few of the many occurring on the cotton crop. Native beneficial insects are not widely exploited in cotton pest management because their efficacy is poorly understood and their abundance highly variable. Major challenge for the cotton researchers is to develop techniques to better manipulate and exploit beneficials through understanding of basic biology and ecology. In the present context. only conservation of native natural enemies deserves more attention in the form of designing ecosystems favourable for higher predation. Augmentative releases for generalist natural enemy should be inoculative and not inundative. Any pest management option, whatsoever may be the effectiveness. incurs certain cost. Nevertheless. models of integrated pest management designed based on the native natural agents can successfully increase yields and profit without the need for expensive augmentative inputs besides reducing the use of chemical insecticides. As of now. with the given scenario of sucking pests and available pest management options. the strategy should be to grow sucking pest tolerant cultivars of cotton without seed treatment so that jassids and aphids are available on the crop and play an important role for the build up of the coccinellids and chrysopids.

ACKNOWLEDGEMENTS

The authors acknowledge with gratitude the help rendered by the supporting staff associated with field experiments. Thanks are also due to the Director, Central Institute for Cotton Research, Nagpur for providing facilities and constant encouragement.

REFERENCES

Agarwala, B. K. and Ghosh, A. K. 1988. Key records of aphidophagous coccinellids in India: A review of bibliography. *Tropical Pest Management*, **34**: 1-14.

Balasubramanian, A., Mahadeven, N. R., Venugopal, M. S. and Muralibaskaran, R. K. 1998. Influence of intercropping on infestation of early season sucking pests of cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences*, **68**: 315-316.

Dhawan, A. K., Sidhu, A. S. and Simwat, G. S. 1988. Assessment of avoidable loss in cotton (*Gossypium hirsutum* and *Gossypium arboreum*) due to sucking pests and bollworms. *Indian Journal of Agricultural Sciences*, **58**: 290-292.

Elsey, K. D. 1974. Influence of host plant on searching speed of two predators. *Entomophaga*, **19**: 3-6.

Kareiva, P. and Perry, R. 1989. Leaf overlap and ability of lady bird to search among plants. *Ecological Entomology*, **14**: 127-129.

Natarajan, K. and Seshadri, V. 1988. Abundance of natural enemies of cotton insects under intercropping system. *Journal of Biological Control*, **2**: 3-5.

Natarajan, K., Sundaramurthy, V. T. and Chidambaram, P. 1987. Whitefly and aphid resurgence in cotton as induced by certain insecticides, pp. 155-159. In: S. Jayaraj (Ed.). *Resurgence of Sucking Pests*. Tamil Nadu Agricultural University, Coimbatore.

Rajendran, T. P. 2004. Challenges for management of sap sucking pests in cotton, pp. 37-41. In: Khadi, B. M., Vamadevaiah, H. M., Katageri, I. S., Chattannavar, S. N., Udikeri, S. S. and Patil, S. B. (Eds.). International Symposium on, "*Strategies for Sustainable Cotton Production- A Global Vision*" *3. Crop Protection*, University of Agricultural Sciences, Dharwad, Karnataka (INDIA), 23-25 November, 2004.

Regupathy, A. and Ayyasamy, R. 2004. Insecticide resistance in sucking pests of cotton and resurgence, pp. 42-53. In: Khadi, B. M., Vamadevaiah, H. M., Katageri, I. S., Chattannavar, S. N., Udikeri, S. S. and Patil, S. B. (Eds.), International Symposium on, "*Strategies for Sustainable Cotton Production- A Global Vision*" *3. Crop Protection*, University of Agricultural Sciences, Dharwad, Karnataka (INDIA), 23-25 November, 2004.

Sankaran, T. 1976. Biotic agents as key mortality factors in integrated control of pests. *PANS*, **23**: 371-378.

Seshadri, V. and Natarajan, K. 1989. Effect of different intercrops on growth and yield of upland cotton (*Gossypium hirsutum*) and their economics. *Indian Journal of Agricultural Sciences*, **59**: 227-230.

Siegel, S. 1956. *Non-parametric statistics*. McGraw-Hill, New York, 329 p.

Snedecor, G. W. and Cochran, W. G. 1967. *Statistical methods*. Oxford and IBH Publishing Co. 593 p.

Vennila, S. 1998. Relationship between sucking pests (*Amrasca biguttula biguttula*, *Aphis gossypii*) and their predators (*Cheilomenes sexmaculata*, *Chrysoperla carnea*) on cotton cultivars. *Journal of Entomological Research*, **22**: 349-353.

Vennila, S. 2001. Influence of soil fertility and cropping pattern on the entomofauna of cotton ecosystem. *Journal of Cotton Research and Development*, **15**: 111-112.

Vennila, S. and Banerjee, S. K. 2001. Crop phenology and *Helicoverpa armigera* population in relation to insecticide use on cotton, p. 31. In: Proceedings of the National Symposium on "*Cotton Research strategies in New Millenium*" at CCS Haryana Agricultural University, Hisar, 16th April, 2001.