CROPPING ENTOMOLOGY

REPORT OF WORK

1977 - 1978

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1. GENERAL

Several trials were conducted at ICRISAT Center to determine factors affecting pest incidence, pest-parasitoid ratios and insect induced yield losses on intercropped sorghum and pigeonpea, particularly by gram pod borer, *Heliothis armigera* (Hubner). These were compared with the off-station situation. Experimental work in the pest-parasitoid complex in mixed/inter cropping was intensified. Surveys were made to elucidate factors involved in maximizing the action of natural control agents of *H. armigera* on mixed/inter crops in Andhra Pradesh and neighbouring states.

We continued to determine the pest-spectrum and studied in detail the seasonal variation in pest-numbers and how these are affected by different crop systems.

2. *Heliothis armigera* (Hubner)

One hundred and five crop and alternative hosts of this noctuid have been recorded in surveys. Data are given on the number of host plant species and families found harbouring this noctuid larva in our field surveys and compared to data from the Indian literature in Table 1. In the instance of the cultivated hosts Dicot families predominated - 19 as compared to three Monocot families. Similar indications were found

Table 1. Recorded host fauna of gram pod borer, *Heliothis armigera* (Hubner).

Plant category		No. of plant					
		Species			Families with		
		Cultivated hosts	Uncultivated hosts	Total hosts	Cultivated hosts	Uncultivated hosts	Total hosts
Monocot	Field surveys	9	1	10	3	1	4
	Indian literature	10	0	10	5	0	5
	Total	12	1	13	5	1	6
Dicot	Field surveys	42	53	95	19	19	29
	Indian literature	71	23	94	26	12	30
	Total	83	69	152	28	24	40
Overall	Field surveys	51	54	105	22	20	33
	Indian literature	81	23	104	31	12	35
	Total	95	70	165	33	25	46

with weed plants - of the 20 families recorded as hosts only one in the Commelinaceae, is a Monocot. Plant species from the Compositae were the most important alternative crop and weed hosts in the region.

Larval population was low in April-May. The most important "carry over" hosts in the hot summer season were irrigated tomato, maize and a cucurbit *Lagenaria vulgaris* Ser. among cultivated plants, and *Datura metel* L. and *Gompherana* sp. among the weeds. Local sorghum raised with irrigation was free of both eggs and larvae in the summer.

At ICRISAT Center the total area cropped increased steadily from 1974 to 1978 and this appeared to influence moth population. There was only a marginal increase in annual natural control by larval parasitoids in the period (Table 2).

Studies on the pest-parasitoid relationship are giving an understanding of natural population regulation of *Heliothis* in the region and particularly at ICRISAT Center. Data obtained on approximately 18,000 eggs collected on a range of crops and weeds have provided a preliminary running index to parasitism levels by *Trichogramma confusum* Viggiani and useful information was collected on crop preference. Egg parasitism levels in cereals were highest on sorghum (80% in late December), in legumes on cowpea (80% in mid April) and in weeds on *Gompherana* sp. (9% in late March). Both cropping systems and insecticide usage affected egg parasitism. Levels were higher in vertisols than in alfisols. Pigeonpea and chickpea were least attractive to this egg parasite and

Table 2. Total crop area (ha), light trap records of adults of gram pod borer, *Heliothis armigera* (Hubner) and annual natural larval control by parasitoids, ICRISAT Center, 1974-78.

Year	Area in cultivation at Research farm (ha)	Adult moths trapped at light** (No.)	Larval parasitism (%)
1974-75	230	2521	11.7 (1,747)
1975-76	345	2491	12.4 (4,488)
1976-77	413	3591	13.4 (20,801)
1977-78	556	34735*	22.3 (26,758)

* A migratory influx of moths from elsewhere during December, 3-23 accounted for 25,959 moths.

** At Crop Improvement building.

Figures in parentheses are total field collected larvae incubated for parasite emergence.

this is an important contributory factor in the high larval build-up and heavy yield loss on these two pulses in the region.

Larval parasitism studies at the ICRISAT Center were intensified. A collection of 26,758 larvae from a range of crops and weeds revealed that Nematodes (mermithids) were predominant in mid/late July, Hymenopterans in mid-late September/early October and Dipterans in early December (Fig. 1). Overall parasitism levels on selected cereals and legumes are given (Table 3). Dipterans dominated in pigeonpea while Hymenopterans were predominant on sorghum, pearl millet and chickpea and mermithids on groundnut. Parasitism levels were higher on unsprayed pigeonpea (upto 59%) compared to sprayed blocks (7 to 38%) and on vertisols (38%) as compared to alfisols crop (7%) at Research Center (Table 4). A similar trend was observed on chickpea crop (Table 5).

A culture of a potentially important naturally occurring Ichenumonid larval parasitoid of *H. armigera* on sorghum and chickpea in this region was supplied to the Indian Station of C.I.B.C., Bangalore.

Summarised data on light trap records of this Noctuid for 1977 show that of 31560 moths caught in a trap at C.I.Building, 56% were females, and 80% of these females were caught in the December 3-23rd period, when it is suspected that weather conditions favoured influx of moths from elsewhere (Table 6). The vast majority of the

Fig. 1: Weekly larval collection of *Heliothis armigera* (Hubner) and their natural control by parasitoids (%) in Alfisols and Vertisols, ICRISAT Center, 1977-78.

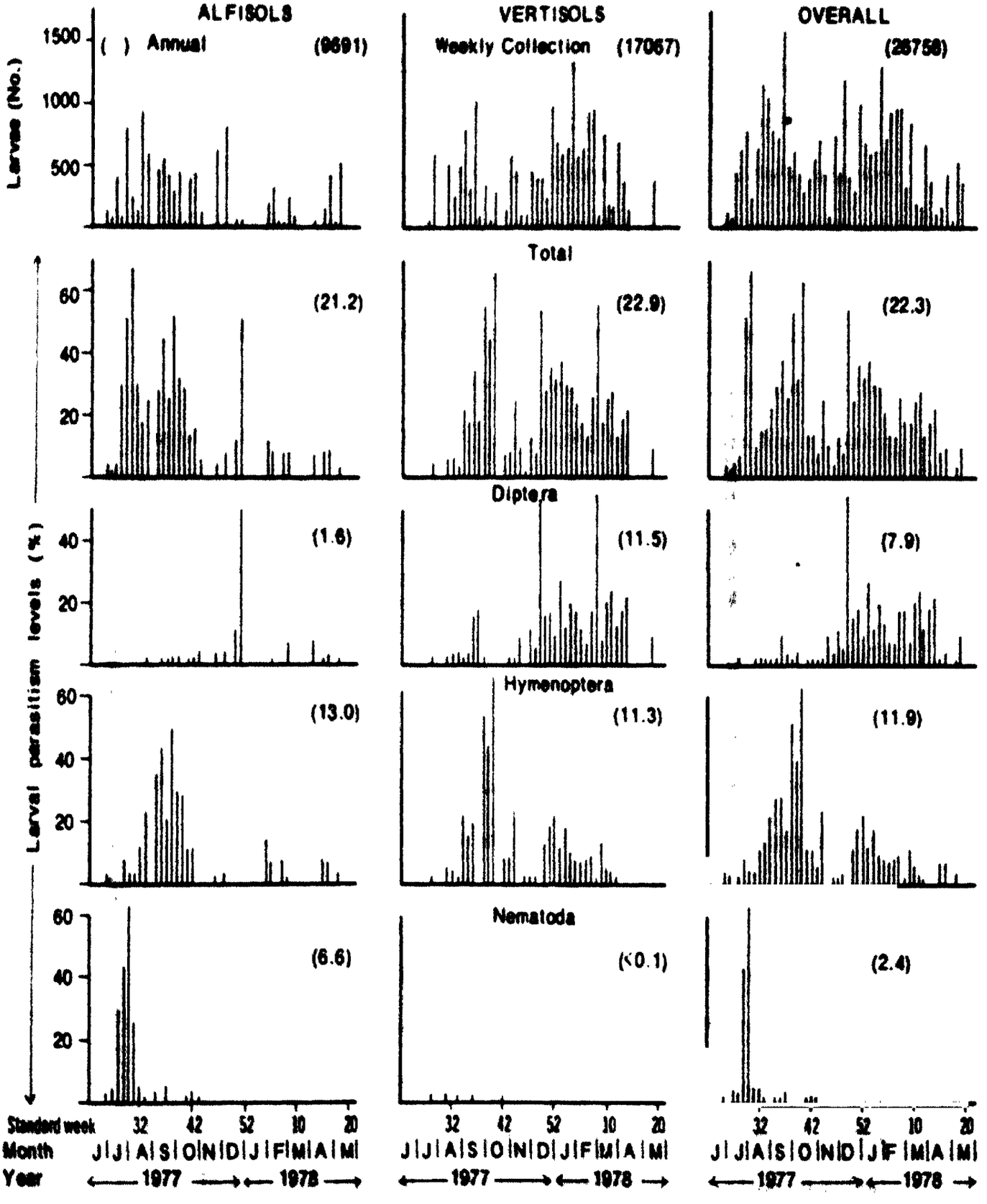


Table 3. Larval parasitism (%) on *Heliothis armigera* (Hubner) on selected cereals and legumes at Research Center and from district surveys in Andhra Pradesh.

Parasites	Location	Parasitism (%)						
		Cereals			Legumes			
		Sorghum	Maize	Pearl millet	Pigeonpea	Chickpea	Groundnut	Cowpea
I. Dipterans	Research Center	0.9	1.3	0.9	17.2	3.6	0.4	2.7
	Dist. Surveys	2.6	0.0		17.4	8.7	3.3	
II. Hymenopterans	Research Center	24.2	2.7	13.5	3.6	14.4	4.0	2.3
	Dist. Surveys	14.9	1.8		1.8	23.5	3.4	
III. Nematodes	Research Center	*	1.0	0.0	0.1	*	3.2	0.0
	Dist. Surveys	0.1	0.0		0.1	0.0	46.7	
Total	Research Center	25.2	5.0	14.4	20.9	18.0	7.6	5.0
	Dist. Surveys	17.6	1.3		19.3	32.3	53.4	
Total larvae studied	Research Center	4713	1240	572	19218	11916	2418	5850
	Dist. Surveys	2738	108		6311	3008	60	

* <0.1%

Table 4. Parasitism (%) on *Heliothis armigera* (Hubner) larvae collected on pigeonpea from pesticide free and sprayed environment, ICRISAT Center, 1977-78.

Parasites	Percentage larval parasitism (Nov. - Mar.)			
	Pesticide free area (vertisols)	Sprayed area (rest of the farm)		
		Vertisols	Alfisols	Overall
Dipterans (4 species)	36.9 (55.6)	26.7 (35.2)	8.3 (0.0)	20.6 (34.2)
Hymenopterans (3 species)	3.6 (3.8)	4.1 (3.0)	2.5 (7.1)	3.6 (3.0)
Total	40.5 (59.4)	30.8 (38.2)	10.8 (7.1)	24.2 (37.2)
No. of larvae incubated	2089 (571)	3750 (503)	1912 (14)	5662 (517)

Figures in parentheses are for February

Table 5. Parasitism (%) on *Heliothis armigera* (Hubner) larvae collected on flowering chickpea from pesticide free and sprayed environment at Research Center, December 1977.

Parasites	Percent larval parasitism		
	Pesticide free area	Sprayed areas	
		Moderate (Watersheds)	Intensive (Breeder's crop)
Dipterans (1 species)	0.0	0.3	0.0
Hymenopterans (3 species)	53.0	11.4	8.7
Total	53.0	11.7	8.7
No. larvae incubated	100	350	195

Table 6. Number of moths of *Heliothis armigera* (Hubner) trapped in light at C.I.Building and their status, ICRISAT Center, 1977.

Catch		Moths trapped in 1977		
		During Dec. 3-23*	Rest of the period	Total
I. Total		25959	5601	31560
II. Percent				
a) Male		43.75	45.28	44.02
b) Female		56.25	54.72	55.98
i) Unmated		47.05	30.96	44.20
ii) Mated with spermatophore(s)		9.20	23.76	11.78
Nos.	0	0.003	0.16	0.03
	1	8.78	17.77	10.39
	2	0.33	4.30	1.03
	3	0.08	1.16	0.26
	4	0.007	0.32	0.06
	5	0.00	0.05	0.009

* Migration suspected

suspected immigrant females were virgin supporting this hypothesis. Most moths were trapped between 2.00 - 3.00 hrs (Fig. 2). Fertility index of these trapped moths declined from 0.54 at 20.00 hrs to 0.10 at 2.00 - 4.00 hrs. Of those mated over 95% had one spermatophore.

The highest catch of *H. armigera* ever was obtained at ICRISAT Center on December 13, when 5,259 moths were caught in one of the three traps operated nightly. An earlier indication of a suspected migration in this moth was observed on November, 14 when 894 moths were caught. Some adult female moths survived for as long as 20 days in December-January in a field experiment indicating that this noctuid could fly considerable distances.

The entry of large populations of these migrant moths in November-December, 1977 (Fig. 3) resulted in a disequilibrium with the local parasite fauna and this led to in a rapid increase in larval populations and heavy yield losses in intercropped pigeonpea and chickpea at the Center and in this region.

Sixteen entomologists in India and abroad have been so far provided with design of the light trap which is in operation at the ICRISAT Center. We hope that the light trap grid which has been actively mooted by us will become fully operational so that we can get some information on sub continental migratory movements of *H. armigera*.

Fig. 2: Hourly light-trap catch of adult Heliothis armigera (Hübner) and physiological status of trapped females at C.T. Building, ICRISAT Center, 6 - 12 Dec 1977.

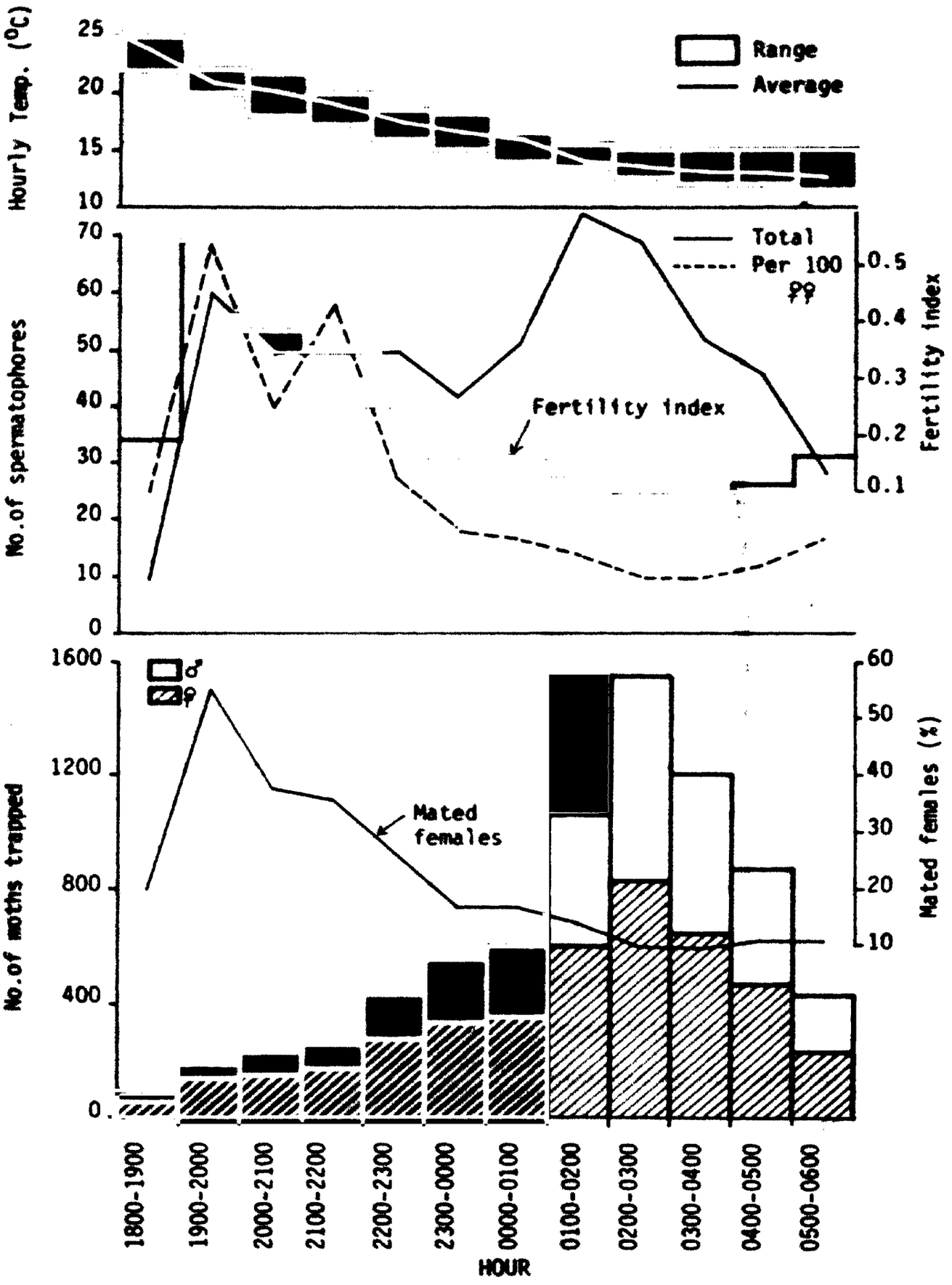
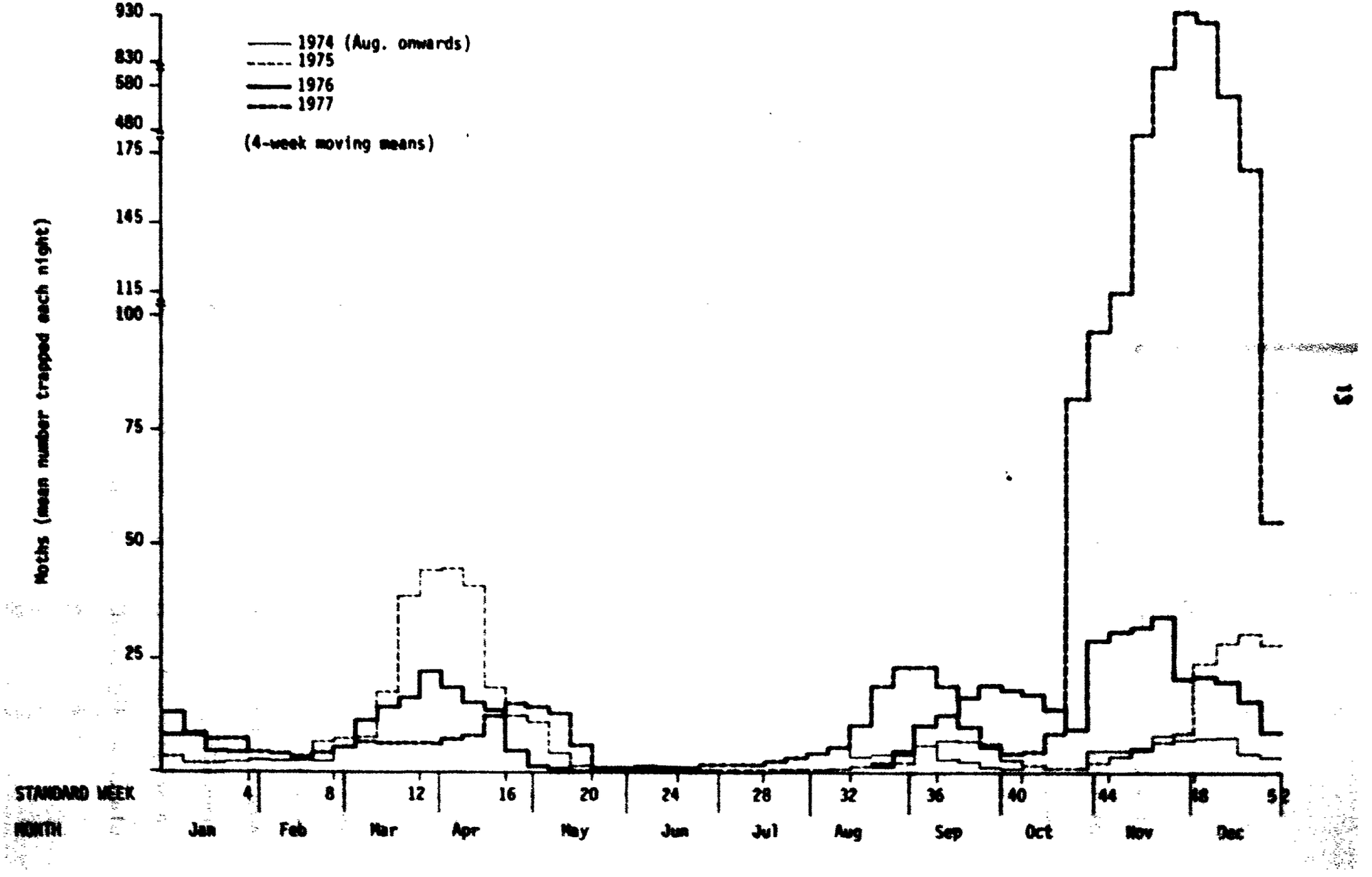


Fig. 3: Catch of Heliothis armigera (Hübner) at light trap No. 1, ICRISAT Center, (Aug 1974-Dec 1977)



Field trials have been initiated to determine if sex lure traps provide a better method than light for early detection of low populations of this noctuid in summer months. Water traps with virgin females in vertisol watersheds attracted more moths at 2.8m above ground - six compared to one at 0.9m in mid May with 36 opposed to two in end May-early June (only one male was trapped in three light traps during this latter period). Work on this important aspect will be intensified.

Preliminary field tests in collaboration with Boyce Thompson Institute, USA using a local strain of Nuclear Polyhedrosis Virus obtained from the Department of Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu for control of *H. armigera* larvae in chickpea were carried out. These showed that a significant reduction in larval numbers could be obtained with high dosages within 14 days of application. There was an increase in larval numbers in plots treated with adjuvants.

3. SURVEYS

In the year surveys of natural control agents of *H. armigera* were intensified in Andhra Pradesh. Over 12,000 larvae were obtained from selected cereals and legumes in eleven districts of A.P. in the period August 1977 - March 1978 (see Table 3). For the second year Dipterans predominated in larvae from pigeonpea while Hymenopterans were dominant in sorghum and chickpea and Nematithids in groundnut. Cropping patterns played an important role on distribution and abundance of parasitoids.

In general, the parasitism levels by Dipterans were higher on larvae collected from intercropped sorghum (August/September) and pigeonpea (October/November) in cotton growing areas. Levels were higher in mixed/intercropped sorghum - 20 percent compared to 13 percent in sole crop (in 2110 and 628 larvae, respectively). However, larvae from sole crop pigeonpea had higher parasitism levels - 27 percent compared to 18 percent in mixed/intercrop (in 827 and 5484 larvae, respectively). Mermithids were active in alfisols only in the rainy season.

On chickpea the parasitism levels declined as the season progressed (January through March). The high parasitism levels recorded on intercropped pigeonpea by Dipterans in some regions (e.g., 50 percent in district Adilabad with upto 75 percent in one field) was possibly the result of a parasitic shift from the main cotton crop. Larval and pupal mortality (other than by parasitoids) was higher on sorghum (12 percent) compared to pigeonpea and chickpea (3-4 percent).

Data so far obtained indicate that the conservation and encouragement of natural enemies is a potential means of providing more effective management of *H. armigera* populations especially in subsistence/mixed farming where insecticidal control is often uneconomical and beyond the reach of most farmers. It was again observed that diapausing pupae were produced only from larvae obtained from pigeonpea (8.5 percent from 6311 larvae) and chickpea (0.6 percent on 3008 larvae) from surveys. Moths from these pupae emerged in April/May. Two dipteran parasitoids, *Goniophthalmus halli* Mes. and *Carcelia illota* Curran. were recovered from the diapausing pupae.

Hyperparasitism was observed on cocoons of *Diadegma* sp. - a major larval parasite of *H. armigera*. Upto 34 percent cocoons on sorghum and 24 percent on chickpea yielded hyperparasites. *Habrocytus* sp. was the main hyperparasite on sorghum and *Brachymeria* sp. on chickpea in surveys.

4. FIELD TRIALS ON MIXED AND INTERCROPPED SORGHUM/PIGEONPEA

A large scale (total area - 14 ha and individual plot - minimum 0.25 ha) replicated trial using sorghum (CSH-6) and pigeonpea (ICP-1) was sown in low fertility conditions in mid to late June at 7 locations - 2 locations each in alfisols and vertisols of Research Center and 3 locations in vertisols in adjoining villages. Mixed crops were only grown at the Research Center as the farmers refused to grow a mixed crop with the hybrid sorghum. The treatments were sole crop of pigeonpea [PP], sorghum intercropped with pigeonpea at full stand [S/PP] and at half stand [S/PP($\frac{1}{2}$)] and sorghum with pigeonpea seeds mixed and broadcasted [S+PP($\frac{1}{2}$)]. Sorghum in the trial was not sprayed but pigeonpea had a spray/no spray split between the locations at the Research Center and within each location in the three farmers' fields.

4.1 Sorghum

No significant differences in levels of shootfly, *Atherigona soccata* Rond. attack were recorded on sorghum sown mixed or intercropped with pigeonpea with equal plant populations. Twenty three days from emergence highly significant differences ($P<0.01$) in levels of shoot fly attack were observed between these locations within a radius of 15 km,

with high incidences at the Research Center and low in the adjoining villages. The percentage of plants with eggs and dead hearts ranged from five to fifty and two to twenty, respectively and the number of eggs and dead hearts/100 plants from five to 76 and two to 20, respectively. Subsequent counts in August/September indicated that though there was a tendency for increased shoot fly incidence with decreased pigeonpea populations (from 29 to 17 thousand/ha), this was not statistically significant. Location differences were once again highly significant. In early September there were more plants with dead hearts on alfisols than vertisols (42 to 43 percent opposed to 23 to 34 percent, respectively). This was supported by observations on 100 plants when 72 to 77 dead hearts compared to 46 to 67 were recorded. These data confirmed last seasons' findings that a delay in sowing and a slow initial growth are important factors in encouraging shoot fly attack on intercropped sorghum in low fertility conditions in alfisols. At harvest upto 22,500 dead hearts/ha were recorded in one of the alfisols fields at Research Center with 110,000 intercropped sorghum plants/ha.

Damage by stem borer, *Chilo partellus* Zeller. was low. In early September, intercropped sorghum in alfisols carried significantly ($P<0.05$) more larvae of a lepidopteran cutworm, *Mythimna separata* Walker than in vertisols (58 to 80 compared to 14 to 32/100 plants, respectively).

Damage by earhead bugs, *Calocoris angustatus* Leth. was high on intercropped sorghum with upto 82% earheads affected in some locations. This was related to slight delay in flowering and maturation. Healthy

earheads yielded 4.2 kg grain/100 heads compared to 2.7 kg and 0.5 kg from 100 moderately and heavily attacked earheads, respectively. A measure of grain yield loss was obtained by calculations from actual and potential weight of the grain assuming all harvestable earheads had been healthy. Losses were low at village sites compared to ICRISAT Center - 7 to 15 percent opposed to 17 to 44 percent.

Studies on the pest-parasitoid ratio in mixed/inter cropping was further intensified in 1977/78. Highly significant differences in both egg number of *H. armigera* and egg parasitism by *Trichogramma* sp. were observed on intercropped sorghum at and around Research Center (Table 7). At the Research Center the levels were once again higher in vertisols.

Subsequently a collection of larvae from all seven locations revealed that the differences in larval parasitism levels were highly significant by location ($P<0.01$) - there were higher levels at the Research Center (35 to 60 percent) than at the village sites (19 to 27 percent). Of the eight larval parasitoid species recovered (Diptera-3, Hymenoptera-4 and Hermithid-1), *Diadegma* sp. was most important on sorghum parasitising 35 to 57 percent larval population at the Research Center and 8 to 17 percent in the village sites.

Sorghum in mixed/inter cropping was an important source of buildup of *Trichogramma* sp., an egg parasite and *Diadegma* sp., a larval parasite of *H. armigera*, but this was of no advantage to the immediate intercrop pigeonpea in this region as this parasite complex that builds up in *Heliothis* on sorghum does not transfer with the pest to pigeonpea.

Table 7. Mean egg numbers of *Heliothis armigera*/10 earheads of intercropped sorghum (CSH-6) with pigeonpea (ICP-1) and egg parasitism (%) by *Trichogramma confusum* Viggiani on 7 fields in and around ICRISAT Center (A.P.), 1977-78.

	Location	Soil	Field	Mean eggs/ .10 earheads* (No.)	Eggs parasitised (%)
A.	Research Center	Deep Vertisols	1	31.2	49.0 (44.4)
			2	66.2	61.1 (51.4)
		Alfisols	1	14.5	42.0 (40.1)
			2	20.0	56.7 (48.9)
B.	Village sites	Vertisols	1	13.2	24.1 (29.0)
			2	16.7	26.6 (27.2)
			3	11.5	14.5 (19.4)
	LSD (5%)			15.8	(13.5)
	SE ±			6.4	(5.5)
	F-test (Field)			**	**

* On 5 days old earheads after 15 days of 1st earhead emergence.

** Highly significant ($P<0.01$)

Figures in parentheses are the Arc sine transformed values used for analysis.

We hope to improve our understanding in this complex area in coming seasons and attain an ability to predict what effects parasitism has in cereal/legume cropping systems.

4.2 Pigeonpea

There were no significant differences in pest numbers, pest-parasitoid ratios and insect induced final yield losses between intercrop [S/PP(½)] and mixed crop of pigeonpea/sorghum [S+PP(½)] with equal plant stand. However, significant differences in these factors were observed in blocks with solecrop and intercropped pigeonpea [PP and S/PP]. Plant population levels of pigeonpea were kept constant in these two crop systems.

At the Research Center the number of eggs laid and number of larvae of *H. armigera* were far higher on unsprayed crop grown in vertisols than in the alfisols (a similar trend appeared in the moth numbers trapped at light). The first peak of oviposition occurred on a moonless night in November at all the locations. A similar situation was observed in the intercrop grown at the village sites. No yield was obtained from the early flower flush produced in unsprayed pigeonpea in deep vertisols, since the large numbers of larvae which occurred even consumed flower buds, leaves and apical tips. This was a result of migratory influx of moths in this season but such situation made final yield loss assessments very difficult. The loss of the first crop resulted in a second flower flush in intercrop and even a third flush in solecrop pigeonpea. A second and third oviposition peak was observed 5 to 7 days prior to a moon less night

in January and on a moon less night in February. More flowers were produced in alfisols (Fig. 4). Significantly more eggs and larvae/100 terminals of pigeonpea were present in intercropped blocks at peak oviposition than in solecrop blocks, a repetition of 1975-77 findings. A similar trend was found with eggs and larval numbers of Lycaenids and plume moths. As expected there was no correlation in ovipositional behaviour of Lycaenids and lunar phase.

Over 5100 larvae of *H. armigera* were collected from flowering pigeonpea in this trial. This overall larval parasitism by Diptera was again higher (23.8 percent) than Hymenoptera (3.2 percent). The levels were higher at the Research Center than in the village sites (29 percent opposed to 14 percent), on unsprayed than on sprayed crop (32 percent to 17 percent) and in intercrop pigeonpea as opposed to solecrop blocks (27 percent to 23 percent) (Table 8).

The highest parasitism levels were obtained in early February (63 percent) and once again Dipterans predominated, parasitising 58 percent larvae collected. These Dipterans are of less importance in affecting the immediate pigeonpea yield since they killed larvae when they were in prepupal or pupal phase i.e., after the host larva already caused pod damage. In contrast to the situation on sorghum the egg parasitism levels on pigeonpea were almost nil - a total of 18 egg parasites reared from a collection of over 5000 eggs.

A collection of larval Lycaenids and *Adisura atkinsoni* Warr. (200 each) from an unsprayed intercrop pigeonpea grown on vertisols in mid

Fig. 4: Light-trap catches of Heliothis armigera (Hübner) in relation to flower, egg, and larval numbers/100 terminals on intercropped and sole-cropped pigeonpea on Vertisols and Alfisols, ICRISAT Center, 1977-1978.

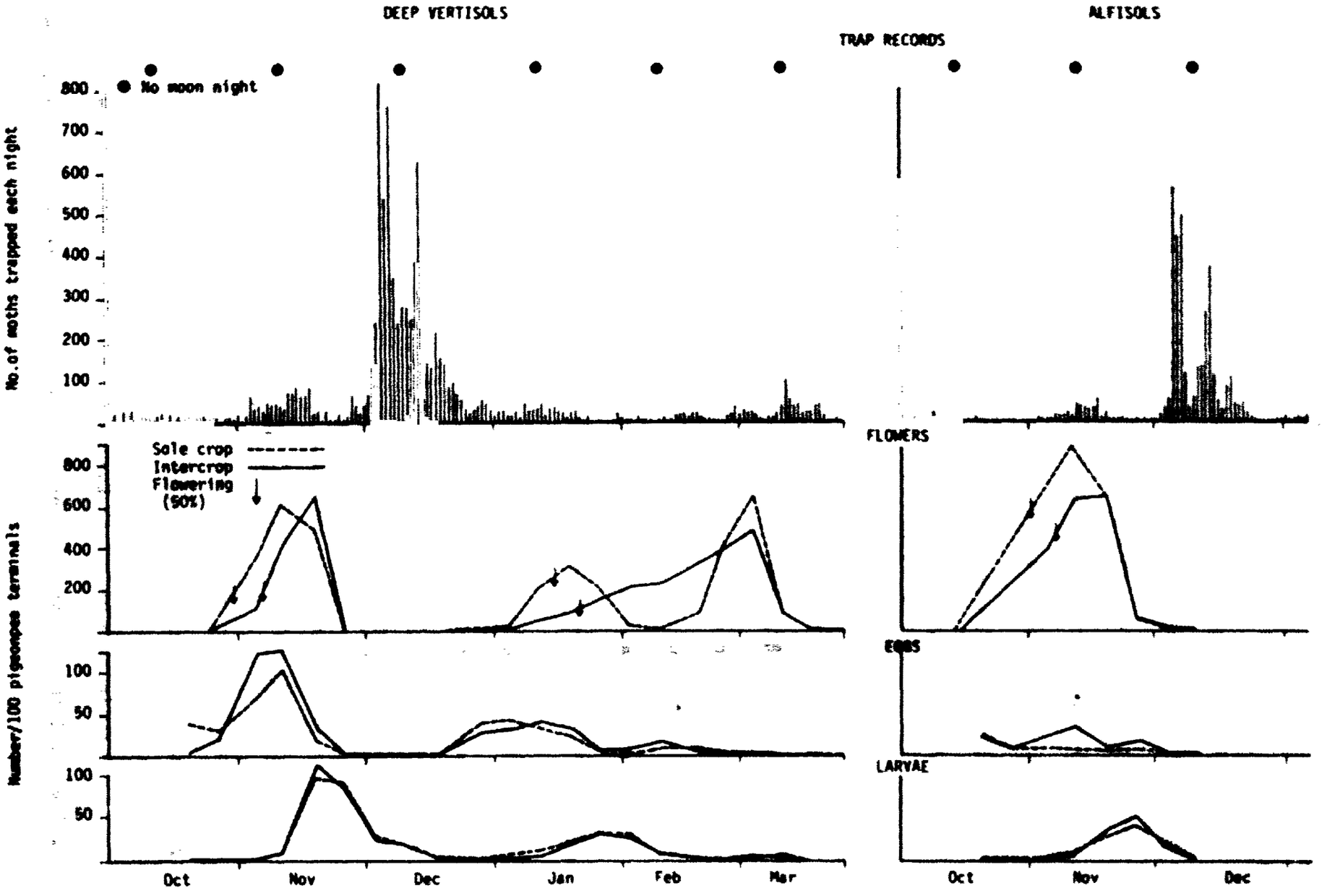


Table 8. Parasitism levels (%) on field collected larvae of *Heliothis armigera* (Hubner) from solecrop and intercrop pigeonpea (ICP-1) with sorghum (CSH-6), ICRISAT Center and adjoining villages, 1977-78.

Particulars	Parasitism levels (%)										
	Nov.		Dec.			Jan.		Feb.		Mar.	Overall
	14	26	2	10	17	3	19	1	14	3	
I. Location effects											
1. Research Center		8.6		48.8	47.2	32.0	36.5	63.3	50.3	17.0	28.6
2. Adjoining villages	1.8		15.6		27.3						14.2
II. Soil effects											
1. Vertisols	1.8	9.9	15.3	52.9	40.9	28.8	36.5	63.3	50.3	17.0	29.9
2. Alfisols		7.4		11.1		25.3					13.3
III. Cropping systems effects											
1. Solecrop	0.0	6.7	16.8	39.3	42.8	29.5	30.0	57.0	47.6	16.3	22.8
2. Intercrop	2.4	9.3	15.1	52.1	40.7	32.8	38.7	65.3	51.9	17.4	27.0
IV. Pesticide effects											
1. Sprayed crop*	0.0	7.5	15.8	7.1	11.1	38.8					16.5
2. Unsprayed crop	3.2	9.8	20.3	50.1	43.7	25.3	36.5	63.3	50.3	17.0	30.5
V. Time effects	1.8	8.6	15.6	48.8	40.9	32.0	36.5	63.3	50.3	17.0	25.9
	(7.9)			(29.3)		(33.5)		(59.4)		(17.0)	
No. of larvae incubated	167	1600	818	451	208	800	400	400	171	176	5191
	(1767)			(1477)		(1200)		(571)		(176)	

Figure in parenthesis is for the given month.
* Crop sprayed twice with DDT-50% (W.P.) @ 2 kg/ha in 200 l in early/mid November and late November/early December, respectively.

February gave 36 percent and 27 percent parasitism levels, respectively. Hymenopterans were predominant in the Lycaenids and Dipterans in the latter pest.

The sprayed trial in deep vertisols was harvested in 169 to 170 days compared to 260 to 270 days unsprayed intercrop trial. In general, the physiological maturity of intercropped pigeonpea was delayed by 10-15 days compared to solecrop pigeonpea.

Data obtained on pigeonpea [PP and S/PP] at final harvest at Research Center are summarised in Table 9. Significantly more pods/ plant were produced in solecrop blocks - 4325 opposed to 2234 pods/25 plants in intercrop situation ($P<0.05$). The final loss in seed weight due to insect pests was significantly ($P<0.05$) more in intercrop blocks - 50 percent opposed to 30 percent in solecrop pigeonpea. Insect damage was also reflected by calculating shelling percentages from bulk harvest, percentages were significantly lower from intercrop blocks - (44 percent opposed to 59 percent, respectively). Significantly higher yields were obtained in solecrop (509 kg/ha) than in intercrop block (202 kg/ha) ($P<0.05$). Losses were significantly lower in sprayed blocks (27 percent opposed to 54 percent) ($P<0.05$).

In village sites pest-numbers, parasitism levels and yield losses on pigeonpea were lower than at the Research Center. At one site irrigation of the flowering intercrop hybrid sorghum in mid-late September subsequently gave significantly high flower production/100 terminals of

Table 9. Final harvest assessments on solecrop and intercrop pigeonpea (ICP-1) with sorghum (CSH-6), ICRISAT Center, 1977-78.

Pigeonpea grown	Plants/ ha	Pods/ 25 plants	Yield/ ha(kg)	% yield loss	Shelling percentage
Intercrop (S/PP)	27818.1	2234.1	202.1	50.1	44.1
Solecrop (PP)	26545.4	4325.3	509.3	29.9	58.6
LSD (P <0.05)	2306.4 NS	1015.5 *	205.2 *	9.2 *	8.6 *

pigeonpea than in unirrigated sites (802 opposed to 412 at peak flowering), more egg and larval numbers of *H. armigera* (eggs - 107 opposed to 20 and larvae - 46 opposed to 9 at peak activity period), high larval parasitism levels (23 percent opposed to one percent) and increased insect-induced yield loss at final harvest (45 percent opposed to 18 percent) ($P<0.05$). A lesser yield/ha. of pigeonpea was obtained from the irrigated field compared to the unirrigated sites (446 kg opposed to 534 kg).

5. VILLAGE LEVEL OBSERVATIONS ON INTERCROPPED PIGEONPEA

Useful entomological observations on intercropped pigeonpea from a village level study in collaboration with economics group were made. Data obtained from the selected villages in Andhra Pradesh and Maharashtra indicated that in general, the intercropped pigeonpea with low plant population at subsistence farming level was attractive to ovipositing moths and had high larval populations. Heavy losses in unsprayed situations were observed (e.g., in Aurepalle and Kanzara villages of Andhra Pradesh and Maharashtra, respectively). Parasites affected upto 25 percent of larvae and Dipterans were once again predominant on pigeonpea in cotton growing areas (e.g., in Kanzara). Loss assessments at harvest showed that unsprayed crop suffered 60 to 64 percent loss (e.g., in Aurepalle and Kanzara) compared to only 8 percent when two DDT sprays were used in Allapur near Tandoor in district Hyderabad, A.P. Factors such as low plant population with high pest numbers, absence of egg parasites, low larval parasitism by Hymenoptera and no spraying measures were mainly responsible for high yield losses on intercropped pigeonpea in these areas.

6. LIGHT TRAP STUDIES AND INSECT FAUNA AT RESEARCH CENTER

Dissections of trapped female *C. partellus* have revealed that unlike *H. armigera* all *Chilo* moths were mated and carried only one spermatophore/female. *Heliothis* moths carried upto 5 spermatophores. The trap catch for November/December in some pest species viz., legume borers - *H. armigera, Maruca testulalis* Geyer.; *Etiella zinckenella* (Tr.), *Adisura marginalis* Walker., *Adisura stigmatica* Warr. and two important cotton pests - *Earias vittella* F. and *Dysdercus* sp. was unexpectedly high this year (Table 10). These differences were presumably due to unusual cyclones experienced at Western coastal region of Southern India in November/December, 1977.

Cereals were very badly affected by a invasion of *Mythimna separata* Walker (see Table 10). The attack started in mid August during the wet spell and by mid September many cereal trials at Research Center were ruined since the leaves of millet, maize and sorghum were stripped. Cereals in vegetative phase carried more larvae than in reproductive stage.

Diapause has been observed in *H. armigera, Heliothis assulta* Guenee, *Cydia ptychora* Meyr, *E. zinckenella, A. stigmatica, Acherontia styx* W. and *Diacrisia obliqua* Walk. The most significant pests, beneficial fauna and hyperparasites on range of crops were authenticated.

Regular field counts and light trapping of over 55 pests and beneficial insects of SAT on cereals and legumes for the past 4 seasons

Table 10. Light trap catches of selected lepidopteran legume borers, cotton pests and cereal cutworm at C.I. Building, ICRISAT Center, 1974-77.

Year	No. of adults trapped							
	Nov. - Dec.							Aug. - Sep.
	Lepidopteran legume borers					Cotton pests		Cereal cutworm
	Heliothis armigera (Hubner)	*Maruca testulalis* Geyer.	*Etiella zinckenella* (Tr.)*	*Adisura marginalis* Wlk.**	*Adisura stigmatica* Warr.***	*Earias vittella* F.	*Dysdercus* sp.	*Mythimna separata* Walk.
1974	349	1650	-	-	-	2509	1136	0
1975	819	2694	570	42	627	893	849	4
1976	1501	603	2150	169	2416	9549	1530	13
1977	29360	1511	4560	1106	6645	8142	13682	493
								(3504)

*,**,*** - Monitoring started from February, June and November 1975, respectively.

Figure in parenthesis is from a trap in vertisols watershed.

is proving useful. This basic information obtained on seasonal variations will be utilized, hopefully in the forecasting and in the development of pest-management strategies at a SAT farmer level, particularly in mixed and subsistence farming.

7. LOOKING AHEAD

Entomological work on intercropping trials will intensify with fewer treatments, increased plot size and more replications. Solecrop sorghum plots will be added to monitor differences in pest-numbers if they exist and comparisons made with "off station" situations. The importance of plant type, plant population, various crop proportions, planting configuration, fertilizer levels and various cultural practices need investigations in subsequent years. With the establishment of the cooperative programmes, including those in India, comparisons of the pest/parasite situation on cereal/legume mixed cropping in different SAT regions will be made. We plan to establish a light trap grid at cooperative centres.

Survey of parasitoids of *Heliothis armigera* (Hubner) will be extended to other areas of SAT. Further data will be obtained on extent and factors governing its natural control in cereal/legume mixed crops, both locally within the sub-continent of India and African SAT. Factors governing the crop preference in egg and larval parasitoids of *H. armigera* will be studied.

Collaboration with COPR, CIBC and BTI on expanding work on bio-control in mixed farming is being discussed. A close liaison with national dry land farming scheme, IITA and CIAT on mixed/inter cropping will be maintained.

The provision of training to the young entomologists from developing SAT regions will be increased. Scope is tremendous for such training particularly in mixed and subsistence farming.