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IMPACT OF SORGHUM ON NATURAL PARASITISM OF *Helicoverpa armigera* (HUBNER) BY *Trichogramma chilonis* ISHII IN COTTON IN SOUTHERN INDIA

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ABSTRACT

Field trials were conducted on three cotton hybrids (MECH 1, MECH 12, and RCH 2) grown alone, and with a sorghum hybrid (CSH 1) as a neighbouring crop at two villages, Ravulapally and Sankeypally, in Ranga Reddy district. Cotton hybrids grown neighbouring to sorghum had significantly higher levels of egg parasitism by *Trichogramma chilonis* than in a monocrop. The enhanced level of parasitism was due to a temporal shift in the *T. chilonis* population from sorghum to cotton during the cropping season. Parasitism on sorghum increased slowly in relation to host egg density at both the village sites and reached a peak of 70% and 60% by mid-September at Ravulapally and Sankeypally respectively. The mean clutch size on sorghum was 2.06, with a maximum of 5 parasitoids emerged per egg. Parasitism of *Helicoverpa armigera* eggs on cotton by *T. chilonis* reached a maximum of 68% in mid-October when grown as a neighbouring crop to sorghum and 45% as a monocrop. The mean clutch size on cotton was 2.24, with a maximum of 5 parasitoids emerged per egg. Among the three cotton hybrids tested, parasitism was significantly higher on MECH 12 either grown alone or neighbouring to sorghum. The results are discussed in terms of the dynamics of *T. chilonis* buildup on sorghum and its subsequent migration to cotton as a management strategy to suppress the population carryover of *H. armigera* on cotton.

Key words: cotton, cropping systems, *Helicoverpa armigera,* sorghum, *Trichogramma chilonis.*

INTRODUCTION

Helicoverpa armigera (Hubner) is an important pest and its impact has dramatically increased because of extensive host range (Pawar *et al.,* 1986). There are indications that the impact of parasitoids on *H. armigera* in cotton declined during the last decades as the use of insecticides increased (Balla, 1982). Further, the evolution of resistance to commonly used insecticides resulting in failure or unreliable suppression of *H. armigera* in diverse agricultural systems, particularly cotton and legumes (McCaffery *et al.,* 1980; Rao, 1998; Armes *et al.,* 1992). This stresses the need to

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develop control.
enemies to reduce the *H. armigera* populations (Greathead and Waage, 1983).

In India, agricultural crops are predominantly grown in small-holder cropping environments, typically comprising a mosaic of small plots of crops such as cotton, sorghum, maize, sunflower, legumes, fruits and vegetables. Planting of different host crops of *H. armigera* as intercrops has influenced the pest and parasitoid populations on a crop directly or indirectly in the adjacent crop. Direct influences include preference of one crop over the other by ovipositing moths and the movement of larvae and natural enemies between interplanted crops; indirect influences arise when *H. armigera* and parasitoid interactions of one crop is influenced by their population buildup or mortality level on neighbouring crops. Neighbouring crops may thus serve as a source or sink of pest infestation, since one crop may be influenced by either the population buildup or mortality level of pests on adjacent crops (Nya
of vegetative growth stage of cotton offers a chance for long-term pest-parasitoid interactions and was thought to keep *H. armigera* as a minor pest in southern Uganda (Coaker, 1969). Thus, the growth stage of the crop present at the pest invasion determines the impact in diverse agroecosystems comprising inter, multiple, and relay cropping systems. The status of maize intercropped or adjacent to cotton in Tanzania (Pearson, 1958), sorghum with pigeonpea in India reduced the attack of *Helicoverpa* spp. on the latter crops (Romeis *et al.*, 1999). On the contrary, intercropped maize has frequently failed to protect cotton from *H. armigera* in Rhodesia and Sudan (Bebbington and Allan, 1933) and from *H. zea* in USA (Henry and Adkisson, 1985; Pimentel *et al.*, 1977) and the cropping pattern of maize and tomatoes established a favourable host sequence for *H. armigera* leading to severe infestations on cotton (Way, 1975). Similarly, there is a shift from one host species to another when suitability of one host declines (Klass, 1978).
alfalfa and cotton, and when alfalfa is harvested for hay they move in large numbers to cotton (Stern, 1969). Robinson *et al.* (1972) observed increased predator populations of coccinellids, *Chrysoperla*, nabids, and spiders on cotton grown adjacent to sorghum than grown alone. It is, therefore, critical to select t
kind of crop diversity for a given microclimate, and/or biotic situations (Fitt, 1989).

The importance of naturally occurring biological control agents for *Helicoverpa armigera* is well documented through India (Nagarkatti and Nagaraja, 1971; Pawar *et al.*, 1986), China (Li, Li-Ying, 1994), Philippines (Famosa and Alba, 1988), Mexico (Filippov, 1990), the former USSR (Nokonov *et al.*, 1990) and East Africa (Van den Berg, 1993). Among them, *Trichogramma chilonis* Ishii is an important egg-parasitoid on lepidopterous pests not only in Andhra Pradesh but also in other States in India (Pawar *et al.*, 1986, 1989).

For the development of sustainable pest management, it is essential to study the ecology and natural mortality factors, and investigate the influence of companion crops on pest-parasitoid interactions. Studies were made over a 2-yr period (1996-98) at two village sites in Ranga Reddy district,
usually flowers prior to cotton in late August to early September by which time it is

highly attractive to *H. armigera* for oviposition, and these eggs are parasitized by *T. chilonis*. The populations of *T. chilonis* emerging from maturing sorghum go in search of *H. armigera* eggs on cotton. This paper reports the impact of sorghum grown neighbouring to cotton on the rate of oviposition of *H. armigera* and parasitism by *T. chilonis* in small-farm sole cotton and sorghum-cotton agroecosystems.

MATERIALS AND METHODS

Experimental sites

During June 1996, six experimental sites (@ 0.5ha) were selected by involving eighteen collaborative farmers for conducting trials at Ravulapally and twelve experimental sites in 1997 at Sankeypally in Ranga Reddy district of Andhra Pradesh. A hybrid cotton, MECH 1 with a medium duration of 150-170 days was planted during the rainy season on 25th June, 1996 in 6 sites at Ravulapally. Among them, 3 sites had neighbouring sorghum *cv.* CSH 1 (with a maturity of 100 days) during the rainy season on 25th June, 1996 at Ravulapally; and one of the two medium duration cotton hybrids, MECH 12 and RCH 2 in 6 sites with 3 sites having sorghum (0.25ha) adjacent to cotton were planted on 6 July 1997 at Sankeypally. The planting geometry was 30cm and 1m between plant to plant, and 60cm and 1m between row to row, for sorghum and cotton respectively at both the village experimental sites.

Sampling of H. armigera eggs

In sorghum, 10 randomly selected sorghum panicles were sampled for *H. armigera* eggs at weekly intervals, between Aug-Sept. Similarly, twenty randomly selected cotton plants per plot were assessed by sampling 75-100 leaves for *H. armigera* eggs approximately at weekly intervals starting from the fourth week after planting to complete boll-formation stage. Only three samples of *H. armigera* eggs were taken on sorghum due to its short flowering period, and 18 samples were taken on cotton. The samples of sorghum panicles and cotton leaves were brought to the laboratory. The eggs removed with a camel hair brush were transferred individually into 5 cm long and 1 cm wide transparent glass vials, maintained at 25±1°C and 60% RH. The vials were examined 7 ranged between 50-280 sample^{-1} over a 7-week period in 1996, and 50-304 sample^{-1} over a 10-week period in 1997 on sorghum and cotton hybrids at both the villages. The number of eggs parasitized was expressed as percentage of the total number of eggs collected, excluding those which failed to hatch for other reasons, such as infertility, damage during collection, or desiccation. The data on per cent parasitism was arcsin square root transformed before being subjected to ANOVA and the means were separated by Bonferroni test (SAS, 1981).

RESULTS

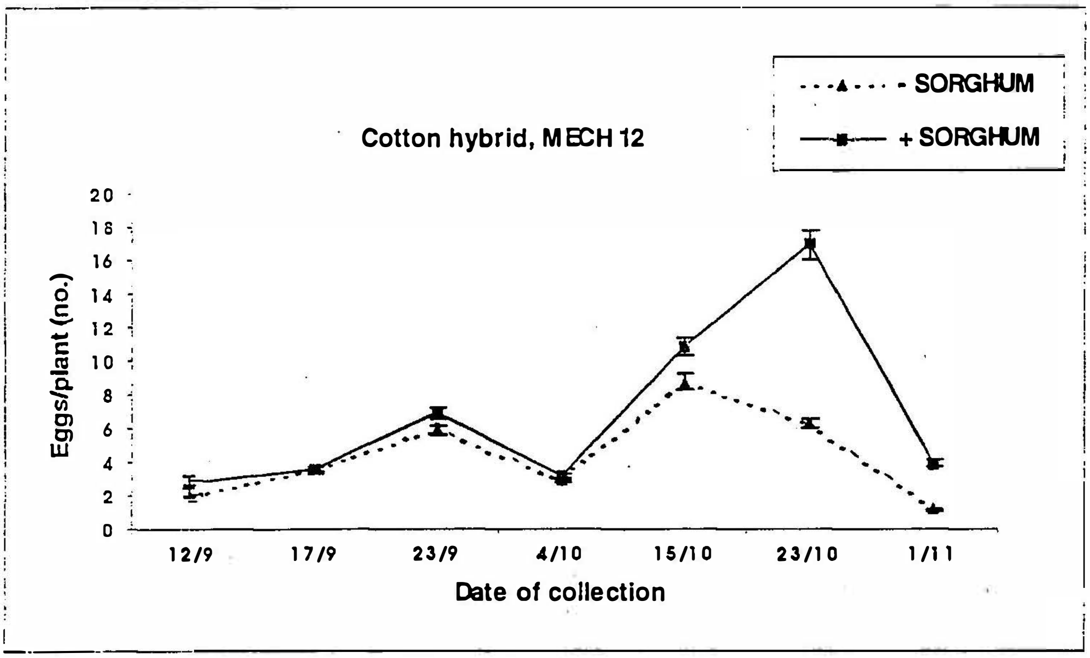
In sorghum, there is a gradual increase in egg density and egg numbers per panicle from August last week to September second week at both the villages. The initial increase corresponded proportional with the egg density observed throughout the sampling period. The total number of eggs collected across sampling dates at both the villages ranged between 75 and 224. Similar trend of increased egg parasitism levels were recorded from 33 to 70% and 27 to 60%, respectively (Table 1). Interestingly, an average of 2.06 and a maximum of 5.00 *T. chilonis* on few occasions have emerged from each parasitized egg of *H. armigera*. In general, the parasitism has reached >70% indicating gregarious parasitism.

Table 1: Mean eggs of *H. armigera* and their parasitism by *Trichogramma chilonis* in sorghum (*cv.* CSH 1) in two villages of Andhra Pradesh

Village	Sampling date	*H. armigera*		*T. chilonis*
		Egg density/ panicle ($\bar{x}\pm$SD)	Eggs (no.) ($\bar{x}\pm$SD)	Parasitism (%)
Ravulapally	Aug-28	3.1± 0.88	.105± 3.80	33
	Sep-08	4.2± 0.77	180± 8.48	61
	Sep-16	10.7± 0.75	224± 8.49	70
Sankeypally	Aug-26	2.7± 0.72	75± 6.70	27
	Sep-07	4.0± 0.12	156± 6.90	48
	Sep-15	11.0± 0.29	166± 4.70	60

In cotton, the oviposition of *H. armigera* moths commenced during the first week of September, and increased gradually by mid-October, but declined in early November which respectively coincided with the flowering, boll-formation, and crop senescence stage of all the cotton hybrids indicating a more prolonged period of oviposition than found on sorghum. The peak egg-laying was corresponded with an average availability of 25 squares and/or young bolls per plant among all the three cotton hybrids tested. However, the mean levels of parasitism of *H. armigera* eggs by *T. chilonis* was significantly low on MECH 1 and RCH 2 from among the cotton hybrids either grown alone or neighbouring to sorghum (Table 2).

This suggests that there is continuous oviposition over a period of 8 weeks on all the cotton hybrids. The moths emerging from sorghum are attracted to the preferred growth stage of cotton hybrids reflecting overlapping generations of *H. armigera*. The curves of parasitism closely followed the oviposition on all the cotton hybrids and at all the sampling dates (Fig. 1-3). However, MECH 12 showed high levels of parasitism due to increased activity by *T. chilonis*. An average *T. chilonis* emergence of 2.00 and 2.24 was noticed on sole cotton and neighbouring to sorghum respectively reaching a maximum of 5.00 (Table 3).



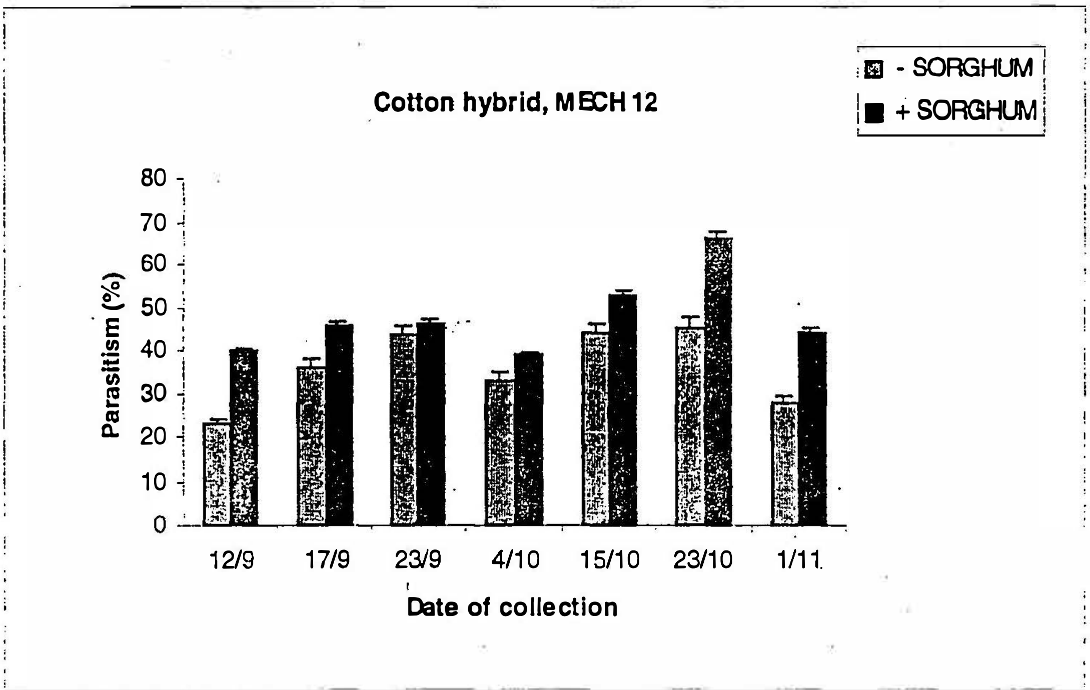
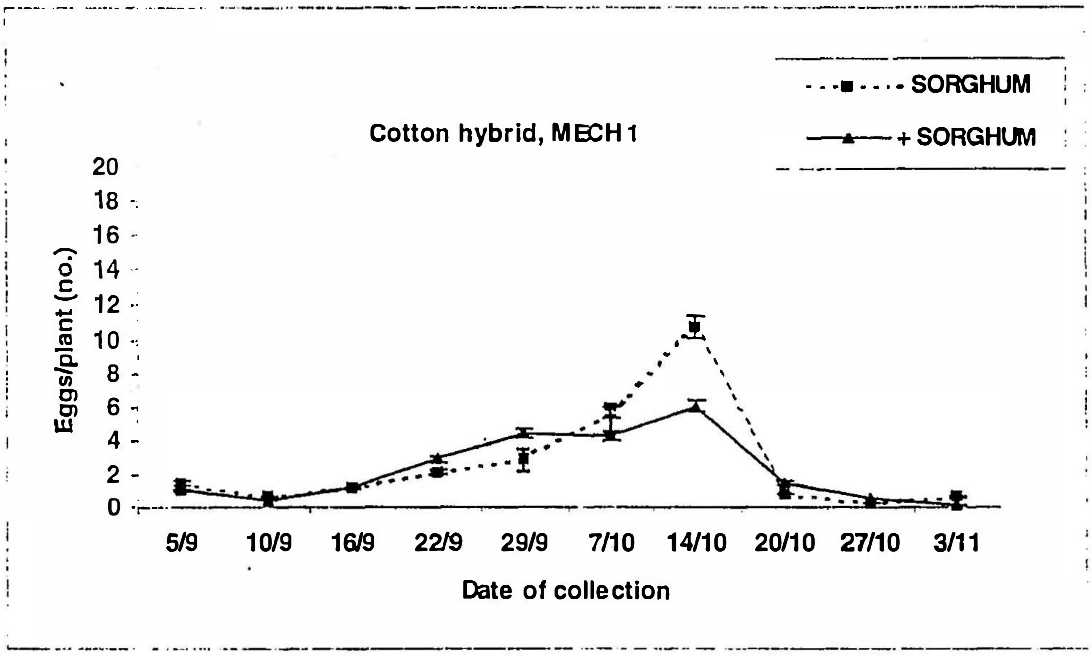


Fig.1: Eggs of *H.armigera* and the levels of parasitism by *T.Chilonis* on the cotton hybrid,MECH 12 grown alone and with neighbouring sorghum at Ravulapally in 1996.



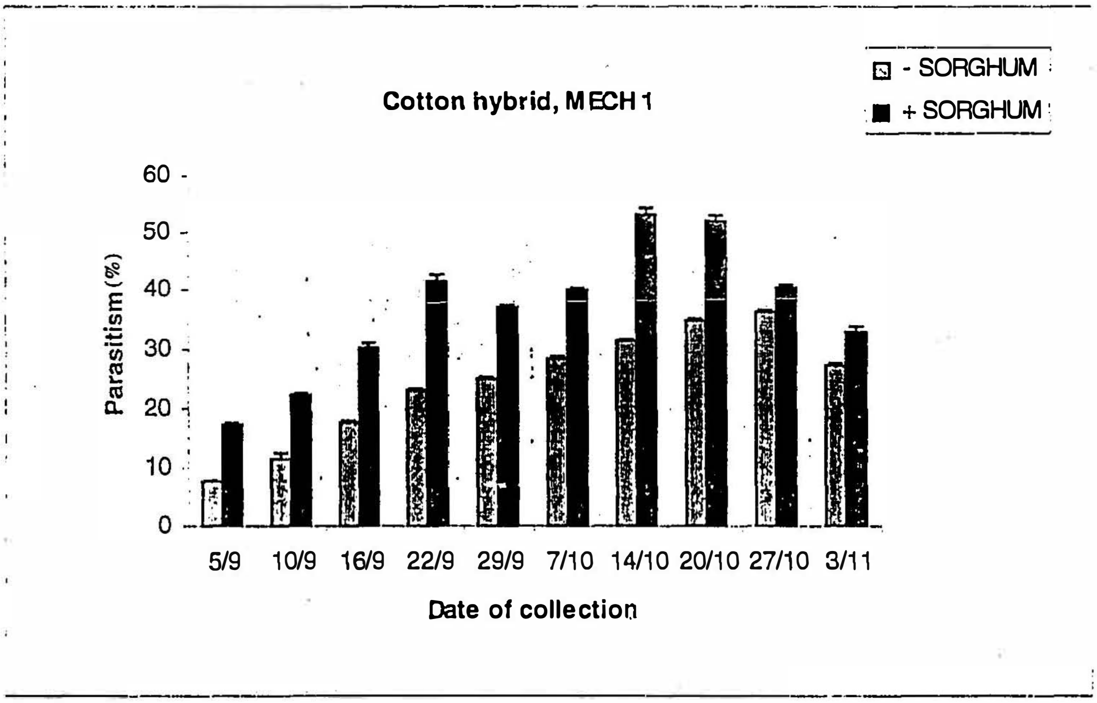
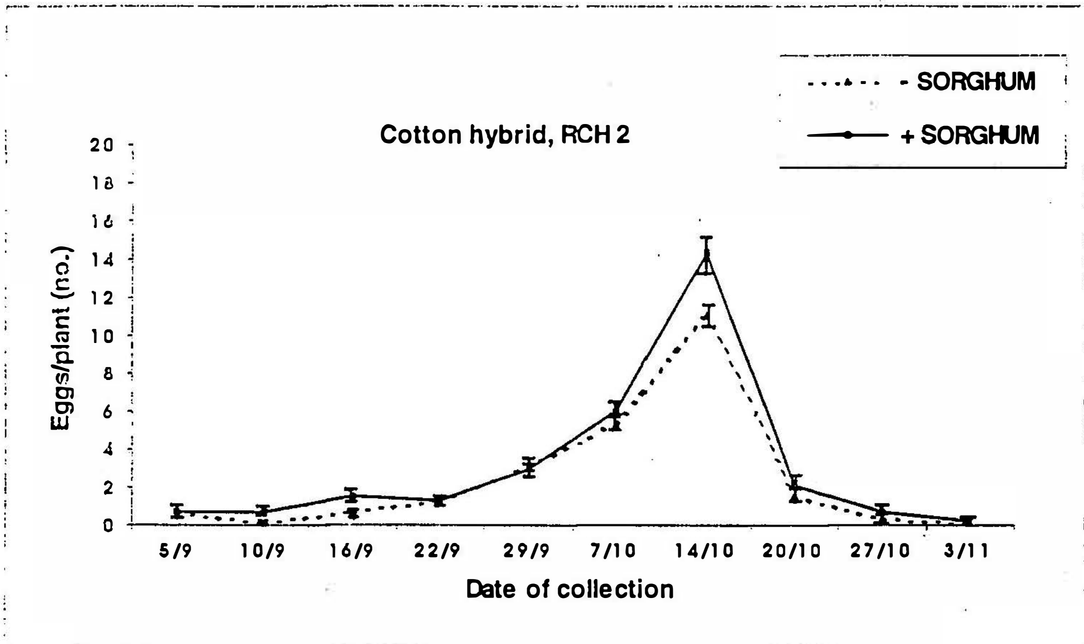


Fig 2 : Eggs of *H.armigera* and the levels of parasitism by *T.Chilonis* on the cotton hybrid, MECH 1 grown alone and with neighbouring sorghum at Sankeypally in 1997.



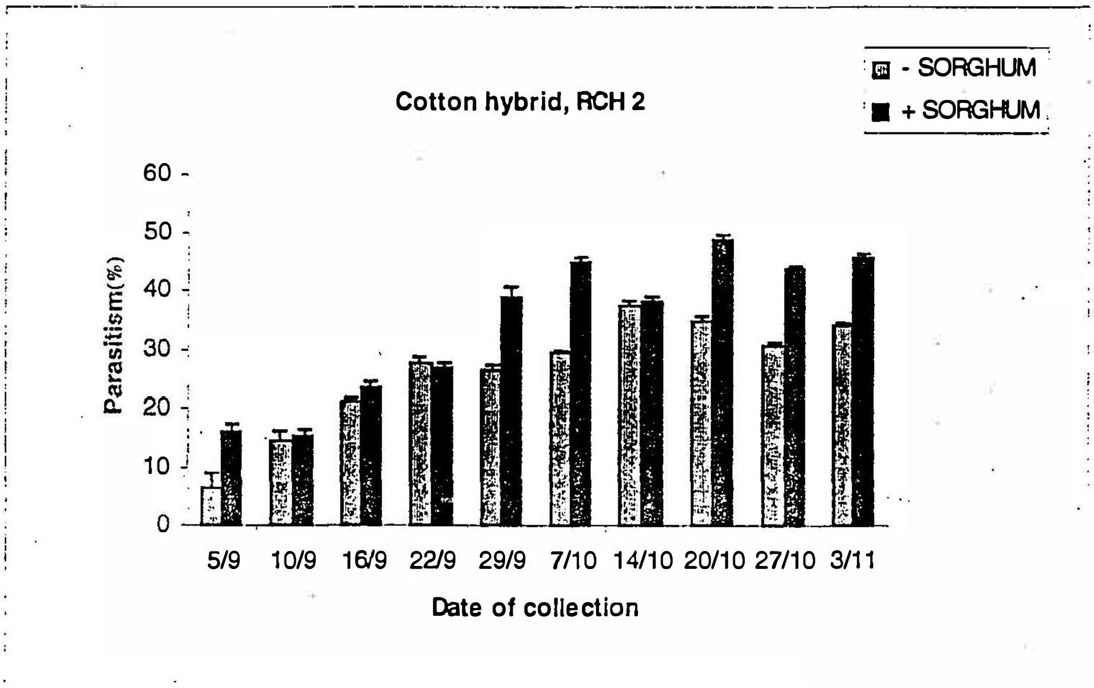


Fig.3 : Eggs of *H.armigera* and the levels of parasitism by *T.Chilonis* on the cotton Hybrid, RCH 2 grown alone and with neighbouring sorghum crop at Sankeypally in1997.

Table 2: Mean levels of parasitism of *H. armigera* eggs by *T. chilonis* on cotton hybrid grown alone and with neighbouring sorghum crop at Ravulapally and Sankeypally villages in Andhra Pradesh

Cotton hybrid	Sole cotton ($\bar{x}$±SE)	Cotton with neighbouring sorghum ($\bar{x}$±SE)
MECH 1	24.20 ± 0.53 b	36.69 ± 0.53 b
MECH 12	36.13 ± 0.53 a	47.69 ± 0.53 a
RCH 2	26.19 ± 0.53 b	34.28 ± 0.53 b

Means with the same letter are not significantly different (Bonferroni test, SAS, 1981).

Table 3: Parasitoid emergence of *T. chilonis* from *H. armigera* eggs and clutch size in different cropping patterns

Cropping pattern	Parasitoid emergence (no.)					Mean clutch size ($\bar{x}$± SD)
	1	2	3	4	5	
Sole sorghum	98	295	80	24	-	2.06±1.58
Sole cotton	490	1479	355	65	6	2.00±1.58
Cotton + Sorghum	451	3013	1490	63	21	2.24±1.58

DISCUSSION

This study has shown that *H. armigera* egg parasitism by *T. chilonis* in cotton agro-ecosystem is strongly associated with its neighbouring crop of sorghum, and these associations are solely the result of narrow periods of activity of parasitioids imposed on a shifting from maturing sorghum to pubescent leaves or fruiting cotton, because no other crops are grown close to the cotton. The peak oviposition period of *H. armigera* on sorghum occurred in September with the onset of flowering and ceased at the soft dough stage. This may also explain the higher levels of egg parasitism on compact sorghum panicles and is consistent with earlier reports (Balasubramanian *et al.*, 1979; Pawar *et al.*, 1989; Romeis *et al.*, 1999). Under field conditions, the parasitised eggs usually took 10 days for the emergence of *T. chilonis*, while the unparasitized eggs of the host hatched in 3-4 days. High rate of gregarious parasitism by *T. chilonis* on sorghum had a greater impact by their dispersal to the degree of accessibility of neighbouring cotton which are in the stage of pubescence or fruiting. An estimated population buildup of *T. chilonis* over 1.25 million ha^{-1} on sorghum has been reported by Duffield (1994).

In cotton, the oviposition continued over a longer period till the boll stage. High levels of parasitism were observed on all the three cotton hybrids when grown adjacent to sorghum than grown alone. This suggests that the *T. chilonis* emerging from infested sorghum panicles disperse to neighbouring cotton. Thus, the crop diversity involving planting of sorghum adjacent to cotton, may enhance parasitoid interactions on the latter crop. Unlike sorghum, where farmers do not spray for controlling *H. armigera*, cotton is frequently sprayed with insecticides because there is no other economic option available to them. Despite insecticide use, the parasitism by *T. chilonis* suggests that the parasitized eggs either escaped from direct contact with the insecticides or became tolerant/resistant to at least few insecticides used on cotton.

Density dependent parasitism of *H. armigera* eggs by *Trichogramma* spp. on cotton has been observed by Murray and Lloyd (1997). In Gujarat, inundative releases of *Trichogramma* spp. did not help to boost the levels of parasitism, but gave an indication that natural control by parasitoids in cotton agroecosystem was advantageous in minimizing the application of insecticides (Patel, 1980). Effective control of *H. armigera* was achieved with *T. chilonis* inundative releases @ 1.5 and 1.0 lakh ha^{-1} in Tamil Nadu (Dhandapani *et al.*, 1992), 1.5 lakh ha^{-1} in Punjab (Gill *et al.*, 1993). There is consistency on the sustenance of parasitoid population on cotton hybrids grown neighbouring to sorghum. The cultivation of a single cotton cultivar over large areas in Telangana region of Andhra Pradesh during December 1997 (Rao, 1998) has encouraged severe infestation of *H. armigera* reaching endemic proportions due to the absence of natural enemies, including *Trichogramma* spp. (Jadhav, unpublished).

The results demonstrate that manipulation of specific crop diversity by growing short duration cultivars of sorghum neighbouring to cotton enables a beneficial shift in the pest and parasitoid populations. Consideration of such habitat manipulation could provide ecologically more suitable niche to enhance the levels of natural enemy activity, and effectively reduce the population buildup of *H. armigera* from reaching the economic threshold levels.

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