PULSE ENTOMOLOGY (PIGEONPEA) REPORT OF WORK

(June 1982 - May 1983)

ICRISAT

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This report has been prepared to share the information that we have gathered in this year, with other scientists who have an interest in pigeonpea improvement.

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In this year the volume of data collected has expanded to an extent that it is no longer practical to print it all. Thus, in most cases summaries of the data are provided. Anyone with an interest in the more detailed data should contact us for further information.

INTRODUCTION

In previous reports we have introduced this report of work with a section that reported upon surveys of the pest caused problems on pigeonpea at ICRISAT Center, across India and internationally wherever we have opportunity to travel. This phase of our work is now complete and we are preparing the survey data of several years for publication.

In 1982-83 the pest caused problems on pigeonpea at ICRISAT Center could perhaps best be described as "average" or "normal". The major pest, as usual, was Heliothis armigera which build up to very large populations on pigeonpea in late November-December, a few weeks later than in most previous years. Thus the early maturing genotypes sown in June-July and flowering in October tended to miss the peak attacks by this pest, but the first flush of the mid maturity cultivars in our unprotected plots was virtually destroyed by Heliothis. The attacks by this pest on pigeonpea abated in January so that the populations at the flowering time of the late maturing genotypes were generally relatively low.

The second most damaging pest on pigeonpea at ICRISAT Center was the podfly, Melanagromyza obtusa, which was found throughout the season but, as usual, was most damaging in the late maturing cultivars and in the second flush of the earlier maturing types.

The hymnopteran pest, Tanaostigmodes sp. was very common in the pods in many fields, both in protected and unprotected conditions. Fortunately this pest is much less abundant in farmers' fields than on our research Center.

As usual, many other insects fed upon our pigeonpeas at various stages during crop growth, but none was of really widespread concern.

In our other trial centers, at Gwallor and Hissar, Heliothis was relatively unimportant on pigeonpea in this year but the podfly was relatively common, particularly at Gwallor.

Our cooperative network of light traps and Heliothis pheromone traps continued to provide valuable information on the incidence of Heliothis throughout India. Data from these traps will be reported separately.

Project: PP-Ent-9(81)

HOST PLANT RESISTANCE TO INSECT PESTS IN PIGEONPEA AND ITS RELATIVES, SCREENING AND IDENTIFICATION OF MECHANISMS

Objectives and Scope:

(a) Continuation of the work on identification of sources of pest resistance in the derivatives of Cajanus cajan x Atylosia hybrids.

(b) Refining the screening techniques and trial methodology, particularly in selecting lines resistant to Heliothis, podfly and with multiresistance factors.

(c) Incorporation of the promising pigeonpea cultivars and lines in a breeding programme for pest resistance in collaboration with breeders.

(d) Screening and selecting the lines from the crosses developed by breeders that are:

Resistant to attack from individual major pests; less susceptible to attack from the pest complex; tolerant to pest damage (including the compensatory habit) and yield more than the currently utilised cultivars under the farmers' conditions of no, or minimal, insecticide use.

(e) Multilocation testing of the Pigeonpea Entomology selections in India in close cooperation with AICPIP scientists and in other countries as opportunities arise.

(f) Studies on the mechanism of resistance in the pest tolerant and less susceptible lines in collaboration with other disciplines but particularly with biochemists both at ICRISAT and at the Max-Planck Institute for Biochemistry at Munich.

Trials 1982-83:

This year we conducted several trials under low input conditions on our Vertisol pesticide free blocks BUS-7B, -2B, -5A and -5D at Patancheru. Many of the trials and selections were grown simultaneously under protected conditions on the Vertisol block BP-6. Some of the promising lines were also grown on the Alfisol block (RUS-6C) for biochemical studies. An area of 3.25 ha was covered under this project at Patancheru. We also tested some of our early maturing cultivars at the Haryana Agricultural University farm at Hissar (on block 25; 0.1 ha) and the mid-late and late maturity selections were tested for podfly susceptibility at the College of Agriculture Farm, Gwalior (0.25 ha).

At Patancheru, endosulfan was used, directed mainly against the H.armigera attack from flowering onwards on the sprayed block. For reducing the multiplication of the hymenopteran pest (Tanaostigmodes) we also sprayed dimethoate.

On all the trials of promising materials, pests were counted at the podding stage. Pods were harvested at 70% maturity and pest damage assessments were recorded from pod samples. On some of these trials we collected the pods for damage assessments in two pickings, one from the first flush, which in some trials had been largely destroyed by H.armigera and the second from the compensatory, or ratoon flush. Harvested pod samples were separated and counted according to their damage characteristics and so we recorded percentage pod damage caused by lepidopteran borers (mainly H.armigera), podfly, hymenoptera (Tanaostigmodes sp.) and bruchids. The total percentage of pest caused pod damage was also determined, this commonly being less than the sum of the individual percentages, for some pods had been attacked by more than one pest group. Plant and plot yields of dry seeds were measured after threshing.

Germplasm screening:

Our germplasm screening block was sown at the end of June 1982. Unreplicated plots of 329 new accessions and 33 entries which failed to produce any results in previous trials, were sown. The plots, each of five hills were grouped in blocks of 25 entries each including a check cultivar. Each block was bordered with infestor rows that had been sown 10 days earlier; these included a mixture of Pant A1, Pusa Agetl, T-21 and ICP-1. The check entries were T-21 (early) ICP-1 (mid maturity) and NP(WR)-15 (late maturing).

At maturity individual plants were selected for reduced susceptibility to the major pests and high yielding characters. Later, the pods were collected from each entry and pod damage assessments were made. We obtained useful results from 355 entries. Out of these, 37 individual plants/lines were selected for further testing in replicated trials in Kharif 1983.

Borer damage was high in most of the lines but a few showed a moderate attack. A maximum of 91% pod borer damage was recorded in one entry. A few of the entries had no podfly damage, the maximum recorded being 80% from one entry. Severe hymenopteran infestation was noticed in some of the lines and a maximum of 66.7% pod damage by this pest was recorded.

Testing of extra early cultivars:

In the search for borer tolerant and less susceptible extra early pigeonpea lines, we tested some of the breeders' advanced lines of this maturity and also a few selections from our previous trials at Hisser, in two RBD-trials, each with 3 replicates. Close spacing was used in these trials (37 cm x 20 cm). One test was conducted under pesticide free conditions and the other was protected with pesticide applications on BP-6 block. Counts of pests and damage were recorded at intervals through the season and both the trials were harvested in mid-November.

Data from these trials are presented in Table 1. In the unprotected trial a moderately high Heliothis attack at flowering and podding resulted in poor pod setting and yields were reduced. The harvested pods also showed severe damage caused by the hymenopteron pest (Innocatigmodes sp.). In the protected trial the Heliothis attack was reduced by the endosulfan sprays and yields ranging from 802 to 1781 kg/ha were obtained from the entries tested. No entry showed any obvious resistance to the peak Heliothis activity. However, some tolerance was observed in entries, ICPL 140 and H-76-20.

In, 1981 we collected 90 single plant selections from the breeders; extra early material grown at HAU-farm, Hisser. The seed from these plants were sown in an observation block at ICRISAT Center in 1982 without replication. They were sown in plots of 2 rows of 4 m in a pesticide free block (BUS-7B). Visual observations and selections were carried out at pod swelling and at the maturity stage in an attempt to select pest resistant/tolerant plants. The Heliothis incidence was so severe that no line had more than 5% undamaged pods. Six progenies which showed less damage and produced higher yields than the other plants were selected from these plots for replicated tests next year.

Testing of selections in preliminary observation trials:

The selections from the 1981-82 germplasm screening block and the interesting materials collected from other places, for which the seed quantity available was not sufficient for three replications, large plot trials were grown under pesticide free conditions in two replicate small plots (2 rows of 4m) for further observation and seed multiplication. There were 65 such entries that were compared with common checks of appropriate maturities. From these observation trials we discarded all the susceptible entries leaving only 20 selections to be carried forward to the next season's large plot trials.

Testing of selections in RBD and BLSD trials:

The lines and cultivars selected from previous years' tests were tested again in Balanced Lattice Square Design (BLSD) trials with 4-5 replications and/or in RBD trials with 3 replicates, in our sequence of testing and further selection. Each trial contained entries of a relatively narrow maturity range (as measured by days to flowering) and well known check cultivars of the appropriate maturity.

The basis of grouping the entries was on the number of days to 50% flowering recorded for these genotypes in the 1981-82 unsprayed tests. The groupings were as follows.

Table 1: Comparison of pigeonpea selections (Extra Early maturity) in pesticide free and sprayed trials on block-BP-6 ICRISAT Center, Kharif 1982. Plot size: 5 rows of 4 m x 3 reps (RBD) - 37 x 20 cm spacing.

Ent.	Cultivar/ lines	Days to flower-ing (50%)	Pod damage mean %				Yield kg/ha	Days to flower-ing (50%)	Pod damage mean %				Yield kg/ha
			Borer	Pod-fly	Hym.	Total			Borer	Pod-fly	Hym.	Total	
			Unsprayed - Harvested 18-11-82						Sprayed - Harvested 18-11-82				
1	ICPL-1	58	28.1	1.6	59.8	78.2	1075	56	14.8	1.4	46.3	58.2	1483
2	UPAS-120	52	26.1	1.6	52.4	71.1	743	52	15.6	2.2	32.9	48.1	1013
3	PUSA-35	54	32.5	2.8	33.7	62.8	961	54	18.8	1.3	25.1	42.7	1137
4	H 76-20	58	30.7	2.4	33.1	52.4	1103	56	15.1	1.3	33.2	47.4	1152
5	H 77-208	52	28.2	3.5	33.0	60.0	980	52	18.3	1.3	24.2	40.8	1112
6	H 77-216	56	28.5	2.6	33.4	61.1	769	56	25.5	2.3	33.1	55.3	802
7	ICPL-140	60	37.2	3.2	16.9	54.8	1543	56	19.1	2.3	17.3	37.0	1509
8	ICPL-148	64	35.8	2.8	16.4	52.7	1231	60	15.7	1.2	10.7	27.5	1597
9	ICPL-185	51	40.8	2.3	4.2	45.8	1000	51	21.4	2.2	8.7	31.6	1491
10	ICPL-85	60	37.1	4.0	9.1	48.0	1162	58	17.3	1.7	8.5	27.1	1379
11	Pant-A1 (Check)	60	37.5	2.4	13.9	52.4	1208	58	16.8	2.2	19.1	36.9	1719
12	ICPL-6	71	26.7	3.7	45.3	67.2	1357	65	14.0	1.0	35.2	47.0	1781
	S.E of mean ±		(1.27)*	0.73	5.58	3.66	138.5		2.59	(1.48)*	5.36	4.67	114.8
	C.V%		18.9	23.7	33.0	10.6	22		25.3	36.0	37.8	19.4	15
	L.S.D at .05		-	-	16.36	10.73	406.4		-	-	15.7	13.69	336.7

* Arcsin $\sqrt{\%}$ transformation was used for the analyses of data.
Data in parentheses are transformed values.
Net plot harvested = 3.9 m^2.

a) Maturity groups for RBD - trials.

	Selection groups	Days to flowering	No. of entries of RBD trials	Checks
I	Early/mid	<130	14	BDN-1
II	Mid/late	131-155	16	C-11
III	Late	>155	32	NP(WR)-15

b. Maturity grouping for BLSD - trials.

	Selection groups	Days to flowering	No. of entries of BLSD trials	Checks
I	Early	<110	9	T-21
II	Mid	111-129	16	BDN-1, PPE-50-1-HB
III	Mid/late	130-155	9	C-11
IV	Late	>155	9	NP(WR-15, CP-8127-E1-HPf

All these selections were sown at the end of June 1982, on plots; 3 rows of 4 m in the RBD trials and 5 rows (75 cm apart) of 4m in BLSD trials, both in the pesticide free Vertisol (BUS) area.

Early and early-mid maturity trials:

In the RBD-trial of early-mid maturity cultivars on the pesticide free block, we included 14 entries. The data from these entries are given in Table 2. The tables include details of the characters for which the entries were selected in 1982 with abbreviations as follows.

L = low, M = moderate; H = high; B = borer damage (mainly Heliothis; Pf = Podfly damage; H (as second letter) = Hymenoptera damage; T = total damage by the pest complex; Y = yield; R = Recovery (compensation); SM = sterility mosaic disease, W = wilt disease; .R (with diseases) = resistant; S = susceptible.

Table 2: Testing of pigeonpea selections (Early-mid maturity) in the pesticide free block BUS-7B. Plot size 3 rows of 4 m x 3 reps (RBD).

Ent. no.	Cultivar/ lines	Days to flowering (50%)	Pod damage mean % Borer	Pod-fly	Hym.	Total	Yield kg/ha	Characters**
1	ICP-10739-E3-2EB	124	99.5	0.2	2.3	99.7	5	MB,HY
2	ICP-2335-E3-2EB	120	99.8	0.2	1.8	100.0	28	MB,LPf
3	ICP-10821-E3-2EB	118	99.4	1.0	2.9	99.7	90	MB,LPf
4	ICP-10716-E3-2EB	122	99.2	0.6	1.6	99.7	41	LB,HY
5	ICP-5766-E1-4EB	126	100.0	0.1	9.4	100.0	1	LB,HR, HPf
6	ICP-10767-E3-2EB	118	99.1	0.3	0.6	99.4	12	LB,LT
7	ICP-3318-E3-2EB	123	99.9	0.2	7.7	100.0	3	LB,LT
8	ICP-10722-E3-2EB	124	98.4	0.7	4.2	98.8	10	LB,HY
9	PPE-45-2(Y)-2B	73	62.9	6.6	15.1	76.9	868	MB,HR
10	ICP-5494-E3-2EB	125	99.4	0.1	3.7	100.0	21	LB
11	ICP-10845-E2-2EB	145	48.9	5.5	10.4	61.9	473	LPf,HY
12	ICP-4732-1-2-S1 - 2EB	154	100.0	0.0	1.6	100.0	32	LPf,HY
13	BDN-1 Check	118	99.6	0.1	1.5	99.7	33	
14	ICP-7182-E1-2EB	125	100.0	0.0	0.8	100.0	1	HY
	S.E. of Mean±		6.18	(1.63)*	(2.51)*	4.84	30.4	
	C.V%		11.5	79.5	40.8	8.8	137	
	L.S.D. at 0.05		17.97	(4.73)	(7.30)	14.06	88.3	

* Arcsin $\sqrt{\%}$ transformation was used for the analysis of data. Figures in parenthesis are transformed values.

** For abbreviations see page 6.

Nine early maturity and 16 mid maturity selections in the advanced stage of testing together with T-21 in the early and BDN-1 and PPE-50-1-HB as checks in the mid group were planted in BLSD trials with 4 and 5 replications each, in the pesticide free block (BUS-7B and -5D). The results of these trials are presented in Tables 3 and 4. As in the past we have found benefit through the reduction of residual errors when using balanced lattice square designs in place of randomised blocks.

There was severe Helicoverpa incidence on the early-mid and mid maturing cultivars. The early flowering/maturing cultivars escaped the peak incidence, so a moderate level of borer damage was recorded in this trial (Table 3) and relatively good yields were recorded from this trial.

Table 3: Comparison of pigeonpea selections (Early flowering) in the pesticide free block BUS-7B. Plot Size. 5 rows of 4m x 4 reps (BLSD).

Ent. No.	Cultivar/ lines	Days to flower-ing	Pod damage mean %				Yield kg/ha
			Borer	Pod-fly	Hym.	Total	
1	FH-2294-77-R-E2-EB	79	34.6	6.5	23.7	56.5	1115
2	FH-2307-77-R-E1-EB	75	33.1	13.3	15.3	57.2	948
3	Prabhat x 3193-12-E1-EB	75	43.1	5.8	11.9	58.7	921
4	Prabhat x 3193-12-E2-EB	79	33.7	5.2	21.3	53.5	1260
5	PPE-45-2-4B	79	61.4	5.6	20.4	77.5	376
6	T-21	73	38.1	7.1	12.2	53.9	893
7	3193-12 x Prabhat-(Mix)F5 a	84	29.8	6.2	18.8	48.9	1410
8	T21 x A.Scare-beeoides (1927-1)F10	93	42.1	8.4	13.5	60.5	1288
9	1918(1G)-4-EB	79	36.4	7.0	11.4	53.4	1408
	S.E. of mean ±		2.88	1.25	4.02	3.13	118.2
	C.V.%		14.7	34.8	48.8	10.8	22
	L.S.D. at 0.05		9.39	4.09	-	10.21	385.2
	Efficiency over RBD%		118.4	135.0	-	113.0	101.3

Table 4: Comparison of pigeonpea selections (mid flowering) in the pesticide free block BUS-SD. Plot size. 5 rows of 4m x 5 reps (BLSD).

Ent. No.	Cultivar/ lines	Days to flower-ing (50%)	Pod damage mean%				Yield kg/ha	Chara-cters
			Borer	Pod-fly	Hym.	Total		
1	ICP-3653-E3-2EB	117	93.9	3.9	3.7	97.1	37	MB,HY
2	ICP-3671-E3-2EB	97	85.7	6.0	1.1	91.6	100	LPf
3	ICP-10806-E3-2EB	112	98.3	0.9	1.3	98.7	2	LB,LPf, HY
4	PPE-50-1-4B	112	96.1	2.8	3.5	98.5	41	HY,MB
5	ICP-10771-E3-2EB	106	97.9	2.7	2.0	99.0	19	LB,HY
6	ICP-5460-E3-2EB	108	98.3	1.9	2.0	99.4	13	HY
7	BDN-1 x PPE-37-3-2EB	106	92.3	4.3	1.5	95.3	97	HY
8	ICP-6588-E3-2EB	115	85.0	5.4	6.6	90.8	65	MB,LPf
9	BDN-3-EB	98	91.4	5.9	0.9	95.2	112	LB,HY
10	K-10/1-78-EB	106	97.6	1.9	1.3	98.8	23	LB,HY
11	ICPH-6-EB	112	97.3	3.0	3.1	99.1	11	LB
12	GS-2-EB	117	99.3	0.3	3.0	99.6	5	LT
13	ICP-2376-EB	106	99.3	1.4	0.8	99.9	10	
14	BDN-1 (check)	98	95.6	1.9	0.04	97.9	102	
15	ICP-10762-E2-2EB	115	97.2	2.9	1.5	98.6	15	HY
16	ICP-2223-1-EB-4EB	126	98.7	0.9	4.0	99.4	5	LB,LPf, HH
	S.E. of mean ±		1.69	(1.65)*	(1.58)*	1.29	15.6	
	C.V.%		4.0	42.6	46.6	3.0	84.9	
	L.S.D. at 0.05		4.88	(4.75)*	(4.55)*	3.73	45.2	
	Efficiency over RBD %		125.2	-	102.7	102.6	117.6	

* Arcsin $\sqrt{\%}$ transformation was used for the analyses of data. Figures in parentheses are transformed values.

** For abbreviations see page 6.

The early-mid and mid maturing cultivars showed a very high level of borer damage to pods and the yields were greately affected (Table 2). One of our selection PPE-45-2(Y) with yellow flowers gave the maximum yield of 868 kg/ha, this was in contrast to the yield of 33 kg/ha from the check BDN-1. Only two selections PPE-45-2(Y) and ICP-10845-E2 gave a reasonable number of damage free pods, the former having flowered earlier than the other entries and the latter was relatively late flowering.

Among the early flowering group (Table 3) a selection from breeders' material (3193-12 x Prabhat) and an intergeneric cross 1981(IG) gave the highest yields. In this trial our selection PPE-45-2 gave a very poor yield, this was a result of a poor plant stand and severe borer and hymenopterar damage.

Mid-late maturity trials:

In this group we sowed 16 entries, including C-11 and ICP-7050 as the checks, in an RBD with 3 replicates under pesticide free conditions. In addition, in the advance stage testing, 9 entries were sown in a BLSD trial with 4 replicates on the pesticide free block. The results are presented in Tables 5 and 6.

The entries in these trials suffered great losses to Helicoverpa, as the flowering and tender pod stage coincided with the peak activity of larvae. We did not harvest the few pods available for the first picking from the RBD trial. Almost all pods that were present on the plants, had Helicoverpa damage. Pod samples were taken in the second picking (mid March 1983) for the damage assessments, and the plot yields were also ascertained at that time. In this trial the very late flowering genotypes had less borer damage and also produced greater yields (Table 5). A low borer selection PI-397731-E3 produced the highest yield of 1591 kg/ha compared with 575 kg/ha from the check (C-11). All but two entries outyielded this check.

In the BLSD trial on BUS-5D severe Helicoverpa incidence was observed on most of the entries at the time of flowering/podding, but some cultivars particularly ICP-4070-E2 and ICP-4881-E3, showed relatively low incidence and damage to pods. This might have been because of non-preference to the ovipositing moths.

Later the migrating larvae attacked these cultivars and severe borer damage was recorded. Only ICP-4070-E2 gave some seed yield in the first flush. All the entries recovered well in the second flush and compensated for the early losses. Only 4 cultivars (S.No.3,5,6, and 8) showed greater compensation than the check C-11(Table 6). Some of the entries also showed reduced susceptibility to podfly. Hymenopteran damage was relatively low in this block.

Table 5: Testing of pigeonpea selections (Mid-late maturity) in insecticide free block BUS-5D. Plot size. 3 rows of 4m x 3 reps (RBD).

Ent. No.	Cultivar/ lines	Days to flowering (50%)	Pod damage mean %				Yield kg/ha	Characters**
			Borer	Pod-fly	Hym.	Total		
1	ICP-6313-E3-2EB	113	95.4	2.4	11.6	97.4	533	HY
2	ICP-7118-E1-EB	115	99.8	0.1	3.0	99.9	612	HY
3	ICP-10727-E3-2EB	148	38.1	15.4	9.6	57.5	958	LB
4	ICP-10836-E3-2EB	139	56.6	23.7	3.0	70.5	1144	LB
5	ICP-8853-S2-EB	139	98.9	1.1	2.6	100.0	952	HY
6	ICP-2351-3-2-1-S1-EB	125	99.4	0.4	5.6	99.6	778	LB,HY
7	ICP-1923-2-1-S1	115	97.7	1.5	12.3	99.8	709	LB
8	ICP-2009-1-2-S1-EB	135	78.0	1.9	6.0	83.9	774	LB,HY
9	ICP-1987-2-1-S1-EB	131	99.2	0.8	4.9	99.3	1071	HY
10	C-11 Check	115	99.8	1.0	4.3	99.9	575	
11	ICP-3700-E3-EB	150	34.7	10.6	2.0	45.2	1280	HY,LPf, HH
12	ICP-7050-EB	115	83.8	3.0	2.0	87.3	139	HB
13	ICP-10847-E1-2EB	125	95.6	3.7	2.7	98.6	748	LB,HY
14	PI-397731-S3 -EB	150	41.6	14.5	5.2	58.3	1591	LB
15	ICP-1644-6-2-S1-EB	137	30.2	32.8	0.8	58.3	948	HY
16	PPE-37-3-4B	150	34.8	17.8	8.4	56.3	858	LB
	S.E. of mean±		8.16	(3.47)*	(2.84)*	6.09	101.0	
	C.V.%		19.1	46.9	41.6	12.9	21	
	L.S.D. at 0.05		23.55	(10.02)*	(8.20)*	17.59	291.8	

Arcsin$\sqrt{\%}$ transformation was used for the analyses of data.
Figures in parentheses are transformed values.
** For abbreviations see page 6.

Table 23: Screening of sterility mosaic/ wilt resistant lines for insect pest resistance (Mid) in pesticide free area, Kharif - 1982/83. Plot size: 2 rows of 2m x 2 reps (RBD) at ICRISAT Center.

Ent. No.	Cultivar/ lines	Days to flowering (50%)	Pod damage mean %				Yield kg/ha
			Borer	Pod-fly	Hym.	Total	
1	ICP-2380-1-1-2-S1*	113	40.3	20.1	0.2	58.5	412
2	ICP-3426-1-1-2-2-1-S1*	111	43.7	22.7	4.9	70.2	107
3	ICP-8054-1-1-1-1-1-S1*	148	48.9	23.4	4.2	69.5	384
4	ICP-2158-1-2-1-1-S1*	115	39.8	53.0	9.1	84.4	493
5	ICP-3259-1-2-1-1-1-S1*	117	34.3	35.2	7.1	68.6	579
6	ICP-3259-1-2-1-2-S1*	117	49.7	17.8	9.6	69.5	626
7	ICP-7227-1-1-1-1-S1*	115	47.4	26.0	2.4	70.1	518
8	ICP-7227-1-1-1-1-2-S1*	117	39.6	17.3	0.7	54.7	618
9	ICP-704-1-2-1-S1*	130	39.5	31.9	0.2	65.7	825
10	ICP-999-2-1-1-1-S1*	123	20.4	5.3	0	24.9	304
11	ICP-3426-1-1-2-2-2S1*	134	31.8	24.3	2.5	43.7	759
12	ICP-8054-1-1-1-1-2-S1*	119	41.0	25.3	3.7	65.9	380
13	ICP-2020-3-1-1-1-S1*	152	22.9	33.1	14.2	62.3	733
14	ICP-2020-3-1-1-2-S1*	130	25.4	42.3	9.9	68.8	979
15	ICP-2045-1-1-1-S1*	130	38.5	21.3	1.2	57.6	562
16	ICP-2045-1-1-2-S1*	123	38.2	24.3	1.9	59.6	720
17	ICP-3689-1-1-1-1-S1*	130	35.9	25.2	1.6	57.6	981
18	ICP-3689-1-1-1-2-S1*	119	44.5	19.3	1.2	60.7	615
19	ICP-3755-1-1-1-1-S1*	115	30.1	29.2	5.1	56.6	650
20	C-11 (check)	115	52.1	27.2	0.7	72.7	1013
21	ICP-3755-1-1-1-2-S1*	117	34.0	20.5	11.6	57.5	640
22	ICP-3756-1-1-1-1-S1*	130	41.4	25.1	17.7	69.9	536
23	ICP-3756-1-1-1-2-S1*	130	31.8	35.5	19.3	73.5	636
24	ICP-4727-5-2-2-1-S1*	130	28.8	31.7	4.7	61.9	698
25	ICP-3920-2-2-2-1-S1*	130	27.3	37.3	1.9	60.4	671
26	ICP-1963-2-1-1-1-S1*	117	29.9	31.8	1.1	57.0	883
27	ICP-1963-2-1-1-1-2-S1*	123	32.0	25.4	2.0	55.2	830
28	ICP-2209-3-2-2-1-S1*	115	34.6	17.4	0.8	51.1	876
29	ICP-8325-1-1-1-1-S1*	149	18.3	22.5	5.1	41.5	1176
30	ICP-410-1-2-1-S1*	117	45.7	24.6	4.7	66.2	318
31	ICP-410-1-2-2-S1*	115	37.7	25.8	6.0	60.2	421
32	ICP-7799-1-1-2-1-S1*	115	22.4	53.6	3.9	72.8	679
33	ICP-1923-4-1-1-1-S1*	122	58.3	22.3	1.7	69.9	566
34	ICP-1923-4-1-1-2-S1*	117	39.0	24.9	1.8	60.4	454
35	ICP-4352-1-1-1-1-S1*	136	23.5	20.7	6.3	46.3	1333
36	ICP-4358-4-2-2-1-S1*	162	30.1	23.7	6.8	56.2	574
37	ICP-4423-1-1-1-2-S1*	134	26.3	32.0	3.3	57.2	1516
38	ICP-4796-2-2-2-1-S1*	136	24.6	21.6	7.5	48.7	753
39	ICP-4796-2-2-2-2-S1*	152	23.8	32.9	7.1	55.9	993
40	7050 (check)	117	51.0	5.9	7.1	61.8	510
41	ICP-5213-1-1-2-2-S1*	130	23.1	29.6	2.1	52.3	595
42	ICP-5542-1-1-1-1-S1*	134	29.9	13.7	2.5	44.4	436
43	ICP-5542-1-1-1-2-S1*	122	33.0	15.5	2.7	48.5	671

44	ICP-5838-1-1-1-2-S1∞	136	25.9	22.2	2.3	46.2	710
45	ICP-5838-1-1-1-1-S1∞	136	27.8	23.3	1.8	48.8	843
46	ICP-7802-2-2-2-1-S1∞	162	23.0	16.4	1.7	55.5	1117
47	ICP-7802-2-2-2-2-S1∞	152	27.5	23.9	2.4	48.3	1172
48	ICP-8304-2-2-2-1-S1∞	130	39.2	30.2	1.3	65.4	181
49	ICP-8316-1-1-2-2-S1∞	170	26.0	12.9	11.3	46.8	1251
50	ICP-8317-1-1-1-1-S1∞	136	41.7	20.7	3.8	60.4	1051
51	5701-WR	130	36.3	29.0	1.0	60.8	1246
52	7855-WR	107	53.8	28.2	0.4	75.3	473
53	9120-WR	170	18.2	9.4	16.3	39.7	625
54	9175-WR	170	23.7	39.8	0.4	58.7	232
55	9213-WR	134	35.4	35.7	3.1	64.6	680
56	9229-WR	130	24.7	20.2	1.2	45.4	1203
57	9255-WR	170	19.6	6.2	21.5	44.2	410
58	10269-WR	170	25.6	33.4	8.7	58.7	1264
59	K-70-WR	170	44.1	21.8	2.7	62.5	538
60	C-11 (check)	117	39.8	32.5	2.0	64.2	877
	S.E. of mean ±		5.44	4.40	(2.33)*	5.45	114.3
	C.V.%		22.6	24.5	29.6	13.2	23.0
	L.S.D. at .05		15.38	12.45	(6.60)	15.41	324.0

* Arcsin $\sqrt{\%}$ transformation was used for the analyses of data. Figures in parentheses are transformed values.

Table 24: Screening of Sterility Mosaic/ wilt resistant lines for insect pest resistance (Late) in pesticide free area, Kharif - 1982/83. Plot size: 2 rows of 2m x 2 reps (RBD) at ICRISAT Center.

Ent. No.	Cultivar/ lines	Days to flower-ing (50%)	Pod damage mean %				Yield kg/ha
			Borer	Pod-fly	Hym.	Total	
1	ICP-260-2-1-2-1-S1e	170	15.1	34.2	17.2	57.3	1208
2	ICP-1946-4-1-1-1-S1e	136	27.1	33.0	3.2	56.1	622
3	ICP-8325-1-1-1-2-S1e	170	19.8	16.5	3.0	37.8	1178
4	ICP-2013-2-2-1-S1e	136	28.9	33.4	6.3	61.1	779
5	ICP-2013-2-2-2-S1e	136	22.7	31.3	11.1	58.5	636
6	ICP-1944-1-1-1-1-S1e	148	23.3	33.5	2.5	48.6	817
7	ICP-1944-1-1-1-2-S1e	170	18.6	29.9	5.2	49.6	769
8	ICP-2241-1-2-2-1-S1e	164	31.9	11.1	6.5	45.9	834
9	ICP-5151-1-1-2-2-1-S1e	170	16.5	26.9	6.9	46.1	642
10	ICP-5151-1-1-2-2-2-S1e	170	21.2	29.0	5.0	45.5	1275
11	ICP-5172-5-2-2-1-S1e	170	18.1	21.4	4.0	39.2	712
12	ICP-5172-5-2-2-2-S1e	170	21.9	20.9	4.2	42.5	492
13	ICP-7337-4-6-1-2-1-S1e	166	12.5	20.8	7.1	39.3	1245
14	ICP-7337-4-6-1-2-2-S1e	170	18.5	14.9	10.5	39.4	1427
15	ICP-8107-1-3-2-1-S1e	170	21.3	48.4	0.4	62.6	447
16	ICP-8107-1-3-2-2-S1e	166	17.2	44.8	3.0	59.9	470
17	NP(WR)-15 check	152	20.0	20.6	5.7	42.7	1269
18	ICP-8464-WR	170	23.0	29.4	7.2	58.5	829
19	ICP-9144-WR	166	20.8	27.1	7.1	47.2	636
20	ICP-9168-WR	172	29.8	8.8	3.8	39.2	1553
21	ICP-9177-WR	170	22.5	11.1	0.0	33.6	78
22	MAU-E-175-WR	176	19.8	15.9	1.4	33.4	719
	S.E. of mean ±		4.30	3.63	1.69	5.23	168.3
	C.V.%		28.5	20.1	43.6	15.6	28
	L.S.D. at .05		-	10.67	4.98	15.39	494.7

Diallel - Borer resistance

	Days to 50% flowering
PPE-45-2	91
ICP-10466	130
ICP-3009	132
ICP-7349-1-S4-EB	117
PPE-50-1-BS	126
ICP-1903	125

Diallel - podfly resistance

ICP-8102-5-S1-EB	152
ICP-7946	142
ICP-7176-5-S4	163
ICP-5651-S3	159
ICP-8127	159

Studies on accumulation of resistance

ICP-2223-1-EB	130
PPE-37-3	148
ICP-3940	174
ICP-8325	140
ICP-5036	142
ICP-8595	155
ICP-3328	126
ICP-7941	140
ICP-3615	146
ICP-4307	135
ICP-7050-BS	139

Screening and selection from pigeonpea crosses:

This year our breeders grew F1s (20 entries), F2s (29 populations) and some insect tolerance selections in F3 and F4 generations (99 entries including ICP-1903 as check) in the pesticide free area (BUS-4A). We scored these progenies at the pod filling stage for pest incidence and damage, when Heliothis incidence was high. Later, at maturity, we selected single plants showing reduced susceptibility and high yields. After harvest the pods from these selections were assessed for pest damage and the best selections were advanced for further testing. The details of these screening trials are furnished in the Pigeonpea Breeding Annual Report 1982-83.

Pest damage in wild relatives of pigeonpea:

This year we planted some of the common wild species in the Vertisol and Alfisol blocks. The pod damage assessment from these are shown in Table 25. During this season we also screened some

Table 25: Pod damage by insects in wild relatives of pigeonpeas (*Atylosia* spp. and *Rhynchosia* spp) during 1982-83 under pesticide free conditions at ICRISAT Center.

Species	Date pods harvested	Total pods on 6 pts.	Pod damage mean %			
			Borer	Pod-fly	Hymn.	Total
Atylosia scarabaeoides	7-12-82	1678	8.9	0.2	25.0	34.4
A.sericea	7-12-82	2060	3.7	0.0	4.6	8.3
A.platycarpa	21-9-82	499	39.7	14.4	0.0	51.9
	5-11-82	1079	25.9	40.7	0.3	63.5
	7-12-82	468	11.1	32.9	0.0	42.5
	15-3-83	107	15.9	17.8	0.0	30.8
A.cajanifolia	7-12-82	343	97.7	1.2	9.9	98.8
Rhynchosia bracteata	15-3-83	113	15.9	0.0	0.9	16.8

collections of the wild species made by the GRU for pest susceptibility. The results of which are not furnished in this report.

Studies on mechanisms of resistance, laboratory and field studies:

We conducted oviposition preference tests and antibiosis studies (larval feeding tests) in the laboratory for studying the mechanisms of resistance in borer resistant genotypes. In the field we intensively observed less susceptible and susceptible selections under pesticide free conditions.

For the assessment of chemicals that may affect resistance/susceptibility that are found on and in the pod walls, we are in collaboration with the scientists at Max-Planck Institute, Munich (W. Germany).

Studies on oviposition preference and feeding preference of Heliothis larvae in the laboratory:

Several tests were carried out in large transparent plastic cages, in which the flowering and fruiting twigs of various test cultivars were kept in small conical flasks containing water. In some trials 12 cultivars, including checks, were tested in 3 replications each by releasing two pairs of 2 day old Heliothis moths in each cage. Egg counts were taken 3 days after release. We similarly tested combinations of 2 to 4 cultivars to ascertain the oviposition preference of the moths. The results were very variable and a large number of eggs were laid on the cage surface and on the cotton wool plugs.

In general, the moths preferred the susceptible cultivars; PPE-50-1, ICP-1691-E3 and -5766-E2 for egg laying. The wild species and the borer resistant lines (PPE-45-2, ICP-10466-EB, -1903-E1, 1925(IG) and PPE-37-3) generally had less eggs.

We tested flowers and pods collected from our resistant/tolerant selections and also from the susceptible cultivars in large (20 cm diameter) petridishes for studying the feeding preference of the Heliothis larvae. Flowers from 2 to 4 cultivars were placed around the perimeter and a 2nd instar larva was released in the center of each dish. This was replicated 4 times.

We obtained interesting results in these tests and found that the flowers and pods of our borer resistant cultivars were relatively unattractive to Heliothis larvae. We intend to repeat these tests with several replications next year.

We also attempted studies of antibiosis and larval preference in pigeonpea seedlings in our net house but the Heliothis NPV disease ruined these trials.

Field studies:

We grew 12 pigeonpea selections that were known to have a wide range of susceptibilities to pests and represented different maturity groups, in two trials. These were sown on two different dates (i.e. on June 22 and July 8, 1982) on a Vertisol block - BUS-2B. These genotypes were replicated twice on plots of 2 rows of 4m each. Intensive weekly observations on the Heliothis eggs and larval populations were made on five tagged plants per row under pesticide free conditions. One row in each plot was left undisturbed, while the plants on the adjacent rows were brushed carefully to remove all the eggs and larvae after taking each weekly count. This procedure was followed for 10 weeks. Later pod damage assessments were made on the tagged plants of the unbrushed and brushed rows. The results from some of the selections representing different susceptibilities and maturities are summarised in Table 26.

Counts from the plants that were cleared of eggs and larvae every week showed that there must have been substantial dispersal of larvae from plant to plant for the counts of larvae on these plants were almost as great as those on the plants from which eggs and larvae were not removed. This would indicate that the larvae have an opportunity to demonstrate preference for plants, at least as far as neighbouring plants are concerned.

Biochemical studies:

We collaborate with the MPI for Biochemistry, West Germany in the biochemical analysis of the pigeonpea pod exudates to ascertain the chemicals responsible for resistance against pests.

In these collaborative studies we grew 15 resistant and susceptible selections of 3 maturities in Vertisol and Alfisol blocks without irrigation (Tables 27-30)

Mr. Hans Tober, a biochemist from MPI spent about 3 months at ICRISAT Centre. He analysed the pod wall exudates, that were collected by washing pods with methanol from these genotypes, using an HPLC-Unit. He also analysed the pigeonpea essential oils extracted from the leaves by steam distillation.

The results are being summarised and compared with the pod damage and other information collected from the field.

Podfly damage parameters:

We normally estimate susceptibility to podfly in pigeonpea by collecting samples of pods from each genotype, examining each pod externally and internally for podfly damage and then comparing the percentage of pods damaged in the test entry with that of the relevant check grown in the same trial.

Table 26: Field tests of Heliothis oviposition and larval preferences on plant that were cleared weekly of eggs and larvae (brushed) and adjacent unbrushed plants in pesticide free trials at ICRISAT Center.

Pigeonpea cultivars	Characters*	Days to flowering 50%	Unbrushed plants			Brushed plants		
			Eggs	Larvae	Borer damage %	Eggs	Larvae	Borer %
I. Date of sowing - June 22, 1982								
PPE-45-2	LB	90	47	11	20	37	11	22
ICP-7203	HB,HY	91	97	39	35	66	38	35
PPE-50-E1	HB	121	99	31	36	103	17	24
ICP-1903-E1	LB,HY	127	63	20	17	46	13	16
ICP-1691	HB,LPF	127	118	76	57	83	69	59
ICP-10466	LB,HY	130	92	20	18	77	22	17
ICP-5766	HB,HPF	130	188	64	21	128	52	36
C.V.%			42.8	32.3	26.5	35.3	31.7	14.9
S.E. of mean ± (in a trial with 12 cv.)			40.5	11.2	6.8	27.7	10.6	4.1
II. Date of sowing - July 8, 1982								
PPE-45-2	LB	86	124	50	53	130	36	52
ICP-7203	HB,HY	86	244	113	70	169	100	63
PPE-50-E1	HB	108	213	145	64	190	96	67
ICP-1903-E1	LB,HY	113	128	47	39	107	37	46
ICP-1691	HB,LPF	108	163	155	91	168	160	83
ICP-10466	LB,HY	113	162	40	32	138	40	42
ICP-5766	HB,HPF	121	307	92	37	247	79	41
C.V.%			34.8	50.9	21.7	40.6	28.7	21.9
S.E. of mean ± (in a trial with 12 cv.)			40.0	25.5	8.2	47.2	13.6	8.21

For abbreviations see page 6

Table 27:Testing of pigeonpea selections (used for biochemical analysis - MPI collaboration) under pesticide free conditions on Alfisol (RUS-6C). Entries: 15 Reps: 2 (RBD), Plot size: 2 rows of 4 m . Net plot harvested = 6 m at ICRISAT Center.

Ent. No.	Cultivar/ lines	Days to flower-ing (50%)	Pod damage mean %					Yield kg/ha
			Borer	Pod-fly	Hym.	Bru--** chid	Total	
		Harvested on 6-4-1983						
1	PPE-45-2	78	17.9	5.6	27.5	8.2	53.5	677
2	ICP-7203-E1	92	16.9	8.9	2.6	10.3	37.1	742
3	ICP-7349-1-S4 -5EB	93	20.7	4.2	7.2	7.8	37.6	1008
4	ICP-1903-E1	113	18.4	5.6	11.9	4.8	37.9	1108
5	ICP-10466-E3	111	16.7	7.5	15.3	7.2	43.9	828
6	ICP-1691-E3	113	22.1	8.0	0.6	11.4	39.3	1195
7	ICP-2223-E8	114	20.5	11.8	16.9	24.4	67.8	764
8	ICP-6840-E3	120	24.6	5.1	11.1	13.3	50.2	1007
9	ICP-6915-EB	135	79.3	10.7	2.8	7.7	89.5	145
10	PPE-50-1	123	22.5	4.7	20.8	16.5	57.8	1261
11	ICP-5766-E3	113	22.3	5.5	4.1	14.9	44.8	964
12	ICP-7946-E3	140	29.8	10.0	8.2	0.9	45.9	1309
13	ICP-7941-E3	158	43.5	6.8	5.6	1.6	54.1	699
14	ICP-7337-2-S4	142	35.4	18.8	46.3	0.6	78.7	119
15	ICP-7050-EB	120	44.0	8.9	5.3	2.6	57.1	827
	S.E. of mean ±		4.55	2.67	(5.23)*	2.13	6.53	119.0
	C.V. %		22.2	8.1	40.7	34.3	17.4	19.7
	L.S.D. at .05		13.78	-	(15.87)	6.46	19.79	360.8

Arcsin $\sqrt{\%}$ transformation was used for the analyses.
Figures in parentheses represent the transformed value.

** Some of this bruchid damage may have occurred after harvest but before pod damage analysis.

Table 28: Testing of early maturing pigeonpea selections (used for biochemical analysis - NPI Collab.) under pesticide free conditions at ICRISAT-Centre (BUS-2B) during Kharif 1982-83. Entries: 3 Reps:3 (RBD), plot size: 4 rows of 4m. Net plot harvested = 12 m².

Ent. No.	Cultivar/ lines	Days to flower-ing (50%)	Pod damage mean %					Yield kg/ha	Pod damage mean %					Yield kg/ha
			Borer	Pod-fly	Hym.	Bru-chid	Total		Borer	Pod-fly	Hym.	Bru-chid	Total	
			1st picking dt.13-12-1982						2nd picking dt.4-2-1983					
1	PPE-45-2	82	12.6	8.9	12.5	6.7	38.2	796	39.6	10.0	40.6	1.3	74.1	681
2	ICP-7203-E1	91	33.5	14.6	3.9	4.1	52.6	893	58.4	6.9	75	0.4	69.7	727
3	ICP-7349-1-S4	76	22.9	8.3	9.9	4.8	43.0	615	59.8	13.6	20.3	1.4	82.4	519
	S.E. of mean ±		2.77	2.18	1.50	1.08	0.67	66.2	3.60	4.06	(6.20)*	(1.79)*	4.07	61.6
	C.V.%		20.9	35.7	29.8	35.9	2.6	15.4	11.9	69.2	40.1	72.4	9.3	16.4
	L.S.D. at .05		10.87	-	5.89	-	2.65	-	14.13	-	-	-	-	-

* Arcsin $\sqrt{\%}$ transformation used for the analysis of data. Figures in parenthesis represent the transformed value.

Table 29: Testing of medium maturing pigeonpea selections (used for biochemical analysis - NPI Collab.) under pesticide free conditions at ICRISAT-Centre (BUS-2B) during Kharif 1982-83. Entries: 8 Reps:3 (RBD), plot size: 4 rows of 4m. Net plot harvested = 12 m².

Ent. No.	Cultivar/ lines	Days to flower-ing (50%)	Pod damage mean %					Yield kg/ha	Pod damage mean %					Yield kg/ha
			Borer	Pod-fly	Hym.	Bru-chid	Total		Borer	Pod-fly	Hym.	Bru-chid	Total	
			1st picking dt.13-12-1982						2nd picking dt.4-2-1983					
1	ICP-1903-E1	111	31.9	14.9	9.8	0.8	53.9	1168	38.0	10.7	16.1	1.8	59.8	1000
2	ICP-10466-E3	111	25.8	24.3	8.6	1.0	55.7	865	27.0	8.4	34.1	0.7	62.7	718
3	ICP-1691-E3	113	77.8	9.6	1.8	0.5	87.0	383	47.0	8.2	4.5	0.6	58.4	389
4	ICP-2223-E8	113	32.5	17.2	7.3	0.3	53.6	860	29.2	8.2	48.3	0.0	73.3	713
5	ICP-6840-E3	113	45.6	13.3	9.5	0.4	64.6	652	50.0	21.3	16.6	1.0	75.5	537
6	ICP-6915-E3	113	96.6	8.5	0.9	0.0	99.1	120	68.0	19.9	0.6	0.1	79.1	128
7	PPE-50-1	113	46.4	19.4	16.7	1.0	74.0	649	47.3	11.0	35.5	0.6	80.5	545
8	ICP-5766-E3	113	55.9	23.2	6.1	0.5	77.1	650	41.3	23.6	5.5	0.7	62.7	697
	S.E. of mean ±		4.88	3.62	(3.10)*	(1.0)*	4.67	77.3	4.37	2.73	(3.85)*	(0.86)*	6.11	84.6
	C.V.%		16.4	38.5	38.4	44.6	11.5	20.0	17.4	35.2	27.9	37.1	15.3	24.8
	L.S.D. at .05		14.8	-	(9.68)	(2.93)	14.18	234.6	13.26	8.29	(11.7)	(2.60)	-	256.7

* Arcsin $\sqrt{\%}$ transformation used for the analysis of data. Figures in parenthesis represent the transformed value.

Table 30: Testing of late maturing pigeonpea selections (used for biochemical analysis - MPI Collab.) under pesticide free conditions, at ICRISAT Centre (BUS-2B) during Kharif 1982-83. Entries: 4 Reps:3 (RBD), plot size: 4 rows of 4m. Net plot harvested = 12 m .

Ent. No.	Cultivar/ lines	Days to flower-ing (50%)	Pod damage mean %					Yield kg/ha
			Borer	Pod-fly	Hym.	Bru-chid	Total	
			Harvested on 4-2-1983					
1	ICP-7946-E3	135	35.6	14.1	4.8	0.1	51.6	1129
2	ICP-7941-E3	151	48.4	8.7	1.8	0.2	57.2	1087
3	ICP-7337-2-S4a	139	28.1	48.2	23.6	0.9	78.4	135
4	ICP-7050-EB	108	55.5	4.2	13.7	0.1	68.8	291
	S.E. of mean ±		2.57	1.89	1.67	0.06	2.16	48.0
	C.V.%		10.1	17.4	26.4	32.9	51.6	12.6
	L.S.D. at .05		8.88	6.55	5.78	0.21	5.84	166.0

Such determinations are tedious for they require the opening and close scrutiny of several hundred pods for each entry and we examine many hundreds of such entries in each year. It would be even more time consuming if we were to determine other parameters of damage such as numbers and percentages of seed damaged per plant or plot, but such extra work may be worthwhile in some stages of our selection.

To determine the relationship of the various parameters of podfly damage we grew a trial which consisted of six pairs of genotypes (two each in the early, mid and late maturity groups) each pair consisting of a podfly resistant and susceptible genotype, in four replications. The resistant and susceptible genotypes had been selected on the basis of their percentage pod damage in a series of trials in previous years. We collected all the pods from each sampled plant and then counted the damaged and undamaged seeds in each pod. Some of these data are summarized in Table 31.

It is evident that the percentage of pods damaged was the clearest discriminator between the resistant and susceptible groups. This was not surprising for this parameter was the major one utilized in the original selection of these genotypes. The relatively small differences among the numbers of pod and seed damaged between the resistant and susceptible entries is largely explained by the fact that the early and mid maturity susceptible selections had relatively few pods per plant. There was great variability for all the characters measured, but with the percentage of pods damaged having the lowest coefficient of variation.

Table 31: Parameters of podfly damage in resistant and susceptible genotypes, Kharif 1982-83 at ICRISAT Center.

	Resis-tant	Suscep-tible	SE	CV%	LSD
Pod damage:					
No. damaged plant	43	48	±7.0	53	NS
% pods damaged	14.8 (22.1)	30.7 (33.0)	±2.5	32	(7.2)
Seed damage:					
No.damaged/ plant	87.6	94.9	±16.0	61	NS
No.damaged/ pod	0.29	0.67	±0.12	86	0.34
% seed damaged	9.3 (17.2)	17.7 (23.8)	(±2.1)	36	(6.1)

Data in parentheses are the arcsin $\sqrt{\%}$ transformed values.

One interesting factor that emerged from these observations was that the mean number of podfly damaged seeds per damaged pod was at least as great in the resistant genotypes as in the susceptible genotypes. Thus, although the resistant selections had a lower percentage of pods attacked, there appeared to be no reduction in the number of podfly larvae in the pods that were attacked.

These data have posed several interesting questions and we intend to follow up these with further detailed observations in a limited number of genotypes.

Pod Characters of Podfly Resistant Genotypes:

We again attempted to determine the pod characters that may be responsible for, or associated with, podfly resistance/susceptibility. For this we examined samples of pods collected from the resistant and susceptible genotypes that were grown in the trial described in the preceding section.

Pod size and fresh weight:

We collected samles of 10 green pods from each of the genotypes and measured and weighed each of these. The summarized data were as follows:

	Fresh wt. (g/pod)		Pod area (cm2/pod)	
	Resis-tant	Suscep-tible	Resis-tant	Suscep-tible
Early maturing group	0.21	0.47	2.5	2.5
Mid maturing group	0.18	0.19	2.5	2.5
Late maturing group	0.15	0.22	NR	NR

These data tended to indicate that the more susceptible genotypes tended to have heavier pods, but with no great difference in the surface area.

Hair density:

The density of the glandular hairs on the pods was measured, with the following results.

	Hairs/unit	
	Resistant	Susceptible
Early maturing group	65	59
Mid maturing group	69	70
Late maturing group	46	37

Thus, there was a small indication that the resistant pods had a denser hair cover, but much greater sample sizes would be required to confirm this.

Phenolics:

In cooperation with our biochemists, the phenolic contents of the pod walls were analysed in three resistant and three susceptible selections. These analyses were of interest for the susceptible cultivars had greater concentrations of phenolics (3.2 mg phenolics/g of dried pod wall) than did the resistant cultivars (2.7 mg/g). This was unexpected for resistance in many crop plants is commonly associated with higher concentrations of phenolics.

We intend to study the mechanisms of resistance to podfly more intensively in the coming season.

Project: PP-Ent-5(81)

STUDIES ON THE BIOLOGY, ECOLOGY AND CONTROL OF PODFLY, *MELANAGROMYZA OBTUSA*

Objectives:

(a) To supplement the current knowledge of the biology of this pest.

(b) To study the ecology, including factors influencing the fluctuations of populations, across areas and years.

(c) To develop our knowledge of the potential elements of practical management of this pest.

Range of observations:

In this year, as in previous years, we studied the podfly both in the laboratory and in the field, not only at ICRISAT Center, but also at other locations, including Gwalior and Hissar. We also enjoyed productive collaboration with several national entomologists in studies of this pest and its natural enemies. The data accumulated in these studies are too voluminous to be fully reported here but will form the basis for a specialised report on this pest which will be prepared in the near future.

Project: PP-CP-Ent-7(81)

STUDIES OF *HELIOTHIS* POPULATIONS

Objectives:

(a) To monitor *Heliothis armigera* populations throughout each year at Patancheru and at a number of other locations, both as larvae on the host plants and as moths in traps.

(b) To attempt to correlate the population fluctuations with the factors that are likely to influence them such as climatic, natural enemies and crop changes.

(c) To determine the role of migration as a factor in population changes.

(d) To modify or develop a model for *Heliothis* populations and to attempt forecast of infestations.

(e) To determine maximum threat periods for *Heliothis* on our target crops in the specified locations and to investigate the possibility of crop maturities that will avoid the peak threats.

(f) To build a bank of *Heliothis* data.

Light Trap Studies:

Three modified Robinson type light traps were operated at ICRISAT Center and one each at Gwalior and Hissar, all of these were operated by ICRISAT staff. In addition we receive data of *Heliothis* catches from several light traps that are operated by national scientists across India. The data from all of these traps will be summarised in the report of the FSRP Cropping Entomology sub-program.

Samples of *Heliothis* female moths from the ICRISAT Center light traps are dissected to determine their mating status. We hope that these data will eventually be of utility in our migration studies.

Pheromone Trap Studies

Trap designs:

In previous reports the development of our standard *Heliothis* pheromone trap was described and that of the modified version which incorporates an inverted cone baffle surrounding the septum, which gave considerably increased catches of the male moths. We also reported that a trap in which the moths had to crawl or fly upwards into the catch box caught very few moths. This was in contrast to

reports from the USA where the most efficient Heliothis spp pheromone traps require the moths to move upwards rather than falling, or flying, downwards, as in the ICRISAT standard trap.

In this year we compared the ICRISAT standard trap, and the modified version incorporating the conical baffle, with traps constructed in accordance with the two designs that have been found to be most efficient in the USA. The first of these, the "Texas Pheromone Trap" consists of a wire mesh cone with a small hole in the apex capped by a wire mesh cylinder. The pheromone septum is placed in the open base of the cone and the moths fly or crawl upwards into the cylinder where they are trapped. The second was a "Wind Vane Trap" which is mounted on a pivot and a large wind vane ensures that the mouth of the trap always faces the wind. The moths are attracted into the trap mouth by the pheromone and then fly or crawl upwards into a catch box. These traps are illustrated in Figure 1.

These four trap types were tested over a 12 week period in a chickpea field. The pheromone septum in each trap was renewed after every 28 days. The traps were interchanged among the four positions at the end of each week so that each trap occupied each position in the field for three separate weeks. Thus, although the traps were not replicated the position of each trap was unlikely to have greatly affected the overall catches.

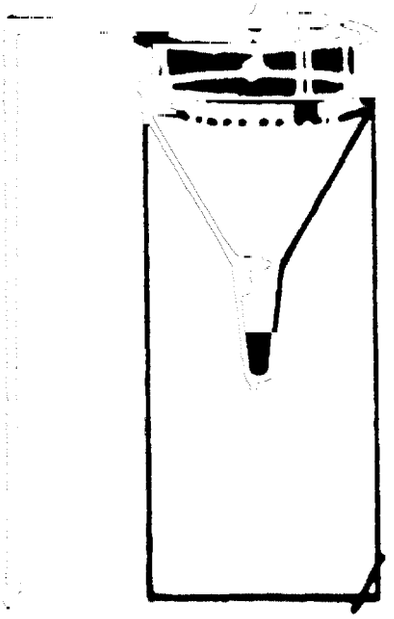
The records of the catches in these traps are summarised in Table 32. It can be seen that the modified ICRISAT trap caught nearly four times as many moths as the ICRISAT Standard Trap which caught far more than the traps constructed according to USA designs.

We conclude that Heliothis armigera is not readily trapped in the USA type traps. It is possible that this may be explained by a differing behavioural pattern of this species, when compared with those of the Heliothis spp which are caught in large numbers in the USA. However, it would be of interest to compare the ICRISAT type traps with the USA design traps in the USA.

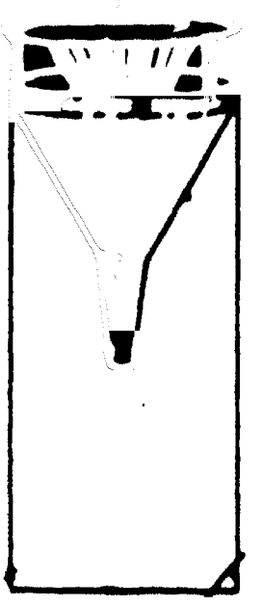
Color of the trap funnel:

In previous years we observed that when the funnel used in our standard trap was white it appeared to give greater catches than traps using funnels of other colors. In this year we compared Standard Pheromone Traps that differed only in the colour of the funnel. We used six different colored funnels in two replications for 18 weeks. For the first 6 weeks the traps were operated in a groundnut field and for the next 12 weeks in a chickpea field. The catches from these traps are summarised in Table 33. The coefficient of variation was high but there was little doubt that the white funnel traps trapped far more moths than did the traps incorporating funnels of other colors.

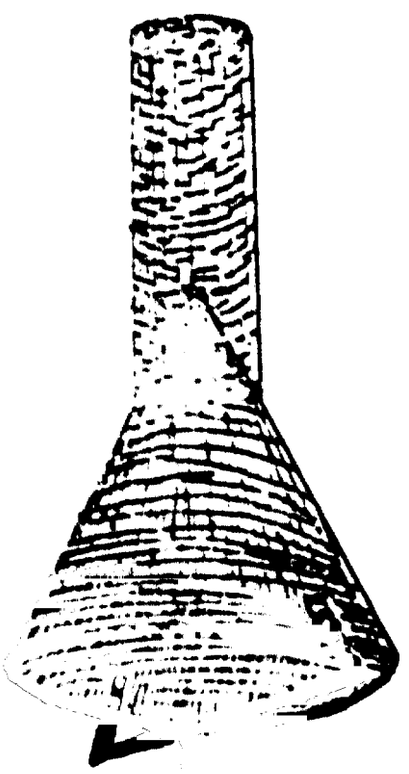
FIG-1



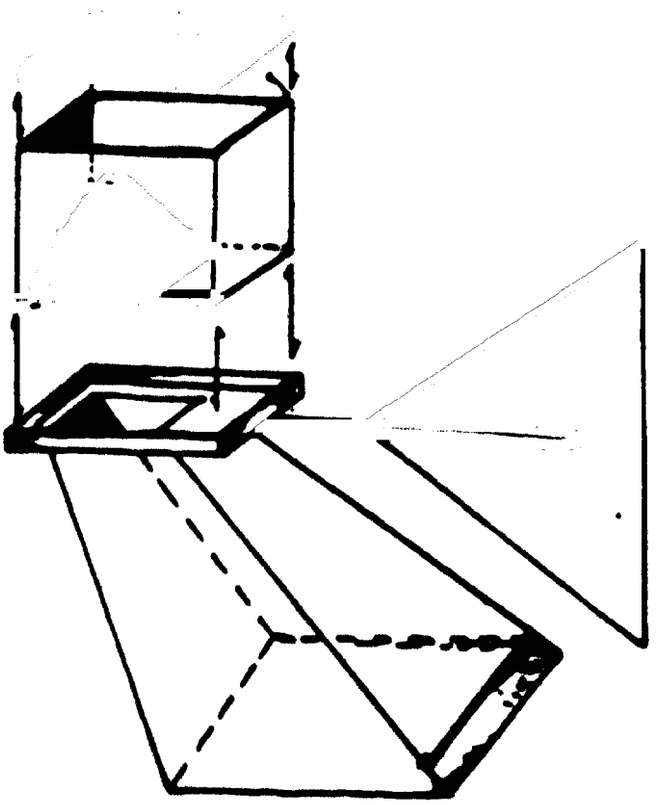
ICRISAT standard trap - a white plastic funnel (dia 21 cm) with an aluminium plate rivetted above at a clearance of 5 cm. The trap is fixed with a nut and bolt and pheromone source is suspended below the plate at the centre. Moths are obtained in the polythene bag wired below the funnel.



ICRISAT standard trap modified by inserting a perforated small yellow funnel (dia 15 cm) around the pheromone. This funnel is secured to the aluminium plate after the placement of pheromone source below the plate.



'Texas Pheromone Trap' - 8/8 wire mesh cone (dia 50 cm) held inverted with a source of pheromone at the mouth of the cone. Moths are trapped in the cylindrical cage on top of the cone (refer American literature).



'Wind Vane Trap' on pivot stand. Moths are obtained in the box at the top of the trap. Composition: 8/8 wire screen, wood and sheet metal (see American literature).

Table 32: Weekly catches of male H.armigera moths in pheromone traps of differing designs in a chickpea field at ICRISAT Center 1982-83.

	Moths per week			
	Wind vane trap	Wire mesh trap	ICRISAT standard trap	Conical baffle trap
16-22 Nov	22	1	42	201
23-29 Nov	3	0	139	349
30-06 Dec	42	4	217	641
07-13 Dec	19	3	128	884
14-20 Dec	47	0	434	1169
21-27 Dec	55	3	203	935
28-03 Jan	69	6	113	474
04-10 Jan	119	3	58	513
11-17 Jan	25	3	87	284
18-24 Jan	2	0	26	121
25-31 Jan	12	1	20	90
01-07 Feb	1	1	8	25
Total	416	25	1475	5686

Table 33: Mean weekly catches per trap of male H.armigera moths in ICRISAT standard pheromone traps incorporating funnels of different colors at ICRISAT Center, 1982-83.

	Moths/week/trap in traps incorporating funnels colored					
	White	Red	Yellow	Green	Black	Orange
15-21 Sep	10.0	11.5	8.5	6.5	4.0	7.0
22-28 Sep	5.5	1.5	1.0	1.0	0.0	1.0
29-05 Oct	1.0	0.0	0.5	0.0	0.0	0.0
06-12 Oct	1.0	0.5	0.0	0.5	0.5	0.5
13-19 Oct	2.0	0.5	1.5	0.0	0.5	0.0
20-26 Oct	1.0	0.0	0.0	0.0	0.0	0.0
27-02 Nov	1.0	0.0	2.0	0.0	0.0	0.0
03-09 Nov	13.5	0.0	3.5	1.0	0.0	1.0
10-16 Nov	23.5	4.5	8.0	5.5	5.0	1.5
17-23 Nov	82.5	7.0	14.0	12.5	4.5	6.0
24-30 Nov	52.0	12.5	11.0	14.0	8.0	10.5
01-07 Dec	114.5	36.0	67.5	35.0	55.0	23.0
08-14 Dec	100.5	26.5	18.5	12.5	21.0	13.0
15-21 Dec	159.0	112.0	54.5	89.5	74.0	38.0
22-28 Dec	40.5	51.0	70.0	53.0	35.0	25.0
29-04 Jan	25.5	24.5	25.5	26.5	12.0	22.0
05-11 Jan	32.0	20.5	13.5	23.5	19.0	15.0
12-18 Jan	28.0	15.5	10.0	19.5	6.0	23.5
Means	38.5	18.0	17.2	16.7	13.0	10.4
SE ±	3.45					

Height of the traps:

We have standardised upon a trap height of 2 m above ground level. This was a result of early trials that indicated such a height, or greater, gave optimum catches. In this year we tested traps 1, 2 and 3 m above ground level in all of ICRISAT's mandate crops - pigeonpea, chickpea, groundnuts, sorghum and millet. There were two replicates and the traps were operated in each crop for a total of 8 weeks.

The summarised data in Table 34 clearly indicate that optimum trap heights vary according to the crop in which they are operated. In the short statured crops, chickpea and groundnuts, maximum catches were recorded in the lowest traps. In the taller crops relatively few moths were caught in the lower traps, which were well below the crop canopy. We therefore conclude that pheromone traps should be set just above the crop canopy rather than at a set height above ground level.

Tests of different septa:

We have been using as pheromone dispensers, white rubber septa loaded with 1 mg of the pheromone mix. These septa have been supplied to us by Dr.B.Nesbitt of the Tropical Products Institute (TPI) of London. These rubber septa, which are manufactured in Israel have been difficult to obtain and Dr.Nesbitt suggested that we should test smaller rubber septa that are manufactured in UK and are relatively cheap and easy to obtain. Consequently, in this year we compared the British septa both at 1 mg and 2 mg pheromone loading with the Israeli septa (1 mg). These tests were carried out with four replications at ICRISAT Center and with two replications at Hissar over 12 week periods, without renewing the septa. The data from these tests are summarised in Table 35. It can be seen that the British septa attracted fewer moths than the Israeli septa when loaded with 1 mg of the pheromone mix. However, where the British septa were loaded with 2 mg, they caught at least as many moths as did the Israeli (1 mg) septa. We are now considering whether to adopt these new septa in our standard traps.

Interaction of Heliothis and Spodoptera pheromones:

Dr.Nesbitt of TPI has supplied us with the pheromones of both H.armigera and Spodoptera litura. The latter pest is occasionally found on pigeonpea, but commonly found on groundnuts. It would be convenient to monitor both these pests, either in separate traps or in a single trap containing both the pheromone mixtures as attractants.

To determine the interactions of these two pheromones we recorded the catches from ICRISAT standard traps baited with (a) H.armigera pheromone (dispensed from Israeli septa), (b) S.litura pheromone (dispensed from plastic vials) and (c) both together. These traps were operated for 8 weeks in a groundnut field with two replications. The data recorded from this trial are summarised in Table 36. Here it can be seen that the traps containing both pheromones had greatly

Table 34: Mean weekly catches of male H.armigera moths in ICRISAT standard pheromone traps fixed at different heights in the mandate crops at ICRISAT Center 1982-83.

	Sorghum(Trap Ht.)			Millet(Trap Ht.)			G.nut(Trap Ht.)		
	1m	2m	3m	1m	2m	3m	1m	2m	3m
10-16 Aug	9.0	10.5	2.5	9.0	31.0	3.0	5.5	3.5	1.5
17-23 Aug	0.5	8.0	10.0	10.5	11.5	3.5	17.0	0.5	0.0
24-30 Aug	0.5	9.5	8.5	1.0	5.5	0.5	27.0	5.0	6.5
01-06 Sep	0.0	19.5	27.5	3.5	19.5	24.5	87.5	40.0	20.0
07-13 Sep	0.0	7.0	16.5	0.5	15.5	11.5	41.5	23.5	9.5
14-20 Sep	0.0	3.0	12.0	0.0	10.0	14.0	21.5	10.0	14.5
21-27 Sep	0.0	0.5	1.5	0.0	1.0	1.0	12.0	6.0	2.0
28-04 Oct	0.0	0.5	1.0	0.0	0.0	0.5	4.5	1.0	0.5
Means	1.3	7.3	9.9	3.1	11.8	7.3	27.1	11.2	6.8
S.E. ±		1.70			2.17			1.39	

	P.pea (Trap Ht.)			C.pea (Trap Ht.)		
	1m	2m	3m	1m	2m	3m
10-16 Nov	0.5	18.5	44.0	9.0	1.5	1.5
17-23 Nov	3.5	17.5	46.0	12.0	4.0	1.5
24-30 Nov	0.5	9.0	28.5	3.5	3.5	5.5
01-06 Dec	0.0	107.5	329.0	86.0	53.5	37.0
07-13 Dec	0.5	109.0	266.5	90.0	89.5	64.5
14-25 Dec	0.0	119.0	584.5	142.0	150.0	70.0
21-27 Dec	2.5	90.5	190.0	71.5	71.5	45.0
28-03 Jan	1.0	77.0	137.5	49.0	32.0	32.5
Means	1.1	68.5	203.3	57.9	50.7	32.2
S.E. ±		8.82			1.61	

Table 35: Mean weekly catch per trap of male H.armigera moths in ICRISAT standard pheromone traps baited with different septa as dispensers for differing loadings of the synthetic pheromone 1983.

	At ICRISAT Center (4 replications)				At Hissar (2 replications)		
	Israeli	British septa			Israeli	British septa	
	1 mg	1 mg	2 mg		1 mg	1 mg	2 mg
28-03 Feb	30.5	32.0	40.3	05-11 Mar	521.5	448.0	658.5
04-10 Feb	13.3	21.8	22.8	12-18 Mar	418.0	368.5	560.0
11-17 Feb	11.3	4.8	8.3	19-25 Mar	881.0	653.0	921.5
18-24 Feb	11.8	3.8	7.5	26-01 Apr	295.5	234.5	354.5
25-03 Mar	2.3	2.0	6.0	02-08 Apr	414.0	325.0	410.5
04-10 Mar	2.0	1.3	3.0	09-15 Apr	245.5	211.5	288.0
11-17 Mar	2.0	3.0	4.3	16-22 Apr	435.5	456.6	512.5
18-24 Mar	30.3	9.5	34.5	23-29 Apr	54.0	36.5	74.0
25-31 Mar	14.0	5.5	10.0	02-08 May	36.5	22.5	51.0
01-07 Apr	24.3	10.0	10.3	09-15 May	60.5	40.5	78.0
08-14 Apr	24.3	13.0	28.8	16-23 May	24.0	7.0	36.0
15-21 Apr	16.5	12.8	18.8	24-30 May	4.5	2.5	8.5
Means	15.2	9.9	16.7		282.5	233.8	329.4
S.E. ±	2.9	2.6	3.6		76.9	63.0	84.8

Table 36: Mean weekly catches of male H.armigera and Spodoptera litura moths in ICRISAT standard pheromone traps baited with the pheromones for each separately and together in a groundnut field at ICRISAT Center 1982.

	Heliothis pheromone	Heliothis + Spodoptera pheromone		Spodoptera pheromone
	Catches of Heliothis	Catches of Heliothis	Spodoptera	Catches of Spodoptera
20-26 Aug	18.0	11.0	45.0	60.5
27-02 Sep	60.5	10.0	54.0	57.0
03-09 Sep	203.0	11.0	166.0	108.0
10-16 Sep	43.0	0.0	46.0	108.0
17-23 Sep	33.0	1.5	86.0	72.5
24-30 Sep	11.0	0.0	122.0	51.0
01-07 Oct	1.0	0.0	67.0	108.5
08-14 Oct	2.0	0.0	195.0	178.5
Means	46.4	4.2	97.6	93.0
SE ±	1.99		7.33	

reduced catches of Heliothis so we conclude that it would not be possible to operate combined Heliothis and Spodoptera pheromone traps.

Pheromone trap and light trap interactions:

We operate both pheromone and light traps at ICRISAT Center and at other locations. To determine whether these traps interfere with each other and if so, the maximum distance at which such interference is discernable, we designed a simple observational trial. Heliothis pheromone traps were operated to the North-East and South-West of a light trap. These directions were determined by the prevailing winds. The light trap was operated and recorded for every night but the pheromone traps were operated for 2 nights on then 2 nights off repeatedly. In the "2 nights off" the traps were baited with S.litura pheromones. For the first 6 nights the pheromone traps were 1 m from the light trap and were then moved after each 16 days to a greater distance from the light trap. The summarised data of the catches are shown in Table 37.

Table 37: Catches of H.armigera moths in pheromone and light trap when operated at differing distances from each other at ICRISAT Center 1982-83.

	Distance between pheromone and traps (m)	Pheromone trap(2) catches	Light trap catches when pheromone traps were Operated		Not operated	
		♂	♂	♀	♂	♀
26-10 Nov	1	0	5	4	3	1
11-26 Nov	5	0	64	72	30	35
27-12 Dec	10	0	97	99	40	50
13-28 Dec	20	1	92	122	79	82
29-13 Jan	30	16	15	10	15	12
14-29 Jan	40	10	6	6	5	8
30-14 Feb	50	14	5	4	6	7
Total		41	284	317	178	195

It can be seen that no Heliothis moths were caught in the pheromone traps while they were within 10 metres of the light trap, a few were caught at a distance of 20 m and many when these traps were 30 metres or more from the light trap. However, these observations were recorded over a period when the populations of the moths were probably declining and it will be necessary to repeat this experiment, but with a different design, before any firm conclusions are drawn.

There was an apparent increase in the light trap catches of Heliothis when the pheromone traps were operated within 20 metres of the light trap. This increase was not unexpected for the male moths, for the pheromone traps may attract males over greater distances than would the light trap, but with the light trap being more attractive over a shorter range. There is no such simple explanation for the increase in catches of female moths. Here again we need to repeat this experiment to determine whether the apparent increase in catches is confirmed.

Pheromone trap catches and moon phase:

An analysis of the catches of several Heliothis pheromone traps over many lunar periods has indicated that moon phase has little discernable effect on catches. This is in strong contrast to the light traps where catches are greatly depressed at full moon periods. However, a series of all night observations indicated that the time of moon rise might have an effect upon the timing of the entry of moths into the pheromone trap. These all night observations showed considerable variation in the timing of the peak catches of moths in each night. In most nights some moths entered the traps in every hour from dusk to dawn.

Pheromone trap, light trap and larval populations comparisons:

It is often postulated that although traps may not catch enough insects to be effective as pest control devices, they are at least useful as monitoring devices. In the case of Heliothis armigera there appears to be a lack of published evidence that light traps or pheromone traps are useful indicators of the populations of this pest. We therefore embarked upon a comparison of the catches in light traps and in pheromone traps with the populations of larvae on all host plants in the area. By August 1983 we had completed 2 years of recording data from three light traps, each subtended by two pheromone traps and from the crops and other host plants in the vicinity. At that time we reduced the work involved by discontinuing one of the light traps with its two nearby pheromone traps, but will continue recording from the other two light traps and four pheromone traps.

Preliminary analysis of the data indicate that the numbers of moths entering the traps do not give very good correlations, either among the two different traps or between the traps and the counts of larvae in the fields. In 1981-82 the correlation (r) between the catches in light traps and pheromone traps was only 0.60 and in 1982-83 only 0.43.

We would not expect catches of moths in the traps to be closely, directly correlated with counts of the larvae in the fields, for the moths in the traps would either be those that gave rise to the eggs and larvae in the field or those that were the result of pupation and emergence from those larvae. In Table 38 we show a series of correlations that are displaced in time in an effort to determine the greatest correlations. If the traps are to be of use in monitoring

for pest control then we require good correlations between moths that give rise to the larval populations, i.e. the moth catches one or two weeks before the larval populations, and the larval populations themselves. The summarised data show very variable correlations, with no obvious peaks to indicate that the data from the traps indicate either the moths that give rise to the peak larval populations, or those that result from such populations.

Although these summaries indicate that the trap catches are unlikely to be of direct use in predicting damaging populations, they should not be written off as being of no utility. We know that several factors such as moon phase and climatic factors can greatly influence the trap catches. We will now embark upon detailed analyses of the factors that are likely to influence the catches in the hope that we will be able to determine correction factors which, when applied to the trap catches, will greatly improve the correlations with larval populations and so allow us to use the traps as useful monitoring tools.

Pheromone traps in individual crops:

As in previous years we operated two pheromone traps in each of our mandate crops, both in the pesticide free and protected areas, continuing the records from these traps until after the harvest of each crop. These data will be compared with counts of Heliothis larvae that are also recorded from these crops. In sorghum the trap catch peak preceded the peak larval population but with no subsequent trap catch peak to indicate the emerging moths. This was in marked contrast to the situation in both pigeonpea and chickpea where the peak moth catches followed the peak larval infestations. We will fully report upon these data and the conclusions that we draw from these differences in a separate publication.

Pheromone trap network in the Indian sub-continent:

Many national scientists are cooperating in recording from the ICRISAT standard Heliothis pheromone traps at locations across India, Pakistan, Bangladesh and Sri Lanka. We now receive data from more than 100 traps from more than 50 locations. We hope that these data will at least give us an indication of the seasonal and geographic variations in moth populations. We also hope to use the data to determine the factors involved in the population dynamics of this moth, including the possible role of migration. These data will be accumulated and will form the basis for a separate report.

Other chemical attractants:

We previously reported that out of a range of chemicals received for testing from Dr.Jacobson of USDA, phenylacetaldehyde was the most attractive when used in our standard traps. In this year we tested 25 more chemicals, supplied by Prof. H. Reinhold of the Max-Planck Institute for Biochemistry, Munich. None of these appeared to be very

attractive to Heliothis moths in field testing.

We continued to test phenylacetaldehyde, both with and without ascorbic acid as an antioxidant, in our standard traps both at ICRISAT Center and at Hissar. These traps caught few moths at ICRISAT Center, but substantial numbers were caught at Hissar as can be seen in Table 39. Here the addition of ascorbic acid appeared to give a small increase in catches in this unreplicated test. Of the 538 H.armigera moths caught during the 12 weeks test 214 (40%) were female. Several other insects including many Dinchrysia orichalcea were also caught in these traps.

The value of identifying attractants/traps that will catch female moths before they have laid eggs is obvious, and the results from this test of phenylacetaldehyde are encouraging. However, the numbers caught in these traps were very low when compared with the numbers of H.armigera male moths caught in nearby pheromone traps (several thousands) over the same period. We will continue the search for more attractive chemicals.

Table :38 Correlation coefficients of comparisons of H.armigera moth catches in pheromone and light traps with counts of larvae in the fields at ICRISAT Center 1979-83.

Counts of larvae	Correlation coefficients (r)					
	Light traps				Pheromone traps	
	1979-80	1980-81	1981-82	1982-83	1981-82	1982-83
3 weeks earlier	0.39	0.18	0.06	0.29	0.31	0.64
2 weeks earlier	0.56	0.29	0.25	0.34	0.42	0.76
1 week earlier	0.66	0.44	0.32	0.45	0.90	0.73
same week	0.51	0.44	0.43	0.71	0.62	0.70
1 week later	0.32	0.43	0.55	0.74	0.70	0.60
2 weeks later	0.27	0.37	0.64	0.53	0.70	0.44
3 weeks later	0.42	0.29	0.64	0.34	0.52	0.20

Table 39: Weekly catches of H.armigera moths in ICRISAT standard traps baited with phenylacetaldehyde, with and without ascorbic acid as an antioxidant at Hissar 1983.

	Catches of moths in phenylacetaldehyde(0.05 ml)traps			
	Without ascorbic acid		With ascorbic acid (0.01)	
	Males	Females	Males	Females
05-11 Mar	21	34	19	38
12-18 Mar	17	13	9	8
19-25 Mar	21	11	31	13
26-01 Apr	0	2	10	3
02-08 Apr	2	1	0	4
09-15 Apr	21	9	30	17
16-22 Apr	45	13	57	22
23-29 Apr	4	0	8	1
30-06 May	3	3	4	1
07-13 May	4	1	1	8
14-20 May	7	2	5	2
21-27 May	2	6	3	2
Totals	147	95	177	119

Project: PP-Ent-6(81)

STUDIES ON THE PROBLEMS OF INSECTICIDE USE ON PIGEONPEA

Objectives:

To study the problems of insecticide use on pigeonpea crops and to develop practicable solutions to these that will be of utility in farmers' fields. An analysis of the economics of pesticide use will be included.

Introduction:

In previous reports we have described the problems of the application of pesticide on this crop and reported that Controlled Droplet Application (CDA) at ulta low volume (ca. 4 l/ha) can avoid some of these problems and give relatively good pest control. In this year we again compared the relative merits of CDA and conventional spraying on this crop, both in a formal trial on ICRISAT Center and in farmers' fields. The results of the testing in farmers' fields will be reported in the FSRP cropping entomology report.

Comparison of CDA and conventional spraying:

In this year we compared the use of the CDA spinning disc sprayers with that of the motorized knapsack sprayers and the hand operated knapsack sprayers in a trial with three replications of 0.1 ha plots. Endosulfan sprays were applied according to counts of Heliothis eggs and larvae on the crop. Two sprays were required during the flowering-podding stage.

As can be seen in Table 40 the pest damage and yields produced by the treatments did not differ significantly, the CDA treatment was at least as good as the conventional methods. However, the work involved in the CDA treatment was much less than in the other two treatments, for only 4 litres of spray mix was required per hectare for CDA, in contrast to 250 l for the motorized knapsack and 500 l for the hand operated knapsack. Ideally the spray mix for the CDA should be in a non-phytotoxic oil of low volatility. As such formulations are not readily available in India, we used a sugar syrup solution as a diluent for the endosulfan concentrate. This tended to reduce droplet evoporation and the droplets on the plants may have proved to be attractive, but toxic, to the pest adults and larvae.

We also attempted to measure the actual coverage of spray on the plants by using a dye in the spray mix and counting the droplet stains on white cards placed at various levels on the plants to simulate leaves. These observations indicated that the motorized knapsack gave the best coverage throughout the plant and particularly on the undersurfaces of leaves. However, this may have been a result of a failure to recognize and count most of the small droplet stains produced by the CDA. For many pests, under leaf and whole plant coverage is of importance but for Heliothis on pigeonpea the flowering

terminals, which are concentrated near the traps of the plants, appear to be the major targets.

Following the successful use of CDA again in this year we intend to encourage greater interest in the use of this method on pigeonpea.

Table 40: Pod damage and yields from a trail comparing the use of differing sprayers on pigeonpea at ICRISAT Center 1982-83.

Sprayer	Percentage of pods damaged by				Yield kg/ha
	Borers	Podfly	Hymn.	All Insects	
Hand operated knapsack	34	20	1	57	1710
Motorised knapsack	40	15	3	61	1570
Controlled droplet Applicator	32	14	1	49	1740
SE ±	6.2	1.7	1.1	4.8	95

Project: PP-Ent-4(77)

BIOLOGY AND ECOLOGY OF PESTS OF PIGEONPEA AND CHICKPEA

Objectives:

To obtain information on the bionomics of the pests of pigeonpeas and chickpeas. To study the effects of differing climatic elements, various agronomic practices and other factors on the life histories and populations.

Studies on thrips:

In this year we concentrated the work in this project on the common thrips which is found in flowers at ICRISAT Center - Megalurothrips usitatus. We collected these thrips from the fields and studied their biology in the laboratory in glass tubes, using a regular supply of fresh flowers from pesticide free plants as food. The data recorded from these observations are summarised in Table 41. The number of nymphs produced by each female under these conditions ranged from an average of less than four in October/November to more than eight in January/February. The mean generation time showed little variability, not surprisingly for the laboratories are generally kept at relatively constant temperatures throughout the year.

Table 41: Observations on the biology of Megalurothrips usitatus feeding on pigeonpea flowers in the laboratory at ICRISAT Center 1983.

	No.of females observed	Egg Incubation period (days)	Nymphs			Adults Longevity
			No emerged	Period (days)	Mortality (%)	
Jan-Feb	50	5.4	413	11.0	45.0	NR
Feb-Mar	185	5.8	1430	10.6	50.5	15.9
Mar-Apr	325	4.4	2050	9.8	59.3	15.7
Apr-May	250	5.2	1073	10.3	53.4	19.5
May-Jun	350	5.7	2332	10.5	53.6	13.6
Jan-Jul	400	5.8	2951	11.1	57.5	12.1
Jul-Aug	450	6.0	3527	10.7	60.6	13.1
Aug-Sep	300	5.7	2288	10.7	70.2	12.8
Sep-Oct	200	6.0	1285	11.2	61.4	12.2
Oct-Nov	350	6.2	1376	11.2	60.4	12.1

To monitor field populations, we sampled flowers from early (T-21), medium (C-11) and late (NP[MR] 15) cultivars throughout their flowering periods. We collected 100 closed and open flowers each week

from each cultivar and counted the number of adults and nymph thrips in each sample. These data are summarised in Table 42. It can be seen that the populations tended to be greatest on the later maturing cultivars. The relatively high ratios of adults to nymphs was rather surprising, for the laboratory observations would indicate that there should be at least as many nymphs as adults in a normal population.

Table 42: Numbers of thrips (mainly *Megalurothrips usitatus*) adults and nymphs counted in weekly samples of open and unopen flowers from three cultivars of pigeonpea from the pesticide free area at ICRISAT Center 1982-83.

Cultivars (maturity)	Standard week	No. of thrips per 100 flowers			
		Open flowers		Unopen flowers	
		Nymphs	Adults	Nymphs	Adults
	40	71	252	91	331
	41	91	395	97	514
T21	42	72	343	108	140
(Early)	43	35	282	95	95
	44	77	214	106	179
	Means	**69**	**297**	**99**	**252**
	45	311	509	343	537
	46	158	418	231	428
C11	47	118	408	186	490
edium)	48	91	281	133	326
	48	91	281	133	326
	49	129	401	142	499
	Means	**161**	**403**	**207**	**456**
	50	115	440	176	496
NP(WR)15	51	43	834	56	878
(Late)	52	36	736	43	688
	01	88	678	113	854
	02	96	677	96	712
	Means	**76**	**673**	**97**	**726**

It can be seen that the average number of thrips per flower varied considerably across the season, there was also considerable variation from flower to flower, with many flowers free of thrips. The overall average of 5.8 thrips per flower confirms that this insect is very common on pigeonpea. Its role is still controversial. Some

workers have found evidence of considerable yield reduction caused by this insect, others consider it to be of little or no concern or even to be beneficial. Earlier studies at ICRISAT Center have indicated that it is not of importance as a pollinator.

Project: PP-CP-8(81)

STUDIES ON THE AUGMENTATION OF THE NATURAL CONTROL ELEMENTS OF THE PULSE PESTS

Objectives:

(a) To supplement existing data on the natural control elements of the pulse pests both on the target crops and on their alternate host plants.

(b) To study the possibilities of augmentation of the natural control elements and to estimate the cost/benefit returns of such measures.

Parasitism of Heliothis larvae collected from the fields:

We continued to monitor the seasonal parasitism of Heliothis larvae by collecting samples from pigeonpea in our pesticide free fields and rearing these individually in tubes. The summarised data from these observations are shown in Table 43. In this year the dominant parasites were tachinids, as in previous years on this crop. Early in the season in November, Carcelia illota was the most common, but in all other months Goniophthalmus halli was dominant.

Analysis of the data according to the size of the larvae when collected showed a much greater incidence of parasitism in the larger larvae (Table 44). This is expected where the tachinids are the major parasites. Similar collections from other hosts including chickpea and the cereals tend to have greater parasitism in the younger larvae, mainly caused by hymenoptera, which tend to be relatively uncommon on pigeonpea.

Eucelatoria release in the field:

We continued to maintain laboratory cultures of the exotic tachinid parasite Eucelatoria bryani. This insect was originally imported from the USA where it is a common parasite on the Heliothis spp in the country. In this year we again attempted to establish this parasite in our pigeonpea fields. For this we sowed four row strips of an early cultivar (ICPL-81) between larger strips (24 rows) of a mid maturity cultivar (ICP-1). This ensured that there was a continuous supply of flowers and pods to act as hosts for Heliothis from October to February. We made four releases of the parasite, totalling 584 mated females from November to January. Recoveries of Heliothis larvae made 22 to 25 days after each parasite release gave no evidence of parasite establishment.

At times there were relatively few Heliothis larvae of the preferred instars (4th and 5th) available on the pigeonpea at the time of parasite release, and this may have accounted for the non-establishment. However, the native tachinid parasites thrived under the conditions and on the Heliothis populations available in

Table 43: Numbers and percentages of H.armigera larvae found to be parasitised when collected from pigeonpea in pesticide free vertisol fields and subsequently reared in the laboratory at ICRISAT Center 1982-83.

Month	No. of larvae			% parasitism	
	Observed	Died	Parasitised	Total	Among Survivors
November	737	207	45	6	8
December	175	89	22	13	26
January	259	123	92	36	68
February	59	26	6	10	18

Table 44: Incidence of parasitism in H.armigera larvae of different sizes collected from pigeonpea from the pesticide free vertisol at ICRISAT Center 1982-83.

	Size of H.armigera when collected		
	Small	Medium	Large
No. of larvae observed	316	452	462
No. of larvae died	152	173	120
No. of larvae parasitised	20	47	98
% of parasitism (total)	6	10	21
% of parasitism (among survivors)	12	17	29

this season. Earlier studies, in large field cages, indicated that this exotic parasite can parasitize the Heliothis larvae in our field conditions. However, in spite of releases in 3 years we still have no evidence of establishment. We will continue to study the reasons for our failure to establish this parasite in our fields, for it is very easy to rear in our laboratories. One major problem may be the lack of synchrony between the generations of the parasite and its host at ICRISAT. The mean generation time for Heliothis being 40 days and that for Eucelatoria, 25 days. As the parasite is restricted almost entirely to attacking the fourth instar larvae of its host, a continual supply of overlapping generations of the host will be required if this parasite is to thrive in field conditions. It is evident that this parasite may be of value in some areas of India, for it has been reported to have established itself at Bangalore and we hope for similar success in other locations.

Studies of predators:

The study and collection of data concerning the parasites of Heliothis is relatively easy, for simple collections of the eggs and larvae from the fields and subsequent rearing and observation of these in the laboratory will give information on the range and extent of the parasites present. Observations of predation are not so easy, for a great deal of tedious observation can give relatively little information and laboratory observations of suspected predators are likely to yield results that are atypical of field behaviour. Consequently there is a paucity of information on the predators of pests in most crops. In previous years we have identified several arthropods that are common on pigeonpea, and which will feed upon Heliothis eggs and young larvae in the laboratory. In this year we again devoted some time to laboratory and field studies of these.

Seasonality of spiders:

We monitored the numbers of spiders and of the larvae of Heliothis in two pesticide free fields at ICRISAT Center, with weekly observations from November 1982 to February 1983. In both fields the numbers of spiders recorded were relatively low, averaging less than two spiders per meter of row, for much of the period. However, there was a distinct peak in the population of spiders in early December, two or three weeks after peak populations of young Heliothis larvae were recorded in these fields. In addition there was a second peak of spider populations in one of the fields in mid January. Here again this peak was two or three weeks after a peak of young Heliothis larvae. These data may indicate a dependance of the spider populations upon the Heliothis populations in this crop.

Effect of DDT spraying:

We sampled predators in two large plots (12 rows of 39 m) of C 11 pigeonpea grown in field BM 14E (vertisol). One of these plots was left pesticide free and the other was sprayed twice with DDT to control the Heliothis populations. There was a significant reduction of the number of Coccinellid adults trapped on sticky boards in the DDT sprayed plot when compared with those in the pesticide free plot. However, there were no significant reductions in the number of spiders and coccinellids recorded from the plants by dislodging nor in the number of ants recorded in pitfall traps in the sprayed plot. This was rather surprising for we expected to find large reductions in the predator populations in the sprayed plot.

Project: PP-Ent-3(77)

INTEGRATED PEST MANAGEMENT ON PIGEONPEA

Objectives:

To develop the concept and practice of ntegrated pest management on pigeonpea. To identify and develop individual components or practices that will reduce pest-caused losses on the crop, and to eventually combine these into a practical package for use at the farmer level.

Components that will be investigated initially are:-

(a) insecticide use, including improved application techniques
(b) host plant resistance (as in PP-Ent-2)
(c) biological control (CP-PP-Ent-4)
(d) cultural practice including intercropping.

Plant density interaction with resistant and susceptible genotypes:

The effect of increasing plant density from 4.4 to 13.3 plants per square meter in a Heliothis resistant genotype (ICP 2223) and in a susceptible genotype (PPE 50) were monitored in trials on both Alfisol and Vertisol in 1981-82. In the Alfisol trial there was a reduction in yield (17%) at closer spacing in the susceptible genotype, but not in the resistant selection. In the vertisol trial the closer spacing led to an increase in yield in both genotypes, but this was greater in the resistant selection (33%) than in the susceptible (5%). The differences were mainly attributable to the pod damage caused by insects, particularly Heliothis, in the first flush.

In this year we conducted two trials at ICRISAT Center, both on Vertisol but with one pesticide free and the other insecticide protected. Each trial was of two genotypes (ICP-2223 and PPE-50) at two spacings - 75 x 30 cm (4.4 plants/m) and 75 x 10 cm (13.3 plants/m). Each trial was of factorial design with four replications of plots 16 rows of 4 m (48 m).

In the trial on the pesticide free block (BUS 5B) there was a severe Heliothis attack during the first flush of flowering and podding so that the pod damage was almost total, even in the resistant genotype (ICP-2223). There was also considerable pod damage in the second flush and the yields from this trial were low. The pod damage and yield data from both flushes are summarised in Table 45. It can be seen that the resistant cultivar gave the lower yields even though it had lower pod and seed damage. The closer spacing gave increased yield in both genotypes, in spite of an increased percentage of pod damage at the closer spacing in ICP-2223. This indicated that the greater pod production, both by the susceptible genotype and at the closer spacing more than compensated for the increases in percentage pod damage associated with these factors. The only differences that were significant were for the second harvest yields, both for spacing

and spacing x genotype interaction and for the pod and seed damage of the second harvest from the genotypes.

Table 45: The effect of plant density on pod and seed damage and yield in Heliothis resistant and susceptible genotypes in a trial on a pesticide free vertisol field at ICRISAT Center, 1982-83.

Genotypes	Plant density/ m²	% pod damage		% seed damage		Grain yld. (kg/ha)		
		1st pick	2nd pick	1st pick	2nd pick	1st pick	2nd pick	Total
ICP 2223	4.4	98	49	86	25	24	358	382
(resistant)	13.3	99	55	92	28	30	418	448
	Mean	98	52	89	26	27	388	415
PPE 50	4.4	98	62	85	36	24	473	497
(susceptible)	13.3	99	63	90	34	9	513	521
	Mean	99	63	87	35	17	493	509
Overall	4.4	98	56	86	30	24	416	440
	13.3	99	59	91	31	20	465	484
S.E. (Factors) ±		0.5	2.4	3.3	1.7	6.2	12.2	11.0
S.E. (Interaction) ±		0.6	3.4	4.7	2.5	8.8	17.3	15.6
C.V. %		1.3	12	11	16	80	8	7

In the protected trial, where three sprays of endosulfan were applied by a high clearance tractor sprayer, it was obvious that the spraying was not very successful in controlling the Heliothis, for pod damage averaged over 80% in the first harvest (Table 46). Here the first harvest yield from the resistant genotype was considerably greater than that from the susceptible genotype, but the second harvest yield from the susceptible cultivar was more than compensated for this. There was a small and insignificant reduction in yield at the closer spacing in both genotypes. There were no significant interactions. Counts of plants at harvest indicated considerable plant mortality, particularly in the plots of the closer spaced, resistant genotype, the treatment that gave the lowest yields.

Table 46: The effect of plant density on pod and seed damage and yield in Heliothis resistant and susceptible genotypes in a trial protected by endosulfan sprays on a vertisol at ICRISAT Center 1982-83.

Genotypes	Plant density/ m	% pod damage		% seed damage		Grain yld. (kg/ha)		
		1st pick	2nd pick	1st pick	2nd pick	1st pick	2nd pick	Total
ICP 2223	4.4	87	55	73	22	362	548	910
(resistant)	13.4	79	51	60	21	220	573	793
	Mean	83	53	66	22	291	561	852
PPE 5C	4.4	92	54	84	29	33	876	909
(susceptible)	13.3	95	54	88	27	38	848	887
	Mean	94	54	86	28	36	862	898
Overall	4.4	89	54	79	26	198	712	909
	13.3	87	52	74	24	129	711	840
S.E. (factors) ±		2.9	2.6	4.1	2.2	93.2	77.3	80.7
S.E. (interaction)±		4.0	3.7	5.8	3.1	131.8	109.3	114.1
CV %		9	14	15	25	161	31	26

These trials indicated in this year at least, that the spacings tested had little effect on pest damage or yields even though Heliothis populations were greater at the closer spacing. They also showed that the level of resistance to Heliothis in ICP-2223 is insufficient to give a yield benefit under the severe Heliothis attacks that were encountered in this year.

Trial at Hissar:

At Hissar we tested two genotypes, PPE-45 (resistant) and ICP-3228-E1 (susceptible) at two plant densities - 60 x 20 cm (8.4 plants/m) and 30 x 15 cm (22.2 plants/m) in two replications. As at ICRISAT Center the Heliothis populations per unit area were greater at the closer spacing. There was a small increase in the percentage of pod damage (from 30 to 36%) in both cultivars at the closer density. However, a much larger increase in the number of pods produced per unit area at the closer spacing led to a 50% increase in yield, in spite of the greater insect damage, in the resistant genotype and an increase in the susceptible genotype.

Trial at Gwalior:

At Gwalior we conducted a trial of two genotypes, one known to be resistant to podfly (ICP 8102-5 S1-2EB) and the other a susceptible genotype (ICP 8606) at two plant densities 75 x 30 cm (4.4 plants/m) and 75 x 10 cm (13.3 plants/m) in two replications. The total of insect caused pod and seed damage tended to decrease at the closer spacing in the resistant cultivar but there was a slight increase in the damage in the susceptible genotype at the closer spacing. There were large increases in yield in both genptypes at the closer spacing, particularly in the resistant genotype, which substantially outyielded the susceptible genotype.

COLLABORATIVE STUDIES ON NODULE FLY

The studies on Rivellia angulata, the larvae of which commonly damage the nodules on the roots of pigeonpea and on some other legume roots, were continued in cooperation with our Microbiology sub-program.

Fish meal use in trapping adults:

In the previous year we reported that the addition of fishmeal to our traps led to large increases in catches of the nodule damaging fly. In this year we compared traps with and without fishmeal at three locations (BUS 5B, BUS 13A and BM 14E) on ICRISAT Center. The mean number of flies caught per trap/week increased from 80 to 264 (±23.0) with the addition of fish meal. Thus, there is no doubt that moistened fish meal is strongly attractive to Rivellia angulata, as it also is to the sorghum shootfly.

Seasonal populations:

We recorded the numbers of Rivellia angulata adults trapped each week in traps baited with fishmeal in BUS 5B from mid July to mid November. There was a very large increase in catches in August, with more than 500 flies/trap/week. The catches were greatly reduced, to no more than 50 per week, by mid September and from then on steadily declined until no flies were caught in November.

Fish meal application in the soil:

We conducted a trial to determine whether we could induce greater infestation by the nodule damaging fly in plants, by applying fish meal to the soil above their roots. Fish meal was applied twice (August 19 and 26) on two areas of soil in BUS 5B and we then sampled plants from three locations from the treated and control areas in that field on September 9. The mean number of nodules damaged per plant was much greater in the fishmeal treated areas (53) than in the untreated (20). However, the total numbers of nodules per plant also tended to be greater in the fishmeal treated areas, so the percentage of damaged nodules in the plants from the treated plots (89%) was not much greater than that from the control plots (71%). It is clear that we can manipulate nodule damaging fly populations and damage to some extent by the use of fish meal and we intend to further study the practical value of this.

METEOROLOGICAL OBSERVATIONS AT ICRISAT
June 1982 to May 1983

Standard week	Dates	Month	Rainfall in (mm)	Average temperature C		Average % humidity		Average wind velocity (km/h)	Average sunshine (hr/day)	Average daily evaporation (mm/day)
				Max	Min	0717	1417			
23	04-10	Jun	0.0	38.8	26.7	59	25	17.6	7.5	9.7
24	11-17	Jun	131.4	32.6	23.3	83	60	16.0	3.1	4.6
25	18-24	Jun	24.2	31.8	23.1	88	60	19.1	5.3	4.7
26	25-01	Jul	29.1	33.4	23.4	78	51	15.9	6.7	5.9
27	02-08	Jul	9.2	34.2	23.6	76	42	15.0	8.2	8.8
28	09-15	Jul	27.3	30.3	22.1	89	65	14.9	6.4	5.9
29	16-22	Jul	18.9	29.9	22.4	87	62	17.6	4.7	5.8
30	23-29	Jul	50.0	30.2	22.5	88	62	16.5	4.0	6.6
31	30-05	Aug	74.4	30.4	22.3	89	62	14.2	7.5	6.6
32	06-12	Aug	24.9	30.0	22.8	88	62	11.8	3.9	5.4
33	13-19	Aug	14.4	28.8	22.4	88	67	16.1	1.5	5.2
34	20-26	Aug	3.4	29.9	22.4	85	58	15.0	2.4	5.7
35	27-02	Sep	0.8	31.5	22.3	80	51	9.9	8.0	6.3
36	03-09	Sep	59.1	30.5	21.8	90	58	8.4	5.5	5.8
37	10-16	Sep	40.7	28.2	22.0	96	73	7.4	3.5	3.5
38	17-23	Sep	35.4	30.7	22.3	92	62	4.9	6.7	4.7
39	24-30	Sep	44.9	28.6	21.3	94	72	5.0	5.1	6.4
40	01-07	Oct	0.0	31.5	19.7	87	38	3.9	9.9	5.5
41	08-14	Oct	0.0	32.2	18.9	86	37	5.0	9.9	6.0
42	15-21	Oct	44.5	28.9	19.8	90	60	9.6	6.5	4.3
43	22-28	Oct	14.3	29.0	21.4	93	63	4.6	6.5	3.6
44	29-04	Nov	2.4	29.2	19.0	86	52	7.7	9.2	4.7
45	05-11	Nov	9.4	28.2	20.8	95	63	12.0	6.2	4.1
46	12-18	Nov	0.0	29.8	16.7	88	44	5.0	9.7	4.7
47	19-25	Nov	0.0	27.7	15.0	92	45	5.8	8.7	4.4
48	26-02	Dec	0.0	27.9	15.0	93	43	5.7	7.8	4.1
49	03-09	Dec	0.0	27.7	11.9	90	41	6.1	9.7	4.8
50	10-16	Dec	0.0	28.4	14.1	94	41	6.5	8.4	4.6
51	17-23	Dec	0.0	28.5	13.1	94	42	6.6	10.0	4.9
52	24-31	Dec	0.0	28.5	13.7	92	35	7.1	9.7	5.2
1	01-07	Jan	0.0	27.8	10.5	84	35	4.6	10.3	4.8
2	08-14	Jan	0.0	29.8	12.3	85	30	5.0	10.1	5.0
3	15-21	Jan	0.0	28.5	13.8	91	35	6.9	10.1	5.6
4	22-28	Jan	0.0	28.5	15.4	87	37	10.3	9.6	7.4
5	29-04	Feb	0.0	29.9	13.1	76	28	5.4	10.2	6.0
6	05-11	Feb	0.0	30.6	18.8	87	35	11.4	10.1	6.9
7	12-18	Feb	0.0	33.1	18.9	80	30	9.9	9.6	8.3
8	19-25	Feb	0.0	34.1	16.1	66	19	6.5	10.4	8.2
9	26-04	Mar	0.0	34.4	17.5	57	19	6.9	10.5	8.1
10	05-11	Mar	0.0	35.7	20.5	73	25	10.1	10.3	10.0
11	12-18	Mar	0.0	37.8	20.5	54	17	6.5	10.4	10.1
12	19-25	Mar	12.5	36.0	18.0	64	26	7.4	10.1	9.1
13	26-01	Apr	0.0	37.3	21.5	56	23	9.8	10.4	11.8
14	02-08	Apr	0.0	38.4	21.5	47	18	8.2	10.5	11.7

15	09-15	Apr	0.0	38.3	21.3	55	20	7.7	10.7	11.9
16	16-22	Apr	0.0	37.8	24.1	55	23	11.5	10.6	13.0
17	23-29	Apr	0.0	39.2	24.5	71	28	10.7	9.9	12.3
18	30-06	May	0.0	40.9	25.5	47	18	11.7	11.1	14.8
19	07-13	May	17.4	38.1	24.7	68	34	11.4	8.2	9.8
20	14-20	May	28.7	37.0	24.1	77	40	10.7	6.9	8.0
21	21-27	May	1.2	39.8	26.4	53	26	12.8	9.3	12.6
22	28-03	Jun	0.0	41.5	26.6	42	18	15.7	10.5	16.1