Progress Report - 9

Cropping Systems (Entomology)

Cropping Entomology

Report of Work

1981-82

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

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CROPPING ENTOMOLOGY

PROGRESS REPORT

1981-82

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GENERAL

We continued the identification of pests and parasites on crops and other hosts, studied their seasonal variation and how they affect and are affected by different crops, crop systems and seasons. Surveys of the parasites and predators of Heliothis were continued and attempts were made to rear some. The pest problems of sole and intercrops, using sorghum/pigeonpea, received continued attention both at the research centre and in farmers' fields. Maize/pigeonpea intercropping was also studied. More emphasis was, however, given to the On-farm testing of the ICRISAT Vertisol watershed technology at Taddanpally, a village 43 km north-west of ICRISAT center.

ON-FARM RESEARCH (TADDANPALLY)

In this year we concentrated much of our work in the farmers' fields of Taddanpally, 43 km from ICRISAT centre where farmers were persuaded by the District Department of Agriculture to test the ICRISAT Vertisol watershed based cropping technology. In the 15.42 hectares area of the technology testing the following crop systems were grown.

Kharif	Rabi	Hectares
Sorghum		0.20
Sorghum /pigeonpea		7.32
Sorghum	chickpea	0.15
Maize		0.60
Maize /pigeonpea		0.69
Maize	chickpea	0.52
Maize	safflower	0.86
Mungbean	safflower	0.47
Mungbean	chillies	0.25
Mungbean	chickpea + sorghum	3.36
Fallow	chillies	1.00
		15.42

We recorded the populations of the insect pests and their natural enemies, mainly on cereals and pulses, and monitored the farmers pest control efforts.

Pests and their natural enemies

The incidence of some of the pests recorded on 39-41 day old sorghum and maize in given in table 1. The sorghum dead-hearts caused by shootfly *Atherigona soccata* were less than 2%, both in the kharif

Table 1. Percentage infestation on 39-41 day old kharif sorghum and maize by different pests, at Taddanpally Vertisol watershed, 1981-82

Crop systems	Percent plants infested with**					
	Shoot fly eggs	Shoot fly dead hearts	*Chilo* pin-holes	*Chilo* dead hearts	Aphids *R. maidis*	*Mythimna* spp
Sole crop*						
Maize	0.0	0.0	1.7	0.5	81.4	1.7
Intercrop						
Sorghum/ pigeonpea	2.0	1.1	2.3	1.0	93.9	6.5
Maize/ pigeonpea	0.0	0.0	1.5	0.6	81.2	0.8

*Sole sorghum was killed by *Striga*

**Observations were made on 2000 plants

and rabi, even though three fishmeal traps that were operated in the watershed caught 19925 adults in August and 9212 in November (Table 2). The low incidence of the shootfly in the kharif could be because of the early sowing (early June) of the crop which resulted in the escape of the vulnerable stage of the crop which is the seedling stage.

The dead hearts caused by the stem borer Chilo partellus were also low, being around 1 per cent both in the sorghum and maize. The catches in three water-based sex-pheromone traps that were operated in the watershed were low except in February and March. These catches may have been the result of the emergence of moths from the stalk left over in the fields after harvest. In splitting the stalks after harvest, 10% stalks of the kharif and 15.7% of the rabi were found to contain Chilo larvae.

Mythimna spp caused little damage. The aphid Rhopalosiphum maidis was present on almost all plants of sorghum and maize but caused little stunting. Other pests including Calocoris angustatus, Eublemma siliculana and Euproctis subnotata were also present but in insufficient populations to cause concern. The lady bird beetle Menochilus sexmaculatus was found actively feeding on aphids on sorghum and maize.

Heliothis population

Heliothis armigera was recorded across all the crops in the watershed. In July-August it was on mungbean, in August-September on sorghum and maize, in October-January on pigeonpea, chickpea and safflower (Fig. 1). Rabi sorghum had small population in January-February. The counts on these crops were compared with the catches

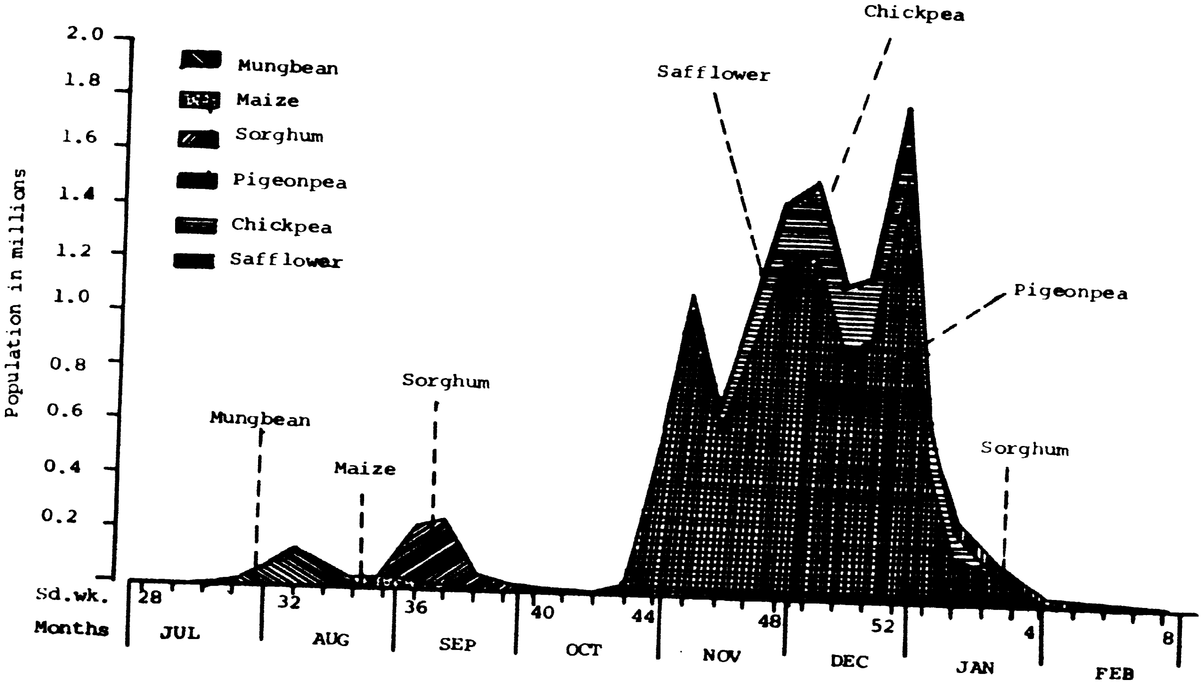
Table 2. Monthly catches of sorghum shoot fly *Atherigona* spp and the stem borer *Chilo partellus* (Swinhoe) in three traps at Taddanpally Vertisol watershed, 1981-82

Month/year	Shoot fly	Stem borer
June* 81	5	5
July	6975	20
August	19925	49
September	16500	6
October	8082	7
November	9212	7
December	8342	69
January 82	3301	63
February	203	195
March	29	296
April**	1	5

*Catches from 15-30th June

**Catches from 1-8th April

Fig. 1: Total population of *Heliothis* larvae on the crops in Taddanpally Vertisol watershed, 1981-82



in two sex-pheromone traps which were operated throughout the year on the bunds. The catches in relation to the total estimate of the larval population in the Vertisol watershed are given in Fig. 2. H. armigera threatened pigeonpea from the time of flowering. We recorded its population in most of the fields and advised the farmers on the spraying of the crop. The mean summarised data recorded from the pigeonpea for this pest and its parasitism are given in table 3. Egg parasitism, as expected, was nil but up to 10% of the larvae were found parasitised, largely by the dipteran Carcelia illota.

On sorghum and chickpea, Heliothis larvae were found to be greatly parasitised (50-60%) by Campoletis chlorideae. Of the other pests, the podfly Melanagromyza obtusa was important on pigeonpea, but was studied only in the pod analysis work.

Plant Protection

Most of the crops grew well throughout without any need for insecticidal application but the pigeonpea and chickpea had more attack of Heliothis and would have benefitted by well timed and correctly applied pesticide use. This problem, was anticipated and was discussed with the District Department of Agriculture well in advance so that they could supply insecticides and sprayers to the farmers. DDT was made available to the farmers at a 50% subsidy and sprayers were provided without any charge. The farmers were shown how to apply insecticide with the hand-operated and motorized knapsacks. Most of the farmers sprayed their crops twice with DDT and some used quinalphos (Ekalux) and endosulfan (Thiodon). An account of spraying undertaken by the farmers is detailed in Appendix 1.

Fig. 2: Comparison of total number of moths caught in pheromone traps and the larval population in the fields of Taddanpally Vertisol watershed, 1981-82

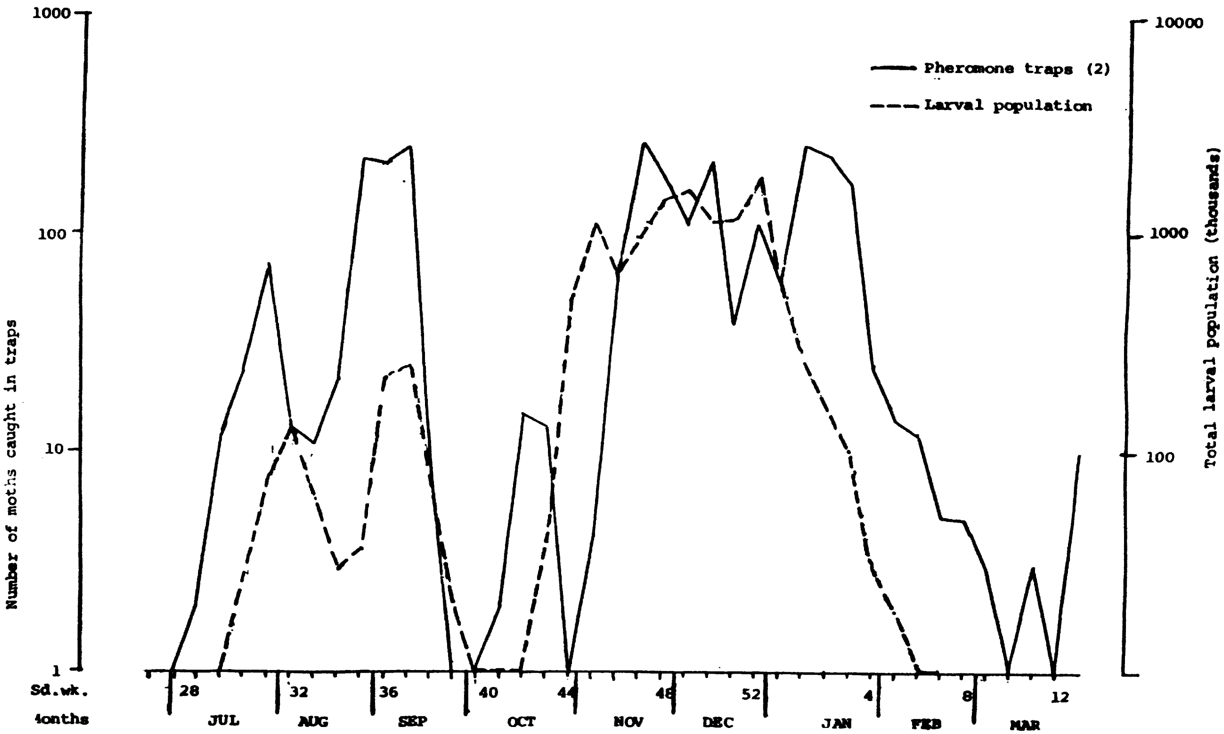


Table 3. *Heliothis armigera* populations at the peak activity period (November) and its parasitism recorded on pigeonpeas in sole and intercrops, Taddanpally, 1981-82

Cropy system & variety	Pest (No.)/100 terminals at peak activity		Percent parasitism at peak pest activity	
	Eggs	Larvae	Egg (n=50)	Larval (n=50)
Sole crop*				
Pigeonpea (ICP-1)	53.5	14.5	0.0	10.0
Intercrop				
Sor./PP (ICP-1)	30.5	17.0	0.0	8.0
Maize/PP (ICP-1)	14.0	21.5	0.0	10.0
Sor./PP (ST-1)	39.0	20.5	0.0	0.0
Maize/PP (ST-1)	24.0	13.5	0.0	0.0
SE ± m	15.5	6.6	-	4.3

*Sole pigeonpea (ICP-1) available in the nearby farmers' field was studied for no sole crop of pigeonpea was taken in Taddanpally Vertisol watershed.

In spite of the application of insecticides, pigeonpea crop suffered a great loss because of the following reasons.

i) Most farmers used DDT at a dosage much lower than the recommended 2 kg of 50% WP/ha. Other insecticides were also used at rates much lower than the recommended rates of the Department of Agriculture.

ii) Spraying was not done at the correct time, in spite of our advice. In most cases the farmers waited until the larvae were large before spraying.

iii) Farmers had no previous experience in handling insecticides, their formulations and sprayers, and they did not obtain a good coverage on the plants.

Pigeonpea pod analysis

We collected the pod samples from 8 plots and analysed them to determine the damage inflicted to pigeonpea pods by different pests. The results of the pod analyses are given in Table 4. The total pod damage averaged 62% of which borer damage averaged 45% and that of the podfly 19%. The damage due to other pests was negligible.

Table 4. Results of pod damage assessments of insecticide treated pigeonpea cultivars grown as intercrop in Taddanpally Vertisol watershed, 1981-82

Crop systems/cultivar	No. of pods analysed	Pod damage (mean) percent*					Yield kg/ha
		Borer	Pod fly	Hymenoptera	Bruchid	Total	
Sorghum/pigeonpea							
ICP-1	2950	46.5	26.5	0.9	0.5	68.0	677
ST-1	5063	46.1	13.9	4.9	0.7	62.3	203
Maize/pigeonpea							
ICP-1	7178	37.2	19.6	0.8	0.1	55.8	625
ST-1	3625	50.9	14.7	1.7	0.5	62.7	574
Mean		45.2	18.6	2.1	0.5	62.2	520
SE ± mean		6.2	4.6	0.7	0.2	4.4	10.5
CD at 5%		-	-	-	-	-	47.2
F test		-	-	-	-	-	S

*Figures are average of 2 replicates

LIGHT TRAP STUDIES

We have been monitoring insects with light traps since 1974. Until 1976, we had only one trap which was outside the ICRISAT boundary, about 200 m away from the northern fence. Since then, we have operated three traps placed suitably to sample cropping area of ICRISAT center. We have information on more than 70 species of insects including parasites and predators, over the years. This information is being utilised to monitor the infestation of insects in the field. To determine the populations of insects in different climatic areas and to study the possibility of migration, as has been suspected in some of the insects, we are operating traps at Hissar and Gwalior, and have convinced some of the national scientists to extend their cooperation. Out of eight other centres where we have supplied our traps, six centres are finding difficulties in operating them, particularly because of the problem of the theft of mercury bulbs and electricity failure. Figure 3 shows the trend of population of Heliothis armigera at four locations, ranging from the north to the south of India. The periods of activity of Heliothis differ from place to place. In general, north India (Hissar and Gwalior) witnesses most H. armigera activity around March-April while in the south the peak is around December. There is certainly a relationship between the peak catch period, the availability of vulnerable crops and the climate in a given area. Since we have a limited spread of operational light traps, we cannot yet determine the relative effects of crops and climate nor can we confirm the incidence of migration. For ICRISAT center we think that the three peak activity periods of Heliothis (Fig. 4) can be simply explained. The September peak corresponds to emergence of

Fig 3: Light trap catches of *Heliothis armigera* at four sites in India (June to May)

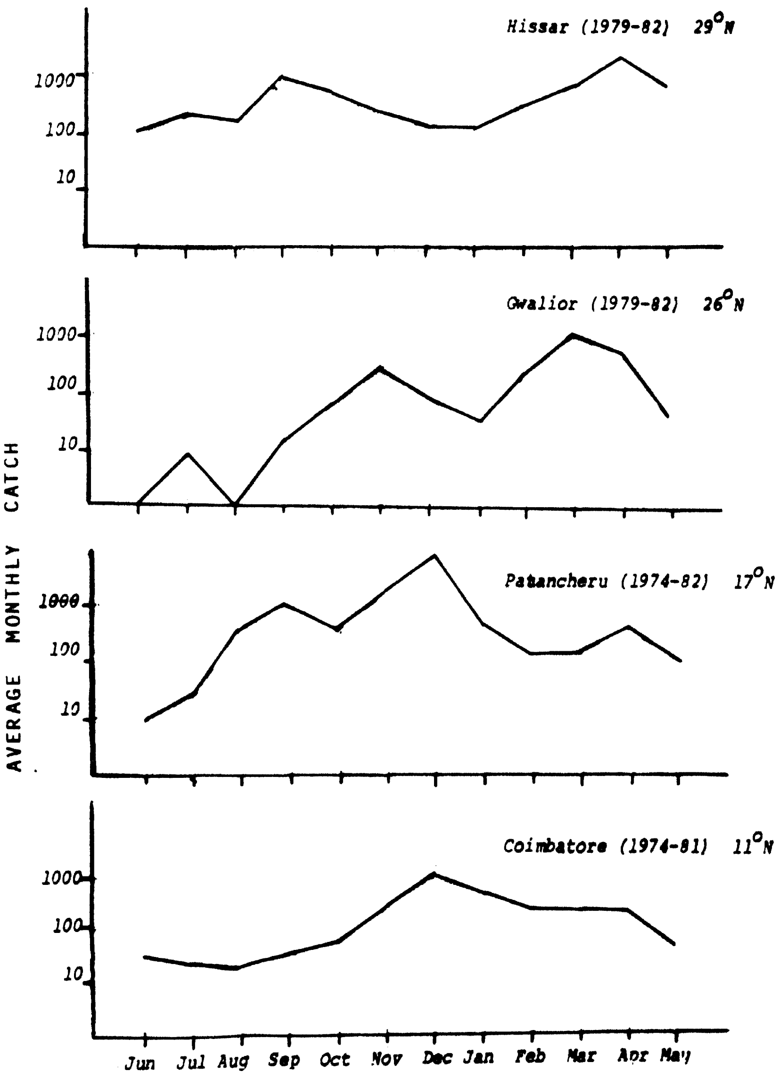
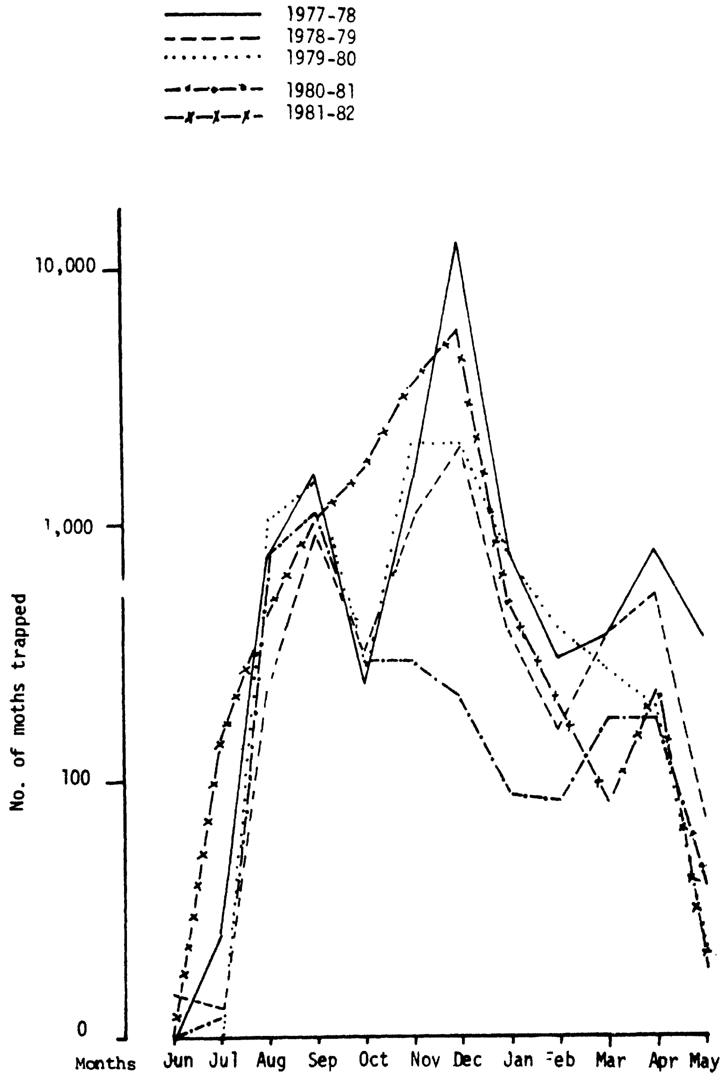


Fig. 4: Monthly catches of H. armigera in light traps at ICRISAT center from 1977-78 to 1981-82 (average of 3 traps)



pupae from groundnuts and attraction to the flowering and grain filling in sorghum and millet, the December peak to the flowering and podding in pigeonpea and growing of chickpea, and the April peak may be a result of the adults emerging from the large number of larvae which fed upon pigeonpea and chickpea. However, this peak appears to be too late to be explained by larvae feeding on the pulses, for populations of such larvae decline in February. The April peak of moths would appear to have little opportunity to infest any crop other than irrigated tomatoes in the farmers' fields.

To supplement the light trap network, we have started monitoring *Heliothis armigera* presently with synthetic sex-pheromone. The detailed account of this work can be seen in the Pigeonpea Progress Report - 9 (1981-82).

Light-trap catches of pests

In this year, the light trap catches of the pests of pulses were higher while those of cereals and other crops were lower than in the past 4 years (Table 5). The total catch of *Heliothis armigera* (37524), was much greater than the 5 year average (18007). The catch of *Adisura marginalis* was seven times and that of *A. stigmatica* and *Etiella zinckenella* two or three times greater than in the previous four years.

The catches of *Chilo partellus* were much less than the catches of the previous two years. *Mythimna* spp catches were also relatively low, and *Mythimna separata* catches have been declining over the recent years.

Table 5. Annual catches of some important legume borers, cereal and cotton pests and the *Spodoptera* complex in a light trap on the Vertisol watersheds, ICRISAT Center (1977-82)

Season	ANNUAL CATCH (No).													
	Lepidopteran legume borers					Cereal pests			Cotton pests			*Spodoptera* complex		
	Adisura marginalis	*Adisura stigmatica*	*Etiella zinckenella*	*Heliothis armigera*	*Maruca testulalis*	*Chilo partellus*	*Mythimna loreyi*	*Mythimna separata*	*Dysdercus* sp.	*Earias insulana*	*Earias vittella*	*Spodoptera exigua*	*Spodoptera litura*	*Spodoptera mauritia*
1977-78	327	1618	6542	16207	2872	3210	2802	3649	11389	524	10640	7949	3328	1283
1978-79	990	4212	6650	10633	1877	4088	12775	2097	13934	205	22732	7696	4406	1658
1979-80	343	1713	5385	18019	955	17882	11705	208	17492	325	19125	17546	3401	1333
1980-81	268	1586	7549	7653	1092	18635	7307	280	59345	290	13770	14294	10491	1124
1981-82	2835	7196	13002	37524	1000	4154	5603	186	4924	431	5610	5010	7708	1987
Average Annual Catch (No.)	952	3265	7825	18007	1559	9594	8038	1284	21417	355	14375	10499	5867	1477

The red cotton bug Dysdercus sp was also caught in lower numbers than in earlier years. The peak of 59,345 bugs in 1980-81 reduced to 4924 in 1981-82. The cotton bollworm Earias spp appear to have been reducing over the years.

Spodoptera spp have shown a slight decline over the years but S. litura has been taking a heavy toll of the rabi groundnuts. It is possible that the reductions of the catches are associated with more effective crop protection on ICRISAT center.

The distribution of catches of these insects over seasons of the year are given in appendix 2. The data indicate no sharp deviation from the general trend in the case of most of insects. For Heliothis armigera, however, there appeared to be continuous increase in population right from June-December, without the decrease in the month of October, which has been observed in all previous years.

Parasites and predators

We have not written much about light trap catches of parasites and predators in our earlier reports, but we have been recording data on these in each year. The catches from our Vertisol watershed light trap of the hymenopterans, Barichneumon sp, Enicospilus sp and Temelucha sp which are parasitic on Heliothis spp are given for the last three years in Table 6. All the three parasites were most prevalent from September-December. Over the three years the first two parasites did not differ much in their catches but Temelucha sp increased considerably in 1981-82, with peak activity in November and May.

Table 6. Monthly catches of three Hymenopteran parasites of *Heliothis* spp in the Vertisol watershed light trap (1979-82)

	Barichneumon sp			*Enicospilus* spp			*Temelucha* sp		
Month	1979-80	1980-81	1981-82	1979-80	1980-81	1981-82	1979-80	1980-81	1981-82
June	0	0	0	1	2	0	3	0	0
July	0	0	0	5	28	10	4	1	0
August	1	4	7	27	98	17	9	6	0
September	39	25	7	20	376	67	3	2230	12
October	13	45	40	13	372	133	94	564	177
November	7	7	19	69	25	124	102	1007	4871
December	10	0	7	274	22	150	104	23	90
January	2	0	2	80	24	73	20	17	4
February	1	0	0	199	32	151	28	1	5
March	0	0	0	42	42	56	63	14	239
April	1	0	0	4	9	11	57	62	163
May	0	0	0	0	1	3	7	20	124
Total	74	81	82	734	1031	795	494	3945	5685

The catches of two predators the reduviid Ectrychotes dispar and the preying mantids are given in Table 7. The preying mantids population remained more or less constant over the years but Ectrychotes dispar increased considerably.

In a monthly collection of Enicospilus spp from the light trap in 1980, which we sent to the British Museum, London, Mr Ian Gauld identified a total of 32 species of which 25 belonged to the genus Enicospilus, 4 to Netelia, 2 to Dicamptus and 1 to Leptophion. The distribution of these species over the months in 1980 is given in table 8.

Table 7. Monthly catches of two predators in the Vertisol watershed light trap (1979-82)

	Ectrychotes dispar			Preying Mantids		
Month	1979-80	1980-81	1981-82	1979-80	1980-81	1981-82
June	0	0	0	0	0	0
July	1	0	1	2	0	0
August	0	0	0	15	12	2
September	0	9	27	6	29	9
October	3	11	76	4	6	10
November	1	2	2	2	2	1
December	0	0	0	1	0	0
January	0	0	0	2	0	1
February	0	0	0	4	0	6
March	0	0	0	2	0	3
April	0	0	0	2	0	1
May	0	0	0	0	0	1
Total	5	22	106	40	49	34

Table 8. Monthly catches of <u>Enicospilus</u> and related species in three light traps at ICRISAT Center, 1980.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Total no. of specimens per species ss
Rainfall mm.	-	4.0	8.6	6.6	18.1	140.9	127.0	305.9	153.2	6.3	0.3	2.0	
OPHIONINAE													
<u>Enicospilus</u> <u>capensis</u> (Thunberg)	74	250	52	5	-	-	1	-	3	3	12	32	432
E. <u>heliothidis</u> Viereck	29	22	7	-	-	-	-	2	33	29	2	4	128
E. <u>signativentris</u> (Tosquinet)	-	-	-	-	-	3	4	27	53	6	-	-	93
E. <u>dolosus</u> (Tosquinet)	-	-	1	-	-	1	22	19	61	5	2	-	111
E. <u>bharatensis</u> Nikam	-	1	-	-	-	-	-	4	45	24	5	-	79
E. <u>xanthocephalus</u> Cameron	2	-	-	-	-	-	-	14	70	10	-	-	96
E. <u>lineolatus</u> (Roman)	-	-	-	-	-	1	2	4	33	2	1	-	43
E. <u>grandis</u> (Cameron)	-	-	-	-	-	-	3	-	-	2	28	3	36
E. <u>aciculatus</u> (Taschenberg)	-	-	-	-	-	-	-	-	2	2	2	-	6
E. <u>tricorniatus</u> Rao & Nikam	-	-	-	-	-	-	1	-	2	1	-	-	4
E. <u>melanocarpus</u> Cameron	1	1	-	-	-	-	-	2	8	9	-	-	21
E. <u>shinkanus</u> (Uchida)	1	-	-	-	-	-	-	10	32	11	2	-	56
E. <u>vestigator</u> (Smith)	-	-	-	-	-	-	1	3	12	2	-	-	18
E. <u>biharensis</u> Townes et. al.	1	-	4	-	-	1	-	1	5	5	-	-	17
E. <u>flavicaput</u> (Morley)	-	-	-	-	-	1	-	-	-	-	-	-	1
E. <u>ashbyi</u> (Brues)	-	-	-	-	-	1	8	2	1	-	-	-	11
E. <u>nigribasalis</u> Nikam	-	-	-	-	-	-	2	-	-	-	-	-	2
E. <u>retus</u> Gauld & Mitchell	-	-	-	-	-	-	3	2	-	1	-	-	6
E. <u>pilmus</u> Gauld & Mitchell	-	-	-	-	-	-	1	-	2	1	3	-	7
E. <u>enicospilus</u> Nikam	-	-	-	-	-	-	1	-	-	-	-	-	1
E. <u>javanus</u> (Szepligeti)	-	-	-	-	-	-	-	-	1	-	1	1	3
E. <u>yonezawanus</u> (Uchida)	-	-	-	-	-	-	-	-	12	4	-	-	16
E. <u>albiger</u> (Kriechbaumer)	-	-	-	-	-	-	-	-	3	1	1	-	5
E. <u>tribindus</u> Rao & Nikam	-	-	-	-	-	-	-	1	2	-	1	-	4
E. <u>breviterebrus</u> Nikam	-	-	-	-	-	-	-	1	-	-	-	-	1
<u>Leptophion</u> <u>maculipennis</u> (Cam)	-	-	-	-	-	-	-	-	-	2	1	-	3
<u>Dicamptus</u> <u>indicus</u> Nikam	-	-	-	-	-	-	2	-	3	1	1	-	7
D. <u>sinuatus</u> (Morley)	-	-	-	-	-	-	-	3	-	-	-	-	3
TRYPHONINAE													
<u>Netelia</u> (N.) <u>latro</u> (Holmgren)	15	1	-	-	-	1	1	4	63	365	19	1	470
<u>Netelia</u> (N.) <u>indica</u> Nikam	-	-	-	-	-	1	-	17	19	29	1	-	67
<u>Netelia</u> (minute species)	-	-	-	-	-	-	-	-	2	-	-	-	2
N. (<u>Apatagium</u>) <u>recta</u> (Enderlein)	-	-	-	-	-	-	-	-	-	1	-	-	1
Others	-	-	-	-	-	-	-	-	-	5	2	-	7
Total no. specimens per month N_m	123	275	64	5	0	9	52	116	467	521	84	41	1757
Total no. species S_m	7	4	4	1	-	5	14	17	23	23	16	4	
32 species in all													

STUDIES ON INTERCROPPING

For the past 5 years we have been studying the sorghum/pigeonpea intercrop in comparison with sole crops and have observed consistently that the intercropping has little effect on the pest incidence on the component crops but does have an advantage in reducing the incidence of some diseases. To confirm our earlier observations pertaining to this system, this year also we raised an unsprayed replicate mono vs intercrop trial of sorghum (CSH-6) and pigeonpea (ICP-1) on a fairly large field (each plot 0.4 ha) in the Vertisol watershed of the ICRISAT center. We also tested mono vs intercrops of maize (Deccan HY-101) and pigeonpea (ICP-1). Observations in farmers' fields on these cropping systems in villages Choutkur (45 km NW) and Tandoor (80 km SW) were also recorded.

Sorghum: The incidence of the shootfly Atherigona soccata and the stem borer Chilo partellus was, in general, lower than in the previous 2-3 years. At ICRISAT Center, 1.2% of the plants in the sole crops and 0.2% in the intercrops showed dead hearts due to shootfly. Chilo dead hearts, both in sole and intercrops, were below 1%. Maxima of 8 and 3 larvae of Mythimna separata were recorded per 100 earheads in sole and intercrops respectively. Maxima of 20 and 12% earheads were recorded to have Calocoris angustatus bugs in the sole and intercrops, respectively. The percentage of plants carrying aphids was in the range of 60-94% across both the systems.

Heliothis infestation was lower than in the previous year. We recorded mean maxima of 98 and 68 larvae/100 earheads in sole and intercrops, respectively, compared with 146 and 162 in the previous year.

Parasitism in Heliothis larvae was recorded to be 28.6% (n = 416) in the sole sorghum and 36.3% (n = 236) in the intercropped sorghum. However, low parasitisms were recorded in the farmers' fields (2 to 11%). Most parasitism was by Campoletis chlorideae. We recorded, at ICRISAT Center, an average of 22 cocoons of this parasite on 100 earheads compared to 32, 90, 58 and 38 in 1980-81, 1979-80, 1978-79, and 1977-78 respectively. Egg parasitism by Trichogramma spp was 58% (n = 200), a figure higher than any recorded at ICRISAT Center in the last 3 years (1980-81 - 40%, 1979-80 - 48%, and 1978-79 - 52%).

Maize: The incidence of the stem borer Chilo partellus was negligible, 0.1 and 0.4% plants showing dead hearts in the sole and intercrops respectively. The aphid population was predominant in the early stage of the crop and caused considerable loss of plants. An average of 78% of the plants were seen infested with aphids.

Heliothis infestation was also low. Larvae were seen on the top of the cob in the silk. Maxima of 13.5 and 16 larvae were recorded per 100 cobs in the sole and intercrops, respectively. The larval parasitism was also low, 8.9% (n = 34) and 3.0% (n = 33) in the sole and intercrops, respectively.

Pigeonpea: The pests' incidence until flowering, as expected, was negligible. The leaf webber Eucosma critica damaged some leaves, but its population did not exceed three larvae/plant both in sole and intercrops. The Heliothis incidence started from mid October with maximum egg laying in early November both at ICRISAT center and in the farmers' fields. At ICRISAT Center, during the peak activity period, 80 eggs/ 100 terminals were recorded in the sole crop and 183 and 86.5 eggs/

on the pigeonpea in sorghum and maize intercrops, respectively. Larval activity which followed closely the egg population, was recorded as 33.5 larvae/100 terminals in the sole and 28.0 and 31.5 in sorghum and maize intercrops, respectively (Table 9).

Egg parasitism, as expected, was very low (< 0.1%) on pigeonpea, although Trichogramma sp parasitised 58% of the eggs on sorghum. Further, hymenopteran larval parasitism, which was common on sorghum and maize, was absent on pigeonpea. Dipteran parasitism was also low (sole pigeonpea = 0.73% n = 275; pigeonpea intercropped with sorghum = 8.3, n = 244; pigeonpea intercropped with maize = 3.5, n = 262).

Insect induced yield losses, calculated by using the actual weight of damaged and undamaged pods and seeds and then calculating the potential yields had all pods been undamaged, are given in table 9. Potential yield loss was although low in maize/pigeonpea intercrop, its actual yield was lower. There appeared no significant differences in the yield and insect induced losses in sole and intercrops, but the land equivalent ratio of order of 1.58 - 1.84 indicated an advantage in terms of biological productivity of the intercropping systems.

The BW-4A field of the Vertisol watershed in which our trial was sited, this year, was heavily infested with Fusarium wilt which killed many plants. We counted the affected plants, both in the sole and intercrop pigeonpea and observed that the intercropping greatly reduced the disease incidence. In the sole crop we recorded 65% plants affected by wilt, but 14% and 34% in the sorghum and maize intercrops, respectively.

Table 9. *Heliothis armigera* (Hub.) at peak activity period and final harvest assessments on pigeonpea (ICP-1) grown as a mono- and intercropped with sorghum and maize, ICRISAT Center, 1981-82[a]

Crop systems	Population ('000 plants/ha)			Pest (No.)/100 teriminals at peak activity		Insect induced yield loss to pigeonpea[b]		Grain yield (kg/ha)			LER
	S	MZ	PP	Eggs	Larvae	%	kg/ha	S	MZ	PP	
Sole crop											
Sorghum	125.2							3601.3			1.0
Maize		70.1							2431.9		1.0
Pigeonpea			48.3	80.0	33.5	22.9	225.4			982.4	1.0
Intercrop											
S/PP (Inter)	137.1		46.7	183.0	28.0	31.5	238.5	3846.7		756.0	1.84
MZ/PP (Inter)		68.1	32.4	87.5	31.5	31.0	148.2		2654.6	478.7	1.58
SE ±	12.4	2.7	6.2	41.3	6.6	-	106.5	690.1	312.1	350.8	-

a - based on 2 sites; b - based on 25 plant analysis; NS - not significant

SURVEY - PARASITES AND PREDATORS

We have been investigating the parasites and predators of Heliothis, and their role in its control, over the last 6-7 years mainly by surveying the farmers' fields in different parts of India. An exhaustive list of the parasites recorded from the larvae collected from different crops, and the predators observed in the fields until 1981 can be seen in our Progress Report - 8 (1980-81).

Parasites: In this year we limited our survey to chickpea and covered about 200 km in the surrounding ICRISAT Center. We collected 4108 H. armigera larvae comprising of both small (1-2 instars) and large larvae (3-5 instars), and observed 50% parasitism in the small and 22% in the large larvae. Only hymenopterans emerged from the small larvae while only dipterans emerged from the large. Among the hymenoptera Campoletis chlorideae was predominant contributing 99% to the total parasitism in the small larvae. The egg and larval parasite Microchelonus curvimaculatus was very rare. Among dipterans Carcelia illota was the major, contributing 95% to the total parasitism. Other dipterans Palexorista sp Sturmiopsis inferens and Goniophthalmus halli were also recorded but were minor.

Predators: In this year, we concentrated on the mud wasps Delta spp that are predatory on Heliothis larvae. We reared them in a field cage and observed them in open fields at ICRISAT Center. We also recorded another species Delta pyriforme (Fab.), in addition to the earlier investigated D. conoideum and D. companiforme esuriens (Fig. 5). In the mud nests collected from the fields and that constructed in the field cage,

Fig. 5a: Three species of wasp found to prey on larvae of Heliothis armigera at ICRISAT center, 1981-82.

DELTA PYRIFORME (FAB.) | DELTA CONOIDEUM (GMELIN) | D. CAMPANIFORME ESURIENS (FAB.)

b: Delta pyriforme (Fab.) wasp attacking Heliothis armigera larva on pigeonpea.

we observed D. campaniforme esuriens preyed mainly upon 2nd and 3rd instar Heliothis larvae while the other two species preyed on the 4th-6th instar larvae. Several other lepidopteran larvae were also seen in the field collected nests, including Plusia spp.

We placed a field cage (2.5 x 2.0 x 1.5 m), containing a few individuals of each species, on Alfisol. A small pool of water was provided and Heliothis larvae were placed on pigeonpea plants grown in pots inside this cage.

The wasps were seen to drink water and then regurgitate onto soil and make small mud balls. Each mud ball was then carried between the fore legs and mouth parts to a solid surface and was used for the construction of the cells making up a "nest". In the cage the nests were built on the metal cage supports while in the fields they were found on rocks, trees and buildings. A single drink of water appeared to be sufficient for the preparation of two or three mud balls and five or six balls were generally required to construct each cell. In the cage, the nests consisted of 5 to 8 cells, but in the fields we have recorded up to 16 cells in a nest. Most nests found in the field were constructed with red soil.

After each cell is constructed the wasp then collects larvae, placing four to seven in each cell. The larvae are paralysed by stinging, pressed between the mandibles and then carried to the nest. A single egg is laid inside each cell, before or after the first larva is introduced

After filling, each cell is then sealed. Only the female wasps build the cells and collect larvae, the males appear to have no role except in mating.

The field collected adult wasps were fed with honey solution in our cage and lived for up to 67 days after capture. In the field we have observed them apparently feeding on the nectar of flowering plants, including Vernonia sp. Each female constructed and filled more than one mud nest. The time taken from cell closure to emergence of the young adult from the cell varied from 34 to 48 days for D. pyriforme and 30 to 40 days for D. conoideum.

The D. campaniforme esuriens wasps in our cage were not successful in reproduction for ants fed on the cell contents before the adult wasps emerged. We also recorded predation by ants in nests in the field. In addition we found that the parasites Chrysis fuscipennis Bruelle, Chrysis quaerita Nurse and Stilbum cyanurum (Forster) emerged from the cells of D. conoideum and D. pyriforme having fed upon either the lepidopteran larvae and/or the wasp larvae. The adults of these parasites were seen to follow the female wasps while they were constructing their nests. These elements obviously limit populations of wasps and hence the level of predation of Heliothis larvae. It is also probable that the activity of the wasps is limited by the non-availability of water.

LOOKING AHEAD

'On-farm' research will be intensified to understand complexities of pests and parasitoids in the real world situation and efforts will be made to demonstrate to the farmers an effective pest management practice in their own fields with whatever components that are available with, and can be made available to them by the national programs. This effort would certainly be of immediate relief to the farmers for they have been losing much of their pigeonpea crops to insect pests.

The study on the seasonal incidence of polyphagous pests Heliothis and Spodoptera will be intensified, covering many locations under the light and pheromone trap net-work and efforts will be made to study the role of environmental factors in determining the incidence of pests in time and space. The collaboration with the Centre for Overseas Pest Research and the Tropical Products Institute of UK, will be strengthened. Cooperation with the Pulse, Groundnut and Cereal Entomology Sub-programs will be sought as usual.

The pest/parasitoid complex in different cropping systems which are traditionally prevalent in the semi-arid tropics but not yet investigated will be studied both at the research centre and in the farmers' fields.

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Appendix 1. The details of insecticide application on pigeonpea at Taddanpally Vertisol watershed, 1981-82

Farmers' name	Plot No.	Area in ha	Sprays					
			1st		2nd		3rd	
			Insecticide	Date of application	Insecticide	Date of application	Insecticide	Date of application
Papaiah	1	1.1	DDT(682)	11.11.81	DDT(1182)	24.11.81	-	-
Lachaiah	4	1.1	Ekalux(102)	10.11.81	Ekalux(159)	27.11.81	-	-
Damoder Goud	5	0.73	DDT(890)	13.11.81	DDT(1712)	26.11.81	-	-
Arjun Goud	6	0.27	DDT(463)	4.11.81	DDT(1481)	16.11.81	-	-
Mallaiah	8	0.20	DDT(625)	5.11.81	DDT(1125)	18.11.81	-	-
Balaiah	9	0.25	Ekalux(148)	10.11.81	DDT(1000)	30.11.81	-	-
Buchaiah	10	0.29	Ekalux(172)	10.11.81	DDT(862)	30.11.81	-	-
Subhan Goud	12	1.5	DDT(529)	6.11.81	DDT(1833)	4.12.81	Thiodon(700)	30.12.81
Multani Sab	13	0.44	DDT(852)	13.11.81	DDT(1761)	30.11.81	Thiodon(700)	18.12.81
Pasha Sab	15	0.19	DDT(789)	13.11.81	DDT(1316)	8.12.81	-	-
Achtar Sultana	16	0.62	DDT(605)	13.11.81	-	-	-	-
Mahaboob Ali	17	0.54	DDT(833)	12.11.81	DDT(1852)	8.12.81	-	- -
Pasha Sab	20	0.19	DDT(789)	13.11.81	DDT(1316)	24.11.81	-	-

NB - Figures in parenthesis refer to the amount of actual angrediant of insecticide applied in kg/ha
DDT 50 WP, Ekalux 25 EC and Thiodon 35 EC were the formulations used by the farmers.
Recommended dosages of insecticides by the Dept. of Agriculture, Medak, A.P., were

DDT	2 kg of 50 WP/ha
Ekalux (Chuinalphos)	750 ml of 25 EC/ha
Thiodon (endosolfan)	2 litres of 35 EC/ha

Appendix 2. Quarterly seasonal distribution and annual catch of some important legume borers, cereal and cotton pests and the _Spodoptera_ complex in a light trap on the Vertisol watersheds, ICRISAT Center (1981-82)

Period	Percent adults trapped during 1981-82 seasons													
	Lepidoptera legume borers					Cereals pests			Cotton pests			_Spodoptera_ complex		
	Adisura marginalis	_Adisura stigmatica_	_Etiella zinckenella_	_Heliothis armigera_	_Maruca testulalis_	_Chilo partellus_	_Mythimna loreyi_	_Mythimna separata_	_Dysdercus_ sp.	_Earias insulana_	_Earias vittella_	_Spodoptera exigua_	_Spodoptera litura_	_Spodoptera mauritia_
June - August	0.56 (7.09)	0.35 (5.29)	0.17 (0.41)	3.66 (29.34)	1.80 (5.13)	1.44 (4.24)	3.34 (6.57)	16.66 (42.86)	9.24 (4.91)	1.62 (7.93)	1.66 (1.02)	29.48 (12.78)	4.63 (6.77)	2.76 (15.12)
September-November	89.91 (81.35)	19.68 (19.24)	13.68 (41.75)	45.05 (51.29)	75.20 (62.45)	41.21 (70.36)	70.81 (72.65)	80.65 (56.78)	78.23 (95.00)	87.71 (89.65)	38.62 (57.51)	24.75 (9.12)	56.98 (15.86)	89.78 (68.05)
December-February	9.18 (7.83)	77.84 (67.4)	64.93 (44.52)	49.69 (10.17)	22.60 (31.05)	21.96 (10.48)	4.85 (2.96)	2.69 (0.36)	12.35 (0.09)	6.03 (0.68)	55.58 (40.45)	14.41 (21.81)	7.80 (9.32)	5.50 (12.91)
March - May	0.35 (3.73)	2.13 (8.07)	21.22 (13.32)	1.60 (9.20)	0.40 (1.37)	35.39 (14.92)	21.00 (17.82)	0.00 (0.00)	0.18 (0.00)	4.64 (1.74)	4.14 (1.02)	31.36 (56.29)	30.59 (68.05)	1.96 (3.92)
Annual Catch (No.)	2835	7196	13002	37524	1000	4154	5603	186	4924	431	5610	5010	7708	1987

( ) Percent adults trapped during (1980-81) seasons.