Departmental Progress Report-20
PULSE ENTOMOLOGY



# PULSE ENTOMOLOGY (PIGEONPEA) REPORT OF WORK

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ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
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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.

**THIS IS NOT AN OFFICIAL PUBLICATION OF ICRISAT AND SHOULD NOT BE CITED**

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 the 1985 rainy season rainfall was below average, particularly in August and September, however it was fairly well distributed so the crops grew moderately well in the early stages but long-duration genotypes were drought affected in their reproductive stages.

The pod borer (Heliothis armigera), which is the major pest of pigeonpea was much less abundant in the 1985/86 season than in previous years at ICRISAT Center. The populations increased as usual in August/September and the short-duration pigeonpea that flowered then was severely damaged. But, from then onwards the populations, which we monitor by counts on the crops and in pheromone and light traps, were much lower than expected. In most years the Heliothis populations on our farm reach a peak in November/December but our moth catches over that period in 1985 were the lowest in our 10 years' records and our medium-duration pigeonpea suffered much less damage than usual.

Of the other lepidopteran pests, the leaf webber (Cydia critica) was more common than usual at ICRISAT Center but relatively rare at Hisar in northern India. There, almost all of the flower and pod webbing that occurred was caused by Maruca testulalis. This pest was also seen to be very common on pigeonpea grown experimentally in Thailand.

The podfly (Melanagromyza obtusa), which is the second most damaging pest of pigeonpea throughout India, built up to large damaging populations in our long-duration genotypes, particularly at Gwalior. The hymenopteran pest (Tanaostigmodes cajani) was again a major pest on our research farm but rare in farmers' fields. The unusually dry rainy season provided ideal conditions for the sucking pests. Aphis craccivora was very common on the seedlings and several species of pod sucking bugs, particularly Clavigralla gibbosa, caused substantial crop damage from September onwards. The blister beetle (Mylabris pustulata) was very common on ICRISAT Center from August through November and we received reports from several areas of India that this pest destroyed many of the flowers of pigeonpea and other legumes. The bruchids (Callosobruchus spp) were common in the pods, particularly where harvesting was delayed and were, as usual, the main pests in the stored pigeonpea.

The jewel beetle (Sphenoptera indica), whose larva tunnels below the bark at the base of the stem and promotes a prominent gall was evident in several fields. An unusually heavy infestation by the red spider mite (Schizotetranychus cajani) developed in a field where we had applied soil insecticides in an attempt to control the nodule damaging fly (Rivellia angulata). This outbreak may have been a result of natural enemy destruction and served as yet another warning that insecticide use may promote unusual pest attacks.

Project: CP-124(85)IC

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

## Objectives

(a) Identification of the sources of insect resistance/tolerance in germplasm, wild relatives, breeders' material. Selecting of material combining insect and disease resistance, compensation for pest damage and greater yield under farmers' conditions.

(b) Refining the screening techniques.

(c) Multilocation testing of selections in India and other countries in collaboration with national programs.

(d) Studies on mechanisms of pests resistance excluding podfly and on biochemical aspects in collaboration with biochemists at ICRISAT and Max-Planck Institute, Munich.

## Trials of 1985-86

During this year we resumed screening of the new accessions of germplasm. Simultaneously, emphasis was given to the large scale screening and testing of the materials developed by our breeders from crosses incorporating pest and disease resistant parents. Further testing of the medium-duration and long-duration maturing selections was also undertaken.

Several trials were conducted under low input conditions on the pesticide free Vertisol blocks - BUS-8C and BUS-5E at ICRISAT Center and also at the HAU-farm, Hisar (field No.19, 0.25 ha). We also tested borer resistant and susceptible genotypes in no choice situations in isolation blocks - RL-25B & C, Q-5 & RUS-6A, BUS-25B & BM-26C and on BS-10 & BS-3A at ICRISAT Center. Crop growth was good in most of these blocks. Irrigation was given to the plots in the Alfisol area to ensure a good plant stand.

Sprayed/unsprayed comparison trials of promising selections in different duration groups were grown on BIL-6A. The sprayed plots were treated with endosulfan, which was directed mainly against *H.armigera* attacks from flowering onwards. Dimethoate was also applied on the long-duration genotypes to reduce podfly infestation. An area of 2.82 ha was covered under this project at Patancheru. In addition pest resistance breeding material was planted on 4.78 ha in unsprayed fields (BUS-7A, B, 11B and BM-16A) at Patancheru.

The pests, *H.armigera*, *Cydia critica*, *Mylabris pustulata*, *Clavigralla gibbosa* and *Dolicoris indicus* caused severe damage to flowers and pods of the very short-duration and short-medium-duration cultivars and a drastic reduction in seed yields in most of the cultivars was recorded. At Hisar, leaf webbing insects, Cydia critica, and Maruca testulalis caused substantial damage to extra short duration cultivars.

In some selected trials intensive counts of pests were made from flowering onwards. At maturity we harvested pods from all the trials and pest damage assessment were recorded from pod samples. From some trials we collected the pods for damage assessment in two pickings, one from the first flush, which had been largely destroyed by H.armigera and the second from the compensatory or ratoon flush. Pod samples were separated and counted according to the damage characteristics. Plant and plot yields of dry seeds were weighed after threshing. As the task of pod sorting and counting for pest damage assessment is laborious and require semi-skilled people for long periods, we resorted to visual scoring in most of the breeders' material planted in BUS-area. In these tests selections which were looking good (with lower rating for pests damage) and giving higher yields were advanced for further testing and the remaining lines were discarded.

Germplasm screening

We resumed the screening of pigeonpea germplasm in this year, having shelved such testing in 1984/85. A set of 560 new long-duration accessions, including the lines for which no data could be obtained in previous trials, were sown in a pesticide free block BUS-5A on 26 June 1985. The plots, each of five hills, were grouped in blocks of 25 entries each including check cultivars of the relevant duration group. Each block was bordered with infestor rows that had been sown 10 days earlier, these included a mixture of Pant A-1, Pusa Ageti, T-21 and ICP-1. The check entry was NP(WR) 15.

At maturity individual plants were selected for reduced susceptibility to the major pests and high yielding characters. Later, the pods were collected from one plant, randomly selected from each entry and pod damage assessments were made. We obtained useful results from 466 entries. Out of these, 21 individual plants were selected for further testing in replicated trials in the rainy season of 1986/87.

There was severe borer and bug damage in these long-duration accessions, which were mostly from East African countries. Poor growth and slow plant development was observed in the initial stage of development, later the plants grew on well but the pod setting was generally poor.

Testing of pigeonpea entomology selections at Patancheru and Hisar

In previous years' trials we selected pigeonpea genotypes of different durations from the germplasm, from breeders materials and from the pathologists' disease resistant selections which showed reduced susceptibility and tolerance to the lepidopteran borers (mainly *H.armigera*) and to podfly (*M.obtusa*). These selections were tested in pesticide free blocks and the best were again advanced for further testing for checking their consistency in performance. Such selections were again grown in trials as shown in the Table 1 and tested and screened during rainy season 1985-86 at Patancheru and Hisar.

Table 1: List of trials with selections of pigeonpea of differing durations conducted at Patancheru and Hisar during the rainy season 1985/86.

| Selection groups | No. of entries | Reps. | Expt. design |
|---|---|---|---|
| I <u>Testing of very short-duration selections</u> (Unsprayed) | | | |
| At ICRISAT Center, Patancheru (BUS-8C): | | | |
| 1. Single plant selections (SPS) | 16 | 2 | Lattice |
| 2. Selections from Patancheru and Hisar | 12 | 2 | RBD |
| At HAU-farm, Hisar (Field No.19): | | | |
| 3. Selections from Patancheru and Hisar | 12 | 2 | RBD |
| II <u>Testing of short duration selections</u> | | | |
| At ICRISAT Center (BUS-8C unsprayed, BIL-6A sprayed/unsprayed): | | | |
| 4. SPS from promising lines | 16 | 2 | Lattice |
| 5. Selections from Patancheru and Hisar | 16 | 3 | Lattice |
| 6. Selections from Patancheru and Hisar | 16 | 3 | Lattice |
| 7. Promising bulks sprayed/unsprayed comparison | 7 | 2 | Split plot |
| At HAU-farm Hisar (Field No.19) | | | |
| 8. Selections from Patancheru and Hisar | 12 | 3 | RBD |
| 9. Selections from Patancheru and Hisar | 15 | 3 | Lattice |
| III <u>Testing of medium-duration selections</u> | | | |
| At ICRISAT Center (BUS-5E unsprayed, BIL-6A sprayed/unsprayed): | | | |
| 10. SPS from promising lines | 16 | 2 | Lattice |

| Selection groups | No. of entries | Reps. | Expt. design |
|---|---|---|---|
| 11. SPS from short-medium-duration promising lines | 28 | 2 | Lattice |
| 12. Selection bulks of short-duration material | 9 | 4 | BLS |
| 13. Selections from medium-duration lines | 9 | 3 | Square Lattice |
| 14. Medium-long-duration selection bulks | 9 | 3 | Square Lattice |
| 15. Medium-long-duration promising bulks sprayed/unsprayed comparison | 18 | 2 | Split block |
| IV Testing of long-duration selections | | | |
| At ICRISAT Center (BUS-5E unsprayed, BIL-6A sprayed/unsprayed): | | | |
| 16. Selections from long-duration material | 30 | 3 | Rectangular lattice |
| 17. Long-duration promising bulks - sprayed/unsprayed comparison | 15 | 2 | Split block |

The summarized data from these trials are presented in Tables 2 to 13. These tables include details of the characters for which the entries were selected in 1984 and 1985 rainy season with the abbreviations as follows:

L = Low; M = Moderate; H = High; B = Borer damage (mainly by *Heliothis armigera*); Pf = Podfly damage; H (as second letter) = Hymenopteran damage; LT = Low total pod damage; T = Tolerance to pest complex; Y = Yield; R = Recovery (compensation); SM = Sterility mosaic disease; W = Wilt disease; R (with disease) = Resistant; S = Susceptible. For growth habit: DT = Determinate; NDT = Indeterminate; SDT = Semi determinate.

I. Testing of very short-duration selections - unsprayed

At ICRISAT Center, Patancheru (BUS-8C):

A trial at Patancheru of the progenies of 14 single plant selections with two check cultivars was planted at Patancheru in a 2 replication - lattice design on 25 June 1985, using plots of 3 rows of 4 m with 37.5 x 20 cm spacing. Pest damage was recorded during the flowering and podding stage and further observations and selections were made at maturity. Out of these, 7 entries were selected and advanced for further testing. A few single plant selections were also advanced for the next season's trial.

In another trial with selections from Patancheru and Hisar, 12 entries were grown on 5 rows of 4 m (with 37.5 x 20 cm spacing) in a 3 replication - lattice. The harvesting of 6 plants, randomly selected, was undertaken in two pickings, (on 18 October and on 2 December 1985). The results of pod damage assessments and the mean sample yields of both the pickings and the final plot yields are furnished in Table 2. There was high insect damage, particularly of *Heliothis* sp. and pod sucking bugs in the first flush. In the second picking hymenopteran pest damage was surprisingly high, which resulted in low total plot yields. No selection outyielded the check Pant A1, and there were no significant differences among the yields of the entries. However, there were significant differences among the borer damage percentages recorded from the first pick and among the hymenopteran damage percentages in the second pick.

Some selections were made on the basis of their reduced susceptibility to borers. ICPL-316 was found to be least attacked by hymenopteran pest in both the pickings. The entries which gave better yields than UPAS-120 were also advanced for further testing.

At Hisar, HAU-farm (field No.19):

The same selections, as tested in Patancheru, were also sown at the HAU-farm, Hisar on an unsprayed block. In this trial 12 entries were planted on 5 rows of 4 m with close spacing, in a 3 replication lattice design on 12 July 1985. Pods from 6 plants per plot were collected (only once) for pests damage assessments. The total plot yields were ascertained from an area of 3.6 sq.m. There was moderate *Heliothis* damage to pods, but podfly and hymenopteran incidence was low and no significant difference were detected. At harvest, very good seed yields were obtained, particularly in entries, ICPL-84044, ICPL-84052, Pant A1 and in DA-6. Many cultivars out-yielded the check UPAS-120, but only two gave greater yields than Pant A-1 (Table 3).

II Testing of short-duration selections

**At Patancheru, unsprayed trials and sprayed/unsprayed comparison:**

At ICRISAT Center, we grew progenies from 14 single plant selections from short-duration pigeonpea lines with 2 checks in a two-replication lattice under pesticide free conditions on block BUS-8C. At maturity, following visual observations, 4 selections were advanced for further testing and the remaining entries were discarded because of the severity of pest damage and poor yields.

We also tested 16 entries in a triple lattice on BUS-8C. In this trial the selections which showed reduced susceptibility in the past 3 to 4 years in our tests were included and a comparison was made with the standard checks. In this test late-flowering genotypes showed less damage by borers and produced greater yields, except for PPE-45-2. Among the early flowering group, entry 82-HO9-12 produced high yields with a moderate pest attack (Table 4).

Table 2: Results of testing very short-duration pigeonpea selectionns in pesticide free conditions at ICRISAT Center on BUS-8C, during the rainy season, 1985/86. Plot size: 5 rows of 4 m (37.5 cm x 20 cm); Net plot harvested: 3.94 sq.m.

| Entries | Growth habit* | DF 50% | Chara-cters 1984* | Pod damage mean (%) Borer | Podfly | Hmn. | Total | Mean sample yield (6 pts) |
|---|---|---|---|---|---|---|---|---|
| <u>1st picking on 18-10-1985</u> | | | | | | | | |
| ICPL-84019 | DT | 40 | Sels. from Hisar | 69.3 | 0.4 | 19.0 | 79.6 | 3.4 |
| ICPL-316 | DT | 46 | " | 65.9 | 0.8 | 12.1 | 74.5 | 1.1 |
| ICPL-84018 | DT | 51 | " | 47.1 | 0.2 | 15.9 | 58.7 | 11.0 |
| UPAS-120 (check) | SDT | 53 | " | 34.1 | 0.6 | 32.9 | 59.6 | 13.7 |
| ICPL-84044 | NDT | 56 | " | 43.0 | 0.8 | 21.7 | 63.6 | 9.0 |
| ICPL-84052 | NDT | 56 | " | 32.3 | 1.2 | 39.6 | 66.2 | 10.7 |
| ICPL-84040 | NDT | 56 | " | 31.9 | 0.2 | 38.0 | 62.3 | 3.0 |
| DA-6 | NDT | 58 | LB | 28.4 | 0.6 | 47.4 | 67.1 | 9.0 |
| Pant A1 (check) | SDT | 58 | - | 49.7 | 0.5 | 20.9 | 62.3 | 11.2 |
| ICPL-187-1-1 | NDT | 62 | LB,HY | 35.7 | 2.7 | 24.0 | 58.2 | 12.2 |
| ICPL-269 | SDT | 63 | LB | 26.3 | 2.3 | 33.8 | 53.3 | 12.1 |
| ICPL-4 | DT | 86 | LB,LPf,HY | 48.9 | 0.2 | 22.3 | 66.4 | 7.0 |
| Trial mean | | | | 42.7 | 0.9 | 27.3 | 64.3 | 8.6 |
| SE of mean ± | | | | 4.41 | (1.72)** | 5.79 | 5.17 | 4 |
| CV% | | | | 16 | 80 | 40 | 13 | 72 |
| LSD at $p<0.05$ | | | | 13.49 | - | - | - | - |

| Entries | Growth habit* | DF 50% | Characters 1984* | Pod damage mean (%) Borer | Podfly | Hmn. | Total | Mean sam-yield (6 pts) | Yield kg/ha (final harvest) |
|---|---|---|---|---|---|---|---|---|---|
| **IInd picking on 2-12-1985** | | | | | | | | | |
| ICPL-84019 | DT | 40 | Sels. from Hisar | 20.5 | 1.1 | 48.6 | 64.5 | 24.3 | 320 |
| ICPL-316 | DT | 46 | " | 30.6 | 0.4 | 25.5 | 53.7 | 21.5 | 320 |
| ICPL-84018 | DT | 51 | " | 23.6 | 0.2 | 53.7 | 71.3 | 16.4 | 400 |
| UPAS-120 (check) | SDT | 53 | " | 14.7 | 1.3 | 51.4 | 62.1 | 33.1 | 610 |
| ICPL-84044 | NDT | 56 | " | 25.0 | 1.9 | 40.0 | 60.1 | 22.7 | 510 |
| ICPL-84052 | NDT | 56 | " | 12.1 | 1.1 | 75.5 | 82.1 | 31.4 | 640 |
| ICPL-84040 | NDT | 56 | " | 16.7 | 2.0 | 50.4 | 63.7 | 29.8 | 530 |
| DA-6 | NDT | 58 | LB | 18.0 | 0.9 | 73.5 | 81.4 | 26.1 | 550 |
| Pant A1 (check) | SDT | 58 | - | 15.9 | 1.0 | 42.6 | 55.9 | 38.7 | 770 |
| ICPL-187-1-1 | NDT | 62 | LB,HY | 11.6 | 1.1 | 70.2 | 77.3 | 33.5 | 680 |
| ICPL-269 | SDT | 63 | LB | 15.4 | 0.7 | 57.4 | 67.4 | 20.3 | 500 |
| ICPL-4 | DT | 86 | LB,LPf,HY | 13.0 | 0.6 | 48.1 | 56.3 | 39.1 | 620 |
| Trial mean | | | | 18.1 | 1.0 | 53.1 | 66.3 | 28.1 | 540 |
| SE of mean ± | | | | 2.94 | (1.73)** | 6.17 | 4.46 | 3.88 | 77 |
| CV% | | | | 30 | 65 | 19 | 11 | 28 | 24 |
| LSD at $p<0.05$ | | | | - | - | 18.86 | 13.64 | - | - |

* For abbreviations see page 5.
** Arcsin-$\sqrt{\%}$ transformation was used for the analysis of data. Figures in parentheses are the transformed values.

Table 3: Results of testing very short-duration pigeonpea selections in an RBD (3 reps.) grown in pesticide free conditions at Hisar, during the rainy season, 1985/86. Plot size: 5 rows of 4 m; Net plot harvested: 3.6 sq.m.

| Cultivars/ lines | DF 50% | Chara- cters 1984* | Pods per pt. (18)pts. sampled | Pod damage mean (%) Borer | Pod- fly | Total | Mean sample yield g | Yield kg/ha |
|---|---|---|---|---|---|---|---|---|
| ICPL-84019 | 51 | LPf | 62 | 30.9 | 2.2 | 33.1 | 74.3 | 1590 |
| ICPL-84018 | 53 | LPf | 39 | 32.6 | 1.6 | 34.2 | 62.7 | 1820 |
| ICPL-316 | 60 | LPf | 86 | 29.0 | 3.2 | 32.0 | 102.2 | 2030 |
| ICPL-4 | 60 | LB,LPf, HY | 65 | 23.3 | 1.3 | 24.5 | 73.3 | 2270 |
| Pant A-1 (check) | 65 | LPf | 81 | 16.6 | 1.5 | 18.0 | 110.0 | 2720 |
| ICPL-84052 | 65 | LB,LT, HY | 73 | 14.1 | 3.4 | 17.4 | 125.4 | 3000 |
| ICPL-84040 | 68 | LPf | 63 | 25.2 | 0.7 | 25.9 | 99.5 | 1810 |
| UPAS-120 (check) | 68 | LPf | 47 | 15.9 | 2.1 | 17.4 | 58.7 | 1910 |
| ICPL-84044 | 70 | HY | 71 | 18.7 | 4.1 | 22.8 | 165.2 | 3160 |
| DA-6 | 70 | LB,LPf | 111 | 23.3 | 1.6 | 24.7 | 152.4 | 2500 |
| ICPL-187-1 | 71 | LB,LPf, LT | 98 | 11.3 | 1.4 | 12.6 | 161.0 | 2460 |
| ICPL-269-EB | 73 | LB,LT | 103 | 12.5 | 2.0 | 14.5 | 158.5 | 2010 |
| Trial mean | | | | 21.1 | 2.09 | 23.1 | 111.9 | 2272 |
| SE of mean ± | | | | 3.81 | (1.56) | 3.94 | 17.70 | 273 |
| CV% | | | | 31 | 35 | 30 | 27 | 21 |
| LSD at p<.05 | | | | 11.05 | - | 11.43 | 51.33 | 791.1 |

* For abbreviations see page 5.

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

Table 4: Testing of short-duration pigeonpea selections (from Patancheru and Hisar) at ICRISAT Center, Patancheru during the rainy season 1985/86 on BUS-8C. Plot size: 3 rows of 4 m, 3 reps (lattice square); Net plot harvested: 9 sq.m.

| Cultivars/ lines | DF 50% | Characters 1984 | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| PUSA-35 | 66 | HY | 32.2 | 0.6 | 21.9 | 55.6 | 430 |
| ICPL-314 | 67 | LB | 25.2 | 0.7 | 23.8 | 48.3 | 370 |
| ICPL-1 | 69 | LPf | 31.2 | 1.2 | 27.3 | 54.4 | 380 |
| PUSA-33 | 69 | LPf,LT | 31.6 | 1.8 | 14.8 | 44.1 | 470 |
| ICPL-186 | 69 | LPf,LT | 26.9 | 1.1 | 26.5 | 51.2 | 390 |
| ICPL-2● | 72 | LB,LPf,LT | 47.8 | 1.2 | 14.6 | 57.9 | 300 |
| ICPL-269 | 72 | LB,LPf | 39.9 | 2.3 | 26.1 | 60.8 | 360 |
| ICPL-6 | 72 | LB,LPf | 35.7 | 2.1 | 16.8 | 49.5 | 550 |
| 82-H-18-1 | 72 | LB,LPf,HPf | 45.8 | 2.9 | 19.8 | 63.3 | 350 |
| ICPL-288 | 72 | HY | 51.5 | 3.4 | 25.2 | 74.7 | 330 |
| 82-H09-12 | 72 | LB,HY | 26.9 | 1.5 | 48.0 | 71.5 | 650 |
| 82-H03-18 | 82 | LB,LPf,HPf | 53.3 | 1.6 | 35.3 | 76.3 | 580 |
| ICP-7203-E1 | 87 | HY,LT,LPf | 14.0 | 2.8 | 9.6 | 24.4 | 1190 |
| S-80 | 93 | LPf,HY | 10.4 | 2.2 | 28.8 | 39.3 | 1050 |
| P-6410-E1 | 101 | LB | 9.6 | 5.5 | 54.9 | 64.2 | 790 |
| PPE-45-2 | 114 | LB | 10.0 | 0.8 | 44.9 | 53.6 | 240 |
| Trial mean | | | 30.9 | 2.0 | 27.4 | 55.6 | 527 |
| Efficiency % over RBD | | | 79.0 | 100.0 | 100.0 | 102.3 | 88.4 |
| SE of mean ± | | | 5.12 | (1.24)** | 7.81 | 5.79 | 101 |
| CV% | | | 29 | 28 | 49 | 18 | 32 |
| LSD at p<.05 | | | 14.84 | (3.61)** | 22.65 | 16.79 | 293 |

* For abbreviations see page 5.

** Arcsin-√% transformation was used for the analysis of data Figures in parentheses are the transformed values.

In another trial on BIL-6A, we compared short-duration genotypes in sprayed and unsprayed plots. Seven genotypes including a common check were grown on large plots (12 rows of 9 m) in a split-plot design trial. In this experiment 5 sprayings of endosulfan 35% EC, one of monocrotophos and 2 of dimethoate were applied, mainly against *Heliothis*. Borer damage was not high in this block, but the hymenopteran pest was very active in damaging the pods. There was some reduction of borer damage to pods by the endosulfan sprays, but no significant increase in yields was observed. The results of pod damage by different pests and yields of the cultivars tested are furnished in Table 5. In this trial our low borer selections showed less borer damage than the susceptible and check cultivars. No entry showed a high level of resistance to pest attack. The borer damage was low and it was confounded with a high level of hymenopteran pest attack.

## At Hisar

Two trials with 12 and 14 short-duration selections were conducted under unsprayed conditions in field No.19 at the HAU-farm, Hisar. These entries were sown in plots of 5 rows of 4 m in an RBD with 3 replicates. In the first trial, one replication block was affected by salinity, so only the data from 2 reps. were taken for comparison and analyses. In general, pest caused damage was low in these trials, but yields were high for most entries. Pusa 33, ICPL 288 and 82-H09-12 gave greater yields than the checks. Some entries were again selected for further testing and confirmation of results. The details of pests damage and yields of these selections are furnished in Tables 6 and 7.

In the 14 entry short-duration selections trial only five entries matured at the expected time, so the yield comparisons were made on the sample yields.

We also grew breeders' promising lines of short duration for pest susceptibility studies under unsprayed conditions, on plots of 1 row of 4 m. A total of 37 entries were planted in 2 replications in an RBD trial. Plant growth was good in all the entries and there was very good podding in most selections. We assessed pod damage in pods collected from 2 plants per plot at maturity and plot yields were recorded from net plots of 1.8 sq.m. The pest damage and yield data are furnished in Table 8.

At the pod swelling stage we also observed and scored all the lines for pest damage and some single plant selections were also made. A few selections particularly H-77-216, ICPL-8332 and ICPL-314, showed low pod borer damage. The podfly incidence was low in the early maturing genotypes. In the small plot comparisons ICPL-186 produced the greatest yield of 5120 kg ha-1, but ICPL-316 produced a yield of less than 1000 kg ha-1 due to severe borer damage to pods. Only three lines produced more than the standard check (UPAS-120). The selections from this trial will be tested again in a replicated trial next year.

Table 5: Comparison of pigeonpea promising bulks (short duration) under unsprayed and sprayed conditions on BIL-6A, ICRISAT Center, during the rainy season 1985/86. Entries: 7; Reps.: 2 (split plot); Net plot harvested: 60 sq.m.

| Cultivar | Characters 1984* | DF 50% | Pod damage % (mean) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| **Unsprayed** | | | | | | | |
| ICP-909 | LB,LPf | 81 | 6.0 | 9.4 | 41.2 | 55.6 | 1690 |
| Sehore-197 | LB,LT,WT | 82 | 8.8 | 8.1 | 19.7 | 35.5 | 1740 |
| 1918 (IG) | LB,HY | 82 | 8.0 | 6.4 | 38.7 | 51.1 | 1420 |
| T-21 | HB,HH | 83 | 9.1 | 6.4 | 41.3 | 54.8 | 1260 |
| ICP-7203 | HB,HY | 88 | 17.2 | 18.5 | 10.6 | 45.4 | 1870 |
| PPE-82 | LBS | 102 | 7.7 | 11.0 | 39.3 | 55.8 | 1520 |
| PPE-45-2 | LB | 105 | 3.6 | 7.2 | 45.8 | 55.3 | 1300 |
| Mean | | | 8.6 | 9.5 | 33.8 | 50.5 | 1540 |
| **Sprayed** | | | | | | | |
| ICP-909 | LB,LPf | 81 | 4.1 | 6.2 | 54.0 | 60.5 | 1250 |
| Sehore-197 | LB,LT,WT | 81 | 9.6 | 3.4 | 17.2 | 32.8 | 1710 |
| 1918 (IG) | LB,HY | 81 | 6.9 | 3.1 | 42.1 | 51.2 | 1500 |
| T-21 | HB,HH | 83 | 6.1 | 4.6 | 38.6 | 47.6 | 1350 |
| ICP-7203 | HB,HY | 88 | 5.8 | 13.0 | 14.4 | 36.4 | 1910 |
| PPE-82 | LBS | 102 | 5.0 | 9.0 | 47.1 | 58.7 | 1470 |
| PPE-45-2 | LB | 105 | 2.3 | 8.4 | 39.6 | 49.5 | 1350 |
| Mean | | | 6.2 | 6.8 | 36.2 | 48.1 | 1510 |
| **Effect of main treatment (insecticide protection)** | | | | | | | |
| SE of mean ± | | | 1.58 | 0.19 | 2.38 | 0.67 | 76 |
| CV% | | | 30.2 | 3.3 | 9.6 | 1.9 | 7 |
| **Effect of sub-treatment (cultivar)** | | | | | | | |
| SE of mean ± | | | 1.54 | 1.28 | 4.78 | 3.92 | 99 |
| CV% | | | 41.6 | 31.4 | 27.3 | 15.9 | 13 |
| **Effect of interaction** | | | | | | | |
| SE of mean ± | Main | | 2.18 | 1.81 | 6.76 | 5.55 | 140 |
| | Sub | | 2.57 | 1.69 | 6.70 | 5.18 | 151 |

* For abbreviations see page 5.

Table 6: Results of testing short-duration pigeonpea selections in an RBD trial (2 reps.) grown in pesticide free conditions at Hisar, during the rainy season 1985/86. Plot size: 5 rows of 4 m; Net plot harvested: 3.6 sq.m.

| Cultivars/ Lines | DF 50% | Characters 1984* | Pods per pt (12)pts. sampled | Pod damage mean (%) Borer | Podfly | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| PUSA-35 | 69 | HY | 62 | 6.2 | 3.8 | 10.0 | 2200 |
| 82-H03-18 | 69 | HB,HY,LPf | 109 | 15.5 | 0.5 | 16.1 | 1680 |
| UPAS-120(Check) | 70 | - | 87 | 11.8 | 5.1 | 16.9 | 3130 |
| ICPL-288 | 72 | LB,LT,HY | 75 | 10.7 | 6.6 | 17.2 | 3590 |
| ICPL-269 | 75 | HY | 67 | 10.9 | 4.0 | 14.9 | 2060 |
| ICPL-314 | 75 | HY | 99 | 8.8 | 12.3 | 21.1 | 2530 |
| ICPL-2[illegible] | 75 | LB,LT,HY | 134 | 5.6 | 9.4 | 14.9 | 2400 |
| ICPL-1 | 78 | LB,LT,HY | 107 | 7.3 | 7.0 | 14.1 | 2530 |
| PUSA-33 | 80 | HY | 97 | 11.5 | 2.4 | 13.9 | 3890 |
| ICPL-6(Check) | 85 | - | 144 | 3.4 | 3.7 | 7.1 | 2420 |
| ICPL-186 | 87 | HY | 122 | 1.8 | 7.4 | 9.2 | 2480 |
| 82-H-18-1 | 90 | HY | 88 | 12.3 | 4.9 | 17.2 | 2210 |
| Trial mean | | | | 8.8 | 5.6 | 14.4 | 2593 |
| SE of mean ± | | | | (2.73)** | (2.93)** | 3.22 | 524 |
| CV% | | | | 23.3 | 32.4 | 31.6 | 29 |
| LSD of p<.05 | | | | - | - | - | - |

* For abbreviations see page 5.

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

Table 7: Results of testing short-duration selections in an RBD trial (3 reps) grown in pesticide free conditions at Hisar, during the rainy season 1985/86. Plot size: 5 rows of 4 m; Net plot harvested: 4.86 sq.m.

| Cultivars/ Lines | DF 50% | Characters 1984* | Pod damage mean (%) Borer | Podfly | Total | Mean sample yield g(6 pts) |
|---|---|---|---|---|---|---|
| 82-HP-1790 | 65 | HY | 29.8 | 6.8 | 36.6 | 83 |
| P-6410-E1 | 81 | LB | 12.7 | 16.3 | 28.9 | 188 |
| ICP-909-E1 (LB-Check) | 84 | LB,HY | 5.6 | 18.7 | 24.2 | 216 |
| S-80 | 88 | LB,HY | 8.0 | 19.1 | 27.1 | 221 |
| 82-H09-12 | 92 | HY | 4.5 | 14.2 | 18.8 | 208 |
| ICPL-342 | 92 | LB | 6.0 | 24.8 | 30.7 | 118 |
| ICPL-8354 | 97 | HY | 4.0 | 21.9 | 25.9 | 74 |
| ICPL-84016 | 98 | HY | 10.4 | 26.2 | 36.6 | 56 |
| ICPL-84005 | 100 | HY | 6.8 | 25.0 | 31.8 | 100 |
| ICPL-84001 | 104 | HY | 6.4 | 34.3 | 40.7 | 55 |
| ICPL-84003 | 105 | HY | 11.5 | 20.2 | 32.0 | 48 |
| PDA-5-3EB | 107 | LB | 6.2 | 24.8 | 31.0 | 150 |
| ICPL-345 | 110 | LB | 9.3 | 35.3 | 44.6 | 133 |
| ICPL-84011 | 111 | HY | 10.6 | 19.6 | 30.2 | 133 |
| Trial mean | | | 9.4 | 21.9 | 31.4 | 127.3 |
| SE of mean ± | | | (3.41)** | 4.08 | 4.03 | 24.4 |
| CV% | | | 35.3 | 32.2 | 22.2 | 33.1 |
| LSD at $p<0.05$ | | | (9.88)** | 11.83 | 11.69 | 70.6 |

* For abbreviations see page 5.

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

Table 8: Breeders' promising lines for pest susceptibility at Hisar during the rainy season, 1985/86. Entries: 37; Reps.: 2; Plot: 1 row of 4 m (1.8 sq.m.).

| Entry | Pod damage percentage (mean) | | | Yield (kg/ha) |
|---|---|---|---|---|
| | Borer | Podfly | Total | |
| ICPL-186 | 14.5 | 3.3 | 17.8 | 5120 |
| H-77-216 | 4.7 | 2.0 | 6.8 | 4840 |
| ICPL-84059 | 12.2 | 4.8 | 16.9 | 4760 |
| UPAS-120(check) | 6.1 | 4.5 | 10.4 | 4520 |
| ICPL-84050 | 22.9 | 5.4 | 28.5 | 4230 |
| ICPL-8311 | 36.2 | 2.6 | 38.8 | 3860 |
| ICPL-84030 | 24.3 | 3.7 | 28.0 | 3790 |
| ICPL-8327 | 14.7 | 2.0 | 16.7 | 3530 |
| ICPL-84023 | 24.7 | 3.0 | 27.7 | 3480 |
| ICPL-292 | 17.1 | 6.9 | 24.1 | 3400 |
| ICPL-8329 | 13.8 | 14.0 | 27.8 | 3190 |
| ICPL-84055 | 19.9 | 4.1 | 23.9 | 3160 |
| ICPL-317 | 31.8 | 4.5 | 36.2 | 2950 |
| ICPL-8322 | 22.1 | 8.4 | 30.5 | 2810 |
| ICPL-84052 | 21.0 | 4.2 | 25.2 | 2770 |
| ICPL-84029 | 12.9 | 10.0 | 22.9 | 2690 |
| ICPL-8332 | 5.8 | 4.5 | 10.3 | 2640 |
| ICPL-8316 | 15.6 | 6.5 | 22.1 | 2610 |
| ICPL-84026 | 21.2 | 5.0 | 26.2 | 2600 |
| ICPL-84056 | 32.6 | 4.3 | 36.9 | 2590 |
| ICPL-84020 | 43.0 | 3.4 | 46.4 | 2380 |
| ICPL-151 | 21.8 | 6.8 | 28.6 | 2160 |
| ICPL-84031 | 37.5 | 5.9 | 43.4 | 2130 |
| ICPL-84027 | 25.2 | 0.5 | 25.7 | 2050 |
| ICPL-8326 | 15.9 | 4.2 | 20.1 | 2030 |
| ICPL-84042 | 27.9 | 1.7 | 29.6 | 2010 |
| ICPL-8328 | 24.0 | 8.0 | 32.1 | 1950 |
| ICPL-314 | 8.9 | 4.9 | 13.8 | 1890 |
| ICPL-269 | 22.7 | 6.6 | 29.3 | 1870 |
| ICPL-8306 | 39.9 | 3.4 | 43.3 | 1840 |
| ICPL-84018 | 40.3 | 3.5 | 43.2 | 1800 |
| ICPL-8321 | 25.3 | 7.0 | 32.4 | 1770 |
| ICPL-8315 | 47.4 | 3.3 | 50.7 | 1720 |
| ICPL-84040 | 31.8 | 11.0 | 42.9 | 1720 |
| ICPL-4 | 50.3 | 6.8 | 55.0 | 1210 |
| ICPL-84019 | 45.9 | 1.8 | 47.7 | 1110 |
| ICPL-316 | 53.7 | 4.2 | 57.5 | 970 |
| Trial mean | 25.3 | 5.0 | 30.3 | 2710 |
| SE mean ± | (3.35)* | (2.89)* | 5.51 | 400 |
| CV% | 16 | 34 | 25 | 21 |

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

## III Testing of medium-duration selections

Within this group, selections of a wide range of days to flowering were tested in trials of short-medium and medium-long duration types with relevant checks.

Seed from 14 single plant selections from the previous year were sown in BUS-5E with two checks, in a two replication lattice trial in plots of 2 rows of 4 m (rows 75 cm apart). Observations and plot selections were made at maturity in both the replications. Pod samples were collected from selected plots and from check entries for pests damage assessments. Out of 14 selections tested, only 5 bulks were advanced for testing on large plots.

In another lattice trial, 28 entries including 3 checks of medium-long duration were sown on plots of 3 rows of 4 m, in two replicates. In this trial moderately high borer damage was observed and podfly incidence was not severe on the basis of visual observations, particularly on reduced susceptibility and high yield, 4 lines were advanced for further tests. The pod damage assessment data of these entries are not furnished here, as this was a preliminary test.

In another BLS-trial we tested 9 short-medium duration selections under unsprayed conditions on plots of 3 rows of 4 m replicated four times. Six plants samples were taken at maturity for pod damage assessments. For yield comparisons, 9 sq.m. plots were harvested. Borer damage was moderately high and high podfly damage, ranging from 27 to 45%, was recorded. Only one selection PBNA 53, gave a significantly greater yield than the check cultivar BDN-1. Three more selections, including ICP-1903-E1 also produced higher yields than the check (Table 8). With the BLS analyses we obtained a higher efficiency of 109 to 127% over RBD in the case of borer damage %, hymenopteran damage and yield (Table 9).

The medium-duration selections, which were tested in the previous 2-3 years, were grouped in medium and medium-long duration groups and tested in two separate triple lattice square trials with check BDN-1 in one on BUS-8C and C-11 in the other on BUS-5E. The crop growth was good in the beginning, but at the flowering and pod setting stage there was a shortage of soil moisture, due to the long drought period. This water stress caused poor pod setting and seed development particularly in late maturing genotypes. The borer damage ranged from 16 to 39% and podfly damage from 2.6 to 29.7%. Hymenopteran damage was low, except for one entry (DA-15) in which 32% pod damage by this pest was recorded. Only 3 genotypes in the medium duration group and one in medium-long-duration group produced greater yields than the checks, but statistical analyses showed no significant difference among the cultivars.

We recorded greater efficiency (104 to 213%) in the medium-duration trial on square lattices over RBD for the pest damage variables, except for hymenopteran pod damage and yield. However, in the other square lattice trial with medium-long-duration material

Table 9: Results of testing short-medium duration selections under unsprayed conditions during the rainy season, 1985/86 at BUS-5E, ICRISAT Center. Plot size: 3 rows of 4 m (BLSD); Net plot harvested: 9 sq.m.; Harvested on: 5 Feb 1986.

| Cultivars/ lines | DF 50% | Chara- cters* | Pod damage mean (%) Borer | Podfly** | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| BDN-1 (Check) | 119 | LH | 43.2 | 34.8 | 1.6 | 74.8 | 700 |
| ICP-909-E1 | 119 | LB,LPf | 23.9 | 27.4 | 18.1 | 66.2 | 550 |
| 20 (105) | 128 | - | 42.1 | 30.9 | 5.4 | 72.9 | 410 |
| MTH-1 | 129 | HY | 28.6 | 34.4 | 7.6 | 63.8 | 890 |
| PBNA-53 | 129 | LB,HY | 23.7 | 44.6 | 5.5 | 67.9 | 1110 |
| ICP-1903-E1 | 132 | LB,HY | 20.6 | 35.3 | 22.3 | 67.1 | 830 |
| JNAM-421 | 132 | - | 33.0 | 34.6 | 5.1 | 67.5 | 700 |
| ICPL-84060 | 132 | - | 26.1 | 45.6 | 21.9 | 77.8 | 660 |
| MTH-5 | 136 | LT,HY | 18.6 | 35.6 | 9.3 | 61.3 | 870 |
| Trial mean | | | 28.8 | 35.9 | 10.8 | 68.8 | 744 |
| SE of mean ± | | | 2.61 | 3.48 | 2.45 | 2.62 | 83 |
| CV% | | | 18 | 19 | 46 | 8 | 22 |
| LSD at p<.05 | | | 7.60 | 10.14 | 7.13 | 7.62 | 242 |
| Effiency % over RBD | | | 127 | - | 109.0 | 74.0 | 115 |

* For abbreviations see page 5.
** Data analysed as RBD.

there was a lower efficiency (72 to 95%) over RBD (Tables 10 and 11). Some entries, particularly the disease resistant selections, were selected for further testing.

Sprayed/unsprayed comparison

On BIL-6A at ICRISAT Center, we tested 18 promising selection bulks (including BDN-1 and C-11 checks) on plots of 12 rows of 4 m in a two replication split block trial under sprayed and unsprayed conditions. The crop growth was good in all the entries, but plant stand was poor in cultivar ICP-7035 plots, where many of the large seeds failed to germinate, due to lack of moisture in soil at the time of sowing.

In this trial we applied 3 sprays of endosulfan, one of monocrotophos and two of dimethoate, mainly against *Heliothis* and podfly. There was a good protection against *Heliothis* in the sprayed block and podfly incidence was also reduced, but hymenopteran pest damage increased considerably. Most of the genotypes produced very good yields and there was some increase due to protection against pests, but no selection produced yields as good as BDN-1. Genotypes, ICP-3328, ICP-10531, ICP-1903 and PPE-88 showed tolerance to pest attack. The pest damage assessment results and yields of the selections tested are furnished in Table 12.

IV. Testing of long-duration selections

Unsprayed trial at Patancheru (BUS-5E)

The long-duration genotypes do not produce good yields in south India. They are better suited to the north Indian conditions. This year, because of scanty rains, the late varieties suffered from drought stress, that resulted in poor pod setting and seed development. We obtained good comparisons of pest susceptibility in the selections of the long-duration genotypes from disease resistant material from AICPIP-lines and from our pest tolerant mixture bulks.

We grew 30 entries in a generalized lattice design, in plots of 3 rows of 4 m, with three checks under pesticide free conditions. In this trial one entry failed to produce pods, and so was deleted from the analysis. Lepidopteran borer damage ranged from 17% to 42% (Table 13). Some genotypes showed a low level of podfly incidence and they were selected for further testing. The susceptible entries showed 20 to 35% podfly damage in pods. All the selections and checks produced low yields, the maximum being 370 kg/ha in one of our wilt resistant selection. We selected some lines showing multiple disease and pest resistance from this trial.

Testing of long-duration promising bulks - sprayed/unsprayed comparison

On block BIL-6A, we grew 15 bulks of the long-duration group under sprayed/unsprayed conditions in a two replicate split-block trial, in plots of 12 rows of 9 m. Half of the trial was protected from borer

Table 10: Testing of pigeonpea selections (from Patancheru and Hisar) of medium-duration on BUS-8C, ICRISAT Center during the rainy season 1985/86. Plot size: 3 rows of 4 m; Reps.: 3 (Lattice square); Net plot harvested: 9 sq.m.

| Cultivars/ lines | DF 50% | Chara- cters* | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| GS-1 | 107 | LH,LPf, LT | 25.8 | 2.6 | 1.1 | 28.7 | 650 |
| BDN-1 (Check) | 109 | LPf,LH | 26.9 | 3.8 | 1.2 | 32.2 | 710 |
| ICPL 345 | 113 | LB | 23.2 | 18.9 | 3.3 | 43.9 | 560 |
| PDA-5-3EB | 115 | LB | 16.1 | 16.3 | 6.5 | 36.9 | 460 |
| ICP-1903-E1-2EB | 122 | LB | 20.7 | 7.8 | 7.0 | 33.4 | 520 |
| ICPL-342 | 126 | LB,LH, LT | 18.2 | 12.9 | 2.3 | 32.8 | 670 |
| ICPL-84016 | 127 | LH | 21.6 | 10.2 | 1.3 | 35.2 | 650 |
| ICPL-84003 | 128 | LH | 33.6 | 12.2 | 1.2 | 44.8 | 530 |
| ICPL-84005 | 128 | LB,HY | 19.6 | 11.3 | 2.0 | 32.5 | 720 |
| ICPL-8354 | 132 | HY | 23.0 | 5.6 | 3.3 | 31.3 | 600 |
| ICPL-84011 | 131 | LB,LH, HY | 20.9 | 11.5 | 1.4 | 33.8 | 740 |
| ICPL-84071 | 134 | HPf | 33.5 | 9.5 | 1.3 | 41.6 | 450 |
| ICPL-84001 | 136 | LH,HY | 24.7 | 5.9 | 1.3 | 31.1 | 700 |
| ICPL-227 | 139 | LB | 19.7 | 21.1 | 4.2 | 43.6 | 520 |
| ICPL-8363 | 139 | LPf | 31.4 | 8.3 | 1.4 | 40.9 | 480 |
| ICPL-335 | 146 | LPf,HY | 26.7 | 9.7 | 2.9 | 38.4 | 770 |
| Trial mean | | | 24.1 | 10.5 | 2.6 | 36.3 | 608 |
| SE of mean ± | | | 3.05 | 1.60 | (1.95)** | 2.50 | 97 |
| CV% | | | 22 | 27 | 10 | 12 | 28 |
| LSD at p<0.05 | | | 8.79 | 4.61 | (5.62)** | 7.21 | - |
| Efficiency % over RBD | | | 104.2 | 213.4 | 83.5 | 185.5 | 99 |

* For abbreviations see page 5.

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

Table 11: Testing of selections from medium-long-duration pigeonpea under unsprayed conditions, ICRISAT Center (BUS-5E). Plot size: 3 rows of 4 m, triple lattice; net plot harvested: 9 sq.m.

| Cultivars/Lines | DF 50% | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|
| 82 HP-1363-3EB | 93 | 39.1 | 16.9 | 19.8 | 66.8 | 50 |
| C-11 (Check) | 124 | 29.8 | 29.7 | 6.9 | 60.8 | 360 |
| KWR(1)JBR-SW2e | 154 | 20.1 | 25.0 | 11.8 | 53.2 | 370 |
| ICP-7946-E1 | 154 | 30.1 | 8.4 | 1.5 | 39.2 | 170 |
| PI-395272-SWe | 157 | 21.8 | 11.4 | 10.0 | 42.5 | 220 |
| PI-394954-SW1e | 157 | 15.4 | 27.8 | 13.1 | 52.4 | 280 |
| DA-15 | 161 | 22.6 | 19.9 | 32.0 | 66.8 | 130 |
| ICP-8102-5-S1e | 161 | 18.0 | 27.3 | 10.5 | 52.7 | 250 |
| ICP-6443 (Check) | 161 | 28.3 | 15.8 | 12.1 | 52.8 | 300 |
| Trial mean | | 25.0 | 20.2 | 13.1 | 54.1 | 240 |
| SE of mean ± | | 4.15 | 5.51 | (3.48)* | 7.68 | 73 |
| CV% | | 29 | 47 | 30 | 25 | 54 |
| LSD at p<0.05 | | 12.40 | - | (10.38)* | - | - |
| Efficiency % over RBD | | 77.2 | 74.8 | 74.8 | 71.5 | 81 |

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

Table 12: Comparison of pigeonpea promising bulks (medium-duration) under unsprayed and sprayed conditions on BIL-6A, ICRISAT Center, during the rainy seaon 1985/86. Entries: 18; Reps.: 2 (split block); Net plot harvested: 22.5 sq.m.

| Cultivar | Chara-cters 1984* | DF 50% | Pod damage % (mean) | | | | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| | | | Borer | Podfly | Hymn. | Total | |
| **Unsprayed** | | | | | | | |
| PPE-88 | LBS | 104 | 5.3 | 10.1 | 44.8 | 55.9 | 1130 |
| BDN-1 (Check) | HB | 115 | 15.9 | 12.2 | 17.8 | 42.6 | 2320 |
| ICP-1811-E3 | LB,LT,HH | 118 | 10.2 | 16.7 | 34.8 | 57.3 | 2080 |
| GS-1 | LB,LH,LT | 118 | 15.2 | 12.8 | 9.9 | 36.3 | 2110 |
| ICPL-84060 | HY | 124 | 5.8 | 21.1 | 41.2 | 61.6 | 1790 |
| ICP-1691 | HB | 124 | 11.3 | 25.1 | 14.2 | 46.4 | 1750 |
| ICP-3328 | LB,LT,HY | 124 | 13.2 | 20.3 | 34.3 | 59.0 | 1960 |
| ICP-1903 | LB,MPf,HY | 124 | 13.4 | 20.2 | 34.3 | 60.6 | 1810 |
| ICP-10466 | LB,HPf,LW | 124 | 16.3 | 25.9 | 29.6 | 62.2 | 1800 |
| ICP-4070 | LB | 124 | 11.3 | 18.8 | 37.2 | 61.5 | 1210 |
| APAU-2208 | LB,LT,HY | 124 | 17.2 | 11.6 | 23.0 | 47.3 | 1950 |
| ICP-7035 | LB,HH | 124 | 17.6 | 12.4 | 24.1 | 48.1 | 910 |
| ICP-10531 | MB | 124 | 17.7 | 20.7 | 14.7 | 48.2 | 1270 |
| ICP-7941-E1 | HB,LPf | 128 | 21.1 | 16.2 | 16.7 | 50.0 | 1560 |
| C-11(Check) | HB,HY | 130 | 17.9 | 23.4 | 20.2 | 54.6 | 2020 |
| ICP 1-6 | HB | 130 | 17.4 | 26.7 | 27.6 | 65.0 | 1460 |
| ICP-7946-E1 | LB,LPf,HY | 139 | 25.6 | 14.4 | 13.4 | 49.9 | 1080 |
| ICP-8134-1 | LB,HY,HPf | 148 | 30.2 | 30.7 | 22.4 | 70.9 | 890 |
| Mean | | | 15.7 | 18.8 | 25.5 | 54.3 | 1620 |
| **Sprayed** | | | | | | | |
| PPE-88 | LBS | 104 | 3.1 | 7.9 | 42.5 | 51.2 | 1090 |
| BDN-1 (Check) | HB | 115 | 5.1 | 8.6 | 11.6 | 24.6 | 2730 |
| ICP-1811-E3 | LB,LT,HH | 118 | 4.4 | 9.6 | 25.4 | 37.5 | 2570 |
| GS-1 | LB,LH,LT | 118 | 6.9 | 9.8 | 9.1 | 24.5 | 2350 |
| ICPL-84060 | HY | 124 | 4.8 | 13.3 | 36.3 | 50.3 | 1930 |
| ICP-1691 | HB | 124 | 3.4 | 15.7 | 11.4 | 29.0 | 1970 |
| ICP-3328 | LB,LT,HY | 124 | 4.7 | 11.5 | 27.4 | 41.3 | 1970 |
| ICP-1903 | LB,MPf,HY | 124 | 6.5 | 8.4 | 35.4 | 47.5 | 1600 |
| ICP-10466 | LB,HPf,LW | 124 | 3.4 | 17.1 | 23.8 | 41.0 | 1980 |
| ICP-4070 | LB | 124 | 8.0 | 19.7 | 24.6 | 47.7 | 1610 |
| APAU-2208 | LB,LT,HY | 124 | 6.3 | 7.4 | 17.3 | 29.3 | 1160 |
| ICP-7035 | LB,HH | 124 | 8.9 | 11.6 | 19.5 | 37.1 | 600 |
| ICP-10531 | MB | 124 | 8.0 | 7.9 | 18.2 | 32.1 | 1270 |
| ICP-7941-E1 | HB,LPf | 128 | 7.1 | 7.3 | 16.3 | 29.6 | 2220 |
| C-11(Check) | HB,HY | 130 | 4.5 | 19.9 | 21.9 | 43.5 | 2440 |
| ICP 1-6 | HB | 130 | 8.6 | 17.3 | 28.3 | 51.3 | 1560 |

| Cultivar | Chara-cters 1984* | DF 50% | Pod damage % (mean) | | | | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| | | | Borer | Podfly | Hymn. | Total | |
| ICP-7946-E1 | LB,LPf,HY | 139 | 6.5 | 4.7 | 7.7 | 18.2 | 1500 |
| ICP-8134-1 | LB,HY,HPf | 148 | 10.5 | 19.3 | 20.1 | 46.4 | 1490 |
| Mean | | | 6.1 | 12.0 | 20.0 | 37.9 | 1780 |
| <u>Effect of Main treatment (Insecticidal protection)</u> | | | | | | | |
| SE of mean ± | | | 0.53 | 1.25 | 4.25 | 1.84 | 60 |
| CV% | | | 28 | 25 | 18 | 8 | 17 |
| <u>Effect of Sub treatment (Cultivar)</u> | | | | | | | |
| SE of mean ± | | | 1.54 | 1.76 | 4.08 | 4.67 | 288 |
| CV% | | | 20 | 17 | 24 | 14 | 24 |
| <u>Effect of Interaction</u> | | | | | | | |
| SE of mean ± Main | | | 2.17 | 2.59 | 4.60 | 5.01 | 322 |
| Sub | | | 2.17 | 2.81 | 6.2 | 5.30 | 324 |

* For abbreviations see page 5.

Table 13: Testing of long-duration pigeonpea selections under pesticide free conditions on BUS-5E, ICRISAT Center during the rainy season 1985/86. Plot size: 3 rows of 4 m; Reps.: 3 (general lattice); Net plot harvested: 9 sq.m.

| Entry | DF 50% | Chara-cters* | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| ICP-7337-4-6-1-2-2-Sl● | 169 | LB,HY | 13.7 | 20.3 | 27.8 | 56.6 | 250 |
| PR-3639-E1-2EB | 169 | LPf,LH | 33.4 | 6.2 | 6.1 | 44.4 | 150 |
| ICP-5172-5-2-2-1-Sl● | 169 | LB,LH, LT | 18.2 | 21.5 | 5.7 | 44.6 | 160 |
| ICP-8107-1-3-2-1-Sl● | 169 | LH,HPf | 27.2 | 35.1 | 1.9 | 63.3 | 150 |
| ICP-7176-5-E1-4Eb | 169 | LH | 36.4 | 20.3 | 5.6 | 58.8 | 40 |
| ICP-11804-E3-2EB | 169 | LPf | 21.4 | 9.8 | 43.1 | 64.5 | 160 |
| ICP-11368-E3-2EB | 173 | LPf,LT | 26.2 | 6.9 | 8.1 | 40.2 | 180 |
| ICP-9168-WR-E1 | 173 | LH | 32.9 | 8.7 | 4.6 | 51.3 | 200 |
| PI-394954-SW1●-W2●-WB | 173 | LB,HY | 20.3 | 21.1 | 18.1 | 55.0 | 370 |
| Bahar (check) | 173 | HY | 27.3 | 19.4 | 11.7 | 58.8 | 340 |
| PR-3696-E1-2EB | 173 | LH | 31.2 | 9.0 | 4.4 | 44.9 | 100 |
| PI-397731-S3●-2EB | 177 | LPf,LT | 26.4 | 9.5 | 5.2 | 40.2 | 190 |
| ICP-4769-E1-2EB | 177 | LPf | 30.8 | 11.0 | 34.4 | 67.3 | 190 |
| NP-(WR) (Check) | 177 | LPf | 27.2 | 9.7 | 15.2 | 49.0 | 190 |
| PI-394954-SW1●-W1●-WB | 177 | LT | 23.1 | 13.9 | 8.8 | 44.6 | 190 |
| DA-13 | 177 | HB | 41.9 | 2.5 | 3.1 | 47.2 | 120 |
| PI-394571-S2●-2EB | 177 | HH | 24.5 | 0.9 | 37.1 | 58.6 | 200 |
| PI-397731-S1●-2EB | 177 | HH | 22.7 | 15.1 | 36.3 | 64.8 | 280 |
| PI-394568-SW1●-W2● | 177 | LB | 30.7 | 23.9 | 17.4 | 68.3 | 150 |
| PPE-87 | 177 | LPf | 36.6 | 14.3 | 3.7 | 53.3 | 40 |
| ICP-8094-2-S2●-6EB | 177 | LB,LPf | 24.9 | 5.4 | 8.4 | 37.5 | 110 |
| PPE-84 | 177 | LB,LH, LT | 27.2 | 13.4 | 3.4 | 43.7 | 160 |
| DA-2 | 181 | LB | 16.9 | 19.2 | 36.6 | 64.4 | 170 |
| PI-394571-S4●-2EB | 181 | HH | 25.2 | 8.5 | 40.9 | 65.8 | 150 |
| ICP-5151-1-1-1-2-2-EB | 183 | LH | 27.8 | 21.4 | 3.8 | 53.9 | 150 |
| ICP-4745-2-E8-5EB | 183 | LH | 31.5 | 15.9 | 1.5 | 47.4 | 110 |
| PR-4908-E1-2EB | 183 | LPf | 23.8 | 11.3 | 47.8 | 69.7 | 160 |
| T7-(Check) | 183 | - | 27.6 | 21.2 | 12.0 | 61.4 | 220 |
| Banda paleru | 183 | HY | 23.0 | 17.4 | 21.2 | 57.0 | 260 |
| Trial mean | | | 26.9 | 14.3 | 16.3 | 54.4 | 180 |
| SE of mean ± | | | 4.49 | 3.61 | 3.95 | 4.86 | 47 |
| CV% | | | 28 | 41 | 41 | 14 | 42 |
| LSD at p<0.05 | | | 12.82 | 10.32 | 11.27 | 13.88 | 135 |

* For abbreviations see page

and podfly by spraying 3 times with endosulfan and monocrotophos and twice with dimethoate. The crop growth was excellent and dense in the beginning; later the flowering and pod setting was affected due to drought stress.

In the unsprayed treatment borer damage was low but the podfly incidence was high. The results of pod damage assessments and yields are reported in Table 14. It is evident from the table that there was no appreciable reduction in pest damage by sprays and no increase in yields of the earlier flowering entries. In this trial no entry showed any appreciable level of tolerance to pests attacks and the insecticide were found insufficient to reduce the pest damage levels.

<u>Screening of disease resistant lines for insect pests resistance under pesticide free condition</u>

Earlier, our pathologists have screened our selections having reduced susceptibility/tolerance to pests in their wilt and sterility mosaic resistance screening nurseries for 2-3 years. From these they have selected some single plants showing disease resistance to an acceptable level. This year the seed from these single plant selections were supplied to us for confirming their pests resistance under pesticide free conditions. We sowed these selections on BUS-8C at the end of June 1985 on plots of 2 rows of 4 m, in two-replication lattices.

In this trial only a few entries were of medium-duration, the others were very late in flowering. Damage by both the major pests was low and yields were also very poor, except for six entries which produced more than the common check ICP-6443 (Table 15). Some of the entries showed reduced susceptibility to borers and podfly, these were selected and advanced for further testing in the coming season.

<u>AICPIP collaborative trials 1985-86</u>

Under the varietal testing programme of the All India Coordinated Pulses Improvement Project (AICPIP), we received 8 arhar (pigeonpea) genotypes in EXACT, 15 in EACT, 8 in ACT-1, 12 in ACT-2 and 8 cultivars in ACT-3 trials for testing their susceptibility to pests at ICRISAT Center during rainy season 1985-86. These genotypes were tested on the Vertisol blocks BUS-5E and 8C, where no pesticides were applied, and no irrigation was given. The sowings of these trials were completed on June 27, 1985 on plots of 5 rows of 4 m in 3 replication RBD trials, with plant to plant spacing of 37.5 x 20 cm in EXACT and EACT trials and 75 x 30 cm in the other trials. No fertilizers were applied.

Pod damage assessments were carried out in the laboratory after collecting all pods at maturity from 6 plants, harvested at random from each plot. The plot yields were determined from net plots of 3.94 sq.m. in the extra early maturity trials and 7.88 sq.m. in ACT 1 to 3 trials.

Table 14: Comparison of pigeonpea promising bulks (long-duration) under unsprayed and sprayed conditions on BIL-6A, ICRISAT Center, during the rainy season 1985/86. Entries: 15; Reps.: 2 (split block); Net plot harvested: 60 sq.m.

| Cultivar | Chara-cters 1984* | DF 50% | Pod damage % (mean) | | | | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| | | | Borer | Podfly | Hymn. | Total | |
| **Unsprayed** | | | | | | | |
| PPE-83 | LB,LPf | 143 | 14.6 | 25.8 | 20.5 | 55.4 | 730 |
| ICP-7337-2-S4● | HH,HPf | 149 | 25.7 | 33.6 | 28.4 | 73.6 | 470 |
| PPE-36-2 | LB,HPf,HH | 149 | 24.2 | 19.1 | 29.9 | 62.4 | 880 |
| PPE-84 | LBS,LPf | 151 | 34.2 | 20.5 | 23.8 | 66.6 | 890 |
| PPE-87 | LPFS | 151 | 25.1 | 17.5 | 20.0 | 55.5 | 1010 |
| ICP-3615-E1 | LB,HY | 151 | 34.8 | 20.0 | 18.4 | 63.4 | 910 |
| PPE-37-3 | LB,LPf | 151 | 28.7 | 26.2 | 25.9 | 67.4 | 700 |
| ICP-7176-5 | LB,HY | 151 | 29.1 | 26.5 | 20.7 | 66.5 | 770 |
| ICP-6443 | LB,LPf | 155 | 28.1 | 18.8 | 31.7 | 66.5 | 1040 |
| ICP-8127-E3 | HPf,HH | 155 | 30.7 | 19.4 | 25.8 | 63.0 | 570 |
| ICP-8094-2-S2 | LB,LPf | 155 | 26.8 | 17.4 | 32.5 | 62.6 | 780 |
| ICP-8102-5 | LB,LPf, SMR | 160 | 32.7 | 11.2 | 31.0 | 62.8 | 820 |
| ICP-3940-E1 | LB | 160 | 29.2 | 25.7 | 18.7 | 62.5 | 930 |
| ICP-7537-E1 | LB,LPf | 160 | 30.9 | 17.7 | 31.1 | 64.5 | 540 |
| T-7 | HB | 179 | 22.3 | 18.3 | 26.2 | 57.3 | 660 |
| Mean | | | 27.8 | 21.2 | 25.6 | 63.3 | 780 |
| **Sprayed** | | | | | | | |
| PPE-83 | LB,LPf | 143 | 8.4 | 19.8 | 22.7 | 47.3 | 670 |
| ICP-7337-2-S4● | HH,HPf | 151 | 20.0 | 20.0 | 25.3 | 56.1 | 310 |
| PPE-36-2 | LB,HPf,HH | 150 | 18.4 | 17.1 | 32.0 | 58.1 | 580 |
| PPE-84 | LBS,LPf | 151 | 30.1 | 21.7 | 19.5 | 61.3 | 570 |
| PPE-87 | LPFS | 149 | 14.6 | 19.8 | 17.7 | 48.1 | 1080 |
| ICP-3615-E1 | LB,HY | 151 | 19.5 | 16.7 | 23.5 | 53.2 | 740 |
| PPE-37-3 | LB,LPf | 153 | 12.5 | 23.3 | 26.0 | 54.0 | 810 |
| ICP-7176-5 | LB,HY | 152 | 36.8 | 20.8 | 18.9 | 65.0 | 850 |
| ICP-6443 | LB,LPf | 152 | 18.2 | 18.3 | 25.0 | 55.1 | 970 |
| ICP-8127-E3 | HPf,HH | 155 | 20.7 | 17.9 | 31.2 | 59.9 | 720 |
| ICP-8094-2-S2 | LB,LPf | 155 | 18.0 | 18.4 | 31.5 | 59.6 | 930 |
| ICP-8102-5 | LB,LPf, SMR | 157 | 21.9 | 14.0 | 27.5 | 55.3 | 1000 |
| ICP-3940-E1 | LB | 160 | 20.4 | 20.0 | 22.8 | 55.5 | 980 |

| Cultivar | Chara-cters 1984* | DF 50% | Pod damage % (mean) | | | | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| | | | Borer | Podfly | Hymn. | Total | |
| ICP-7537-E1 | LB,LPf | 160 | 30.1 | 15.8 | 35.7 | 67.9 | 640 |
| T-7 | HB | 179 | 27.4 | 24.5 | 30.7 | 65.9 | 750 |
| Mean | | | 21.1 | 19.2 | 26.0 | 57.5 | 770 |
| Effect of main treatment (insecticide protection) | | | | | | | |
| SE of mean ± | | | 0.61 | 0.34 | 1.07 | 1.56 | 20 |
| CV% | | | 20 | 16 | 16 | 6 | 20 |
| Effect of sub treatment (cultivar) | | | | | | | |
| SE of mean ± | | | 2.31 | 2.31 | 2.15 | 2.70 | 112 |
| CV% | | | 13 | 16 | 12 | 9 | 29 |
| Effect of interaction | | | | | | | |
| SE of mean ± Main | | | 3.38 | 2.81 | 3.0 | 4.05 | 158 |
| Sub | | | 3.32 | 2.77 | 3.10 | 3.84 | 15 |

* For abbreviations see page 5.

Table 15: Results of testing disease resistant lines for pest susceptibility under pesticide free conditions during the rainy season 1985/86 on BUS-8C, ICRISAT Center. Plot size: 2 rows of 4 m; Reps.: 2 (lattice square); Net plot harvested: 6 sq.m.

| Cultivar/lines | DF 50% | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|
| PPE-45-2-7B (check) | 108 | 19.7 | 21.8 | 5.5 | 46.8 | 310 |
| BDN-1 (check) | 108 | 27.3 | 13.6 | 5.7 | 44.2 | 270 |
| PI-3615-E1-3EB-1-1-SBe | 115 | 25.6 | 9.0 | 5.6 | 41.4 | 310 |
| C-11 (check) | 122 | 28.0 | 13.1 | 3.1 | 43.2 | 280 |
| ICP-8595-E1-2EB-1-1-1-SBe | 123 | 16.3 | 20.6 | 2.6 | 38.8 | 190 |
| ICP-394440-EB-2EB-1-SBe | 123 | 22.3 | 18.9 | 4.8 | 45.4 | 550 |
| ICP-1903-E1-7EB (check) | 123 | 7.0 | 15.6 | 9.6 | 30.9 | 290 |
| ICP-6831-Sle-SBe | 156 | 10.8 | 4.8 | 3.5 | 21.1 | 450 |
| ICP-8583-E1-2-EB-1-1-SBe | 161 | 18.6 | 17.5 | 2.4 | 41.6 | 240 |
| ICP-8689-E1-2EB-1-1-1-SBe | 171 | 24.0 | 13.5 | 1.8 | 39.0 | 270 |
| PI-396588-EB-2EB-1-1-SBe | 171 | 23.8 | 15.0 | 8.3 | 46.2 | 160 |
| ICP-10659-Sle-SBe | 171 | 10.3 | 12.5 | 11.8 | 34.6 | 330 |
| GW-3-4EB-Sle-SBe | 171 | 34.1 | 12.5 | 1.2 | 50.0 | 250 |
| ICP-8325-E1-3EB-1-1-SBe | 175 | 17.7 | 19.6 | 10.4 | 44.6 | 550 |
| PI-397731-2-1-SBe | 175 | 21.4 | 19.5 | 8.1 | 47.8 | 390 |
| ICP-7198-Sle-SBe | 175 | 17.1 | 21.8 | 4.8 | 46.9 | 250 |
| ICP-4769-Sle-SBe | 175 | 18.4 | 12.1 | 11.0 | 44.9 | 290 |
| ICP-8301-1-2-2-1-SBe | 179 | 19.8 | 28.5 | 14.9 | 55.9 | 180 |
| ICP-8860-5-1-SBe | 179 | 24.7 | 12.0 | 5.2 | 42.1 | 270 |
| PI-397275-1-Sle-SBe | 179 | 31.6 | 11.7 | 2.0 | 44.7 | 410 |
| PI-397677-1-Sle-SBe | 179 | 25.9 | 13.7 | 0.8 | 37.7 | 250 |
| ICP-8094-2-1-Sle-SBe | 179 | 19.8 | 6.6 | 2.3 | 32.8 | 190 |
| ICP-5036-Sle-SB | 179 | 17.6 | 16.4 | 4.7 | 41.7 | 430 |
| ICP-7176-5-E1-1-1-1-SBe | 183 | 49.0 | 7.5 | 11.8 | 66.8 | 100 |
| ICP-8135-1-1-2-1-SBe | 183 | 28.5 | 12.7 | 9.1 | 49.6 | 150 |
| ICP-8128-2-3-2-2-1-SBe | 183 | 15.4 | 19.4 | 17.5 | 53.4 | 290 |
| PI-397731-3-1-SBe | 183 | 19.4 | 14.3 | 10.3 | 46.0 | 140 |
| PI-394571-2-SBe | 183 | 17.0 | 22.1 | 11.0 | 48.1 | 190 |
| PI-394571-3-1-SBe | 183 | 13.6 | 11.3 | 6.0 | 33.2 | 120 |
| PI-394571-4-1-SBe | 183 | 26.3 | 9.0 | 1.4 | 36.6 | 160 |
| PI-394571-5-1-SBe | 183 | 14.1 | 11.0 | 12.1 | 42.0 | 180 |
| ICP-6443 (check) | 183 | 22.4 | 14.8 | 2.0 | 38.8 | 320 |
| ICP-4886-Sle-SBe | 183 | 16.1 | 19.0 | 5.2 | 38.7 | 160 |
| ICP-8102-2-Sle-EB (check) | 183 | 26.7 | 17.7 | 5.4 | 48.9 | 230 |
| PI-396986-1-Slo-SBe | 187 | 19.0 | 11.2 | 7.7 | 43.2 | 120 |
| ICP-8130-E1-2EB-1-1-1-SBe | 187 | 22.1 | 34.5 | 5.8 | 60.9 | 140 |
| Trial mean | | 21.4 | 15.4 | 6.5 | 43.6 | 260 |
| SE of mean ± | | 4.98 | 3.34 | (3.48)** | 6.17 | 66 |
| CV% | | 33 | 31 | 36 | 20 | 36 |
| LSD at p<0.05 | | 14.3 | 9.7 | 10.1 | - | 192 |
| Efficiency % over RBD | | 79.3 | 112.7 | 9.96 | 93.3 | 108 |

* Arcsin /% transformation was used for the analysis of data Figures in parentheses are transformed values.

The plot yields were low in most of these trials, largely because of severe sucking bug infestation in the extra-early cultivars and because of water stress in other trials. This year because of lack of rains there was very rapid maturity in the crop and pod setting and seed filling was poor. There was severe borer damage in the short- and medium-duration entries, but the borer incidence declined in the late flowering ones. Hymenopteran damage was high in the early flowering genotypes. An increase in the podfly incidence was noticed in the medium and long-duration entries. The results of the pod damage assessments and yields are furnished in Tables 16 to 20.

In the EXACT, no entry gave a significantly higher yield than the check UPAS-120 and there were no significant differences between the entries for mean percentage of borer damage and podfly damage. ICPL-269 in EACT showed the least damage by borers and produced the greatest yield. The determinate genotypes suffered most damage due to lepidopteran pests in this trial. Some entries showed less damage caused by the hymenopteran pest (Table 17).

Better yields were recorded in the ACT-1 in which all the entries were indeterminate. Some genotypes showed less pod damage caused by borers and the hymenopteran. Among these, CORG-5 was outstanding in seed yield with moderate damage by borers. No significant differences in yields were detected among the entries in this trial.

In ACT-2 and ACT-3, MRG-66 and ICPL-66 showed least .damage by borers and produced the greatest yields. Some entries from these trials were selected for further testing on the basis of their reduced susceptibility to different pests and greater yields.

Pests damage in wild relatives of pigeonpea

As in previous years, we grew the following wild relatives of pigeonpea this year (in block BUS-8C) under pesticide free conditions on 3 rows of 4 m.

*Atylosia scarabaeoides*
*A.lineata*
*A.platycarpa*
*A.cajanifolia*
*Rhynchosia bracteata*

In the beginning the plant growth was very good and many pods were produced by *A.platycarpa* and *A.scarabaeoides*. Later, the plant growth was severely affected by drought and no pods could be harvested from the other species which flowered later. We harvested pods from *A.platycarpa* in two picks and from *A.scarabaeoides* only once. Pod damage assessments were made in the sampled pods and the pest damage data are furnished in the Table 21.

Multilocation testing of entomology selections

I. In collaboration with the Indian National Program (AICPIP):

Table 16: Results of testing EXACT (AICPIP) pigeonpea cultivars for pest susceptibility under pesticide free conditions on BUS-8C at ICRISAT Center, Patancheru, during the rainy season 1985. Plot size: 5 rows of 4 m (37.5 x 20 cm); Reps.: 3 RBD; Net plot harvested: 3.94 sq.m.

| Cultivar/lines | Growth habit* | DF 50% | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| H.81-1 | DT | 46 | 34.1 | 0.3 | 32.1 | 60.8 | 130 |
| AL-1 | DT | 49 | 47.7 | 0.5 | 30.7 | 69.5 | 190 |
| P-851 | NDT | 51 | 38.5 | 0.6 | 17.5 | 54.4 | 410 |
| ICPL-8306 | DT | 52 | 33.3 | 0.3 | 31.7 | 60.5 | 320 |
| TAT-10 | SDT | 57 | 36.3 | 1.2 | 24.5 | 58.6 | 390 |
| UPAS-120 (Check) | SDT | 57 | 41.9 | 1.5 | 8.6 | 49.8 | 320 |
| ICPL-317 | DT | 57 | 45.8 | 0.6 | 9.4 | 54.6 | 390 |
| AL-101 | SDT/NDT | 57 | 37.9 | 0.5 | 20.3 | 51.5 | 300 |
| Trial mean | | | 39.4 | 0.7 | 21.9 | 57.5 | 306 |
| SE of mean ± | | | 4.95 | (1.22)** | 4.38 | 5.21 | 39 |
| CV% | | | 22 | 52 | 35 | 16 | 22 |

* For abbreviations see page 5.
** Arcsin-$\sqrt{\%}$ transformation was used for the analysis of data. Figures in parentheses are transformed values.

Table 17: Results of testing EACT (AICPIP) pigeonpea cultivars for pest susceptibility under pesticide free conditions on BUS-8C at ICRISAT Center, Patancheru, during the rainy season 1985/86. Plot size: 5 rows of 4 m (37.5 x 20 cm); Reps.: 3 RBD; Net plot harvested: 3.94 sq.m.

| Cultivar/lines | Growth habit* | DF 50% | Pod damage mean (%) | | | | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| | | | Borer | Podfly | Hymn. | Total | |
| Sweta-2 | DT | 63 | 75.7 | 1.1 | 4.3 | 79.8 | 130 |
| AL-13 | SDT | 63 | 37.5 | 1.6 | 18.9 | 54.6 | 270 |
| UPAS-120 (Check) | SDT | 63 | 49.2 | 1.5 | 9.0 | 58.0 | 200 |
| AL-57 | SDT | 63 | 34.7 | 1.8 | 13.1 | 48.0 | 310 |
| AL-56 | SDT | 63 | 41.1 | 1.1 | 23.1 | 58.0 | 240 |
| Pant-A1 (Check) | SDT | 63 | 55.3 | 0.9 | 11.2 | 62.6 | 140 |
| ICPL-8327 | SDT | 63 | 51.0 | 2.1 | 4.5 | 57.2 | 250 |
| TAT-10 | SDT | 63 | 35.5 | 1.4 | 29.1 | 61.8 | 240 |
| ICPL-317 | DT | 64 | 44.0 | 0.6 | 8.9 | 52.7 | 350 |
| H-82-26 | SDT | 65 | 58.8 | 0.3 | 15.0 | 69.4 | 230 |
| MTH-6 | DT | 65 | 46.1 | 0.9 | 34.1 | 72.7 | 250 |
| ICPL-151 | DT | 68 | 58.3 | 2.1 | 12.2 | 68.9 | 260 |
| ICPL-269 | SDT | 69 | 22.6 | 4.1 | 9.6 | 36.3 | 610 |
| GUAT-82-53 | DT | 96 | 64.4 | 1.3 | 17.4 | 78.5 | 60 |
| GUAT-82-85 | DT | 99 | 26.6 | 0.8 | 54.3 | 76.9 | 40 |
| Trial mean | | | 46.7 | 1.45 | 17.7 | 62.4 | 238 |
| SE of mean ± | | | 6.13 | (1.77) | (5.74) | 6.38 | 79 |
| CV% | | | 23 | 51 | 43 | 18 | 57 |

* For abbreviations see page 5.

**Table 18: Results of testing ACT 1 (AICPIP) pigeonpea cultivars for pest susceptibility under pesticide free conditions on BUS-8C at ICRISAT Center, Patancheru, during the rainy season 1985/86. Plot size: 5 rows of 4 m (75 x 30 cm); Reps.: 3 RBD; Net plot harvested: 7.88 sq.m.**

| Cultivar/lines | Growth habit* | DF 50% | Pod damage mean (%) | | | | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| | | | Borer | Podfly | Hymn. | Total | |
| ICPL-186 | NDT | 67 | 22.3 | 2.2 | 21.6 | 46.4 | 620 |
| Pant-A-103 | NDT | 69 | 33.2 | 1.4 | 26.3 | 58.7 | 530 |
| Pant-A-102 | NDT | 69 | 41.1 | 1.5 | 18.2 | 57.8 | 520 |
| Pant-A-104 | NDT | 69 | 33.8 | 2.2 | 9.2 | 46.4 | 560 |
| T-21 (Check) | NDT | 79 | 36.7 | 2.3 | 17.3 | 54.4 | 640 |
| CORG-5 | NDT | 85 | 26.9 | 2.2 | 9.5 | 37.1 | 970 |
| PF-14 | NDT | 88 | 14.9 | 1.9 | 21.1 | 36.2 | 710 |
| PT-20 | NDT | 92 | 18.4 | 2.9 | 39.4 | 56.1 | 720 |
| Trial mean | | | 28.4 | 2.1 | 20.3 | 49.1 | 658 |
| SE of mean ± | | | 3.09 | (1.25)** | (3.20)** | 3.70 | 89 |
| CV% | | | 19 | 27 | 21 | 13 | 23 |

* For abbreviations see page 5.
** Arcsin $\sqrt{\%}$ transformation was used for the analysis of data. Figures in parentheses are the transformed values.

Table 19: Testing of pigeonpea ACT 2 entries of AICPIP for pest susceptibility under pesticide free conditions at ICRISAT Center, Patancheru, during the rainy season, 1985/86. Plot size: 5 rows of 4 m (75 x 30 cm); Reps.: 3 (RBD) on BUS 5E; Date sown: 26 June 1985; Net plot harvested: 7.878 sq.m.

| Cultivar/lines | Growth habit* | DF 50% | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| C-11(CH) | NDT | 125 | 46.8 | 18.0 | 2.9 | 63.9 | 240 |
| AKT-6 | SDT | 125 | 38.4 | 14.9 | 0.9 | 53.2 | 390 |
| AKT-1 | SDT | 125 | 45.6 | 13.1 | 3.2 | 60.1 | 130 |
| PT-22 | SDT | 126 | 46.6 | 15.6 | 6.4 | 65.8 | 190 |
| ICPL-332 | SDT | 131 | 26.2 | 23.9 | 15.1 | 59.4 | 240 |
| MRG-66 | SDT | 131 | 18.5 | 33.5 | 15.7 | 58.9 | 420 |
| MTH-11 | SDT | 131 | 27.2 | 30.6 | 1.7 | 53.9 | 340 |
| MTH-9 | NDT | 133 | 33.4 | 27.8 | 2.1 | 60.6 | 360 |
| MTH-8 | NDT | 135 | 32.0 | 24.9 | 0.8 | 53.1 | 350 |
| G-78-3 | NDT | 135 | 38.3 | 39.6 | 0.2 | 76.2 | 190 |
| AGS-478 | SDT | 138 | 27.5 | 19.6 | 3.3 | 47.7 | 290 |
| MTH-5 | NDT | 138 | 37.6 | 20.4 | 3.2 | 57.2 | 340 |
| Trial mean | | | 34.8 | 23.5 | 4.62 | 59.2 | 291 |
| SE of mean ± | | | 5.05 | 3.74 | (2.98)** | 4.91 | 75 |
| CV% | | | 25 | 28 | 51 | 14 | 45 |

* See abbreviations page 5.
** Arcsin √% transformation was used for the analysis of data. Figures in parentheses are transformed values.

**Table 20: Testing of pigeonpea ACT 3 entries of AICPIP for pest susceptibility under pesticide free conditions at ICRISAT Center, Patancheru, during the rainy season, 1985/86. Plot size: 5 rows of 4 m (75 x 30 cm)-RBD on BUS 8C; Date sown:27 June 1985; Net plot harvested: 7.878 sq.m.**

| Cultivar/lines | Growth habit* | DF 50% | Pod damage mean (%) Borer | Podfly | Hymn. | Total | Yield kg/ha |
|---|---|---|---|---|---|---|---|
| DA-8 | NDT | 89 | 22.9 | 16.1 | 4.7 | 42.0 | 180 |
| ICP-6443(CH) | SDT | 156 | 14.5 | 21.5 | 3.8 | 38.8 | 290 |
| Bahar | NDT | 175 | 24.3 | 32.2 | 5.8 | 57.4 | 190 |
| T-7 (CH) | SDT | 175 | 25.1 | 17.1 | 2.3 | 42.9 | 150 |
| DA-15 | SDT | 177 | 24.3 | 18.6 | 12.1 | 52.6 | 220 |
| ICPL-360 | NDT | 177 | 33.5 | 10.1 | 4.0 | 45.4 | 150 |
| ICPL-366 | NDT | 177 | 19.1 | 26.3 | 0.4 | 44.7 | 320 |
| PDA-10 | SDT | 177 | 16.5 | 27.6 | 4.0 | 47.4 | 220 |
| Trial mean | | | 22.5 | 21.2 | 4.7 | 46.4 | 214 |
| SE of mean ± | | | 5.26 | 4.41 | (2.84)** | 5.50 | 46 |
| CV% | | | 41 | 36 | 45 | 21 | 37 |

* For abbreviations see page 5.

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

Table 21: Pod damage by insects in wild relatives of pigeonpea (*Atylosia* spp.) under pesticide free conditions at ICRISAT Center on BUS-8C, during the rainy season 1985-86.

| Wild species | Pick | Harvested | DF 50% | Pods/pt (6 pts sampled) | Pod damage mean (%) Borer | Pod-fly | Hymn. | Total | Sample yield g. |
|---|---|---|---|---|---|---|---|---|---|
| *Atylosia platycarpa* | I | 30-9-85 | 42 | 64 | 31.2 | 1.8 | 0.5 | 33.5 | 50.4 |
| | II | 20-11-85 | | 37 | 16.4 | 0.0 | 1.4 | 17.8 | 28.3 |
| *Atylosia scarabaeoides* | I | 20-11-85 | 53 | 171 | 3.6 | 0.1 | 48.6 | 52.3 | 21.3 |

Entomologists at various locations cooperated in testing our promising selections at different centers in India. The Principal Investigator (Entomology) suggested trials of the pigeonpea selections of different durations from ICRISAT and other centers and distributed the seeds of these to locations in North, South and Central India. From ICRISAT, we supplied the following selections:

| Very short duration selections | Short duration selections |
|---|---|
| ICPL-2o | PPE-45-2 |
| ICPL-1 | ICP-7349-1-S4o-5EB |
| ICPL-6 | Sehore-197-5EB |
| ICPL-288 | ICP-909-E1-5EB |
| | TT-6 |

| Medium duration selections | Late duration selections |
|---|---|
| BDN-2 | ICP-7946-E1-6EB |
| BDN-7 | AS-71-37 |
| ICPL-84060 | ICP-7176-18-E2-EB |
| ICP-1903 | ICP-4745-2-6EB |
| ICP-3328 | ICP-2-3EB |
| ICP-4070 | ICP-8127-E1-5EB |

These selections together with selections from other stations and relevant checks were tested at Pantnagar, Varanasi, Hisar, Sehore, Badnapur and Rahuri. The results of these trials were summarised by the Principal Investigator (Entomology), Directorate of Pulses Research (ICAR), Kanpur, in their report of 1985/86. The pod damage assessment results and yields of our selections tested at different locations are furnished in Table 22.

In this multilocation testing program there was no uniformity in the recording of pests damage or yield results. Attempts were made by the Principal Investigator to conduct these tests in a uniform manner by keeping the uniformity in plot size, design of experiment and collection and presentation of data. At some locations entomologists reported difficulties in land availability and technical help; such problems led the variability in data and their presentation.

With the available information, it is evident that some selections are not performing uniformly well all the locations. Some are obviously specific to some regions in their performance. The best performing lines from different location are mentioned below.

| | | |
|---|---|---|
| ICPL-1 | Low borer | at Badnapur |
| ICPL-84060 | Low borer | at Badnapur |
| PPE-45 | Low borer | at Badnapur |
| | Low borer and high yield | at Rahuri |
| ICPL-6 | Low borer and high yield | at Hisar |
| ICP-7946 | Low podfly | at Sehore |
| DA-2 | Low podfly, low borer and high yield | at Varanasi |

Table 22: Resulting of testing pigeonpea promising selections at different centers in India by the AICPIP-entomologists during rainy season, 1985/86.

| Pigeonpea Selections | Borer | Pod-fly | Total PD% | Yield Kg/ha | Borer | Pod-fly | Total PD% | Yield kg/ha |
|---|---|---|---|---|---|---|---|---|
| | | Pantnagar | | | | Hisar | | |
| Extra early | | | | | | | | |
| H-77-216 | | NT | | | 12.2 | 9.3 | | 1790 |
| ICPL-1-3EB | | NT | | | | NT | | |
| ICPL-2o-3EB | 21.2 | 18.0 | 39.3 | | 6.2 | 15.3 | | 2207 |
| ICPL-6-3EB | 29.0 | 20.0 | 48.7 | NR | 4.6 | 17.0 | NR | 2295 |
| ICPL-288-3EB | 28.8 | 29.3 | 58.3 | | 11.7 | 22.0 | | 676 |
| TAT-10-3EB | 22.4 | 22.5 | 44.8 | | 12.6 | 2.2 | | 1680 |
| Pant A1 Check | 24.5 | 30.5 | 55.8 | | 12.1 | 13.2 | | 2227 |
| UPAS-120 Check | 20.5 | 24.3 | 45.3 | | 7.2 | 3.3 | | 1226 |
| LSD at p<.05 | 2.51 | 9.10 | NS | | | | | |
| Entries in the trial | | 6 | | | | | 7 | |

| Pigeonpea Selections | Borer | Pod-fly | Total PD% | Yield Kg/ha |
|---|---|---|---|---|
| | | Badnapur | | |
| Extra early | | | | |
| H-77-216 | 40.1 | 14.5 | 51.9 | 660 |
| ICPL-1-3EB | 6.8 | 2.6 | 10.0 | 102 |
| ICPL-2o-3EB | 28.7 | 9.5 | 36.2 | 634 |
| ICPL-6-3EB | 34.2 | 10.8 | 43.0 | 418 |
| ICPL-288-3EB | 27.1 | 16.1 | 39.1 | 152 |
| TAT-10-3EB | 33.1 | 16.1 | 43.1 | 649 |
| Pant A1 Check | 44.8 | 12.5 | 55.8 | 497 |
| UPAS-120 Check | 56.6 | 7.5 | 62.8 | 412 |
| LSD at p<.05 | | | 10.97 | 342 |
| Entries in the trial | | | 9 | |

| Pigeonpea Selections | Borer | Pod-fly | Total PD% | Yield Kg/ha | Borer | Pod-fly | Total PD% | Yield kg/ha |
|---|---|---|---|---|---|---|---|---|
| | | Rahuri | | | | Badnapur | | |
| Early | | | | | | | | |
| PPE-45-2-7B | 11.8 | 11.4 | | 1160 | 13.1 | 6.0 | 18.3 | 172 |
| ICP-7349-1-S4o-5EB | 12.9 | 13.9 | | 944 | 17.9 | 18.0 | 30.8 | 190 |
| Sehore 197-5EB | 15.3 | 11.5 | NR | 819 | 16.8 | 5.4 | 21.9 | 157 |
| T21 check | 12.5 | 20.1 | | 512 | 18.7 | 10.8 | 28.1 | 502 |
| ICP-909-E1-5EB | 13.1 | 10.8 | | 682 | 20.4 | 8.1 | 25.9 | 447 |
| TT-6 | 23.5 | 20.7 | | 569 | | | | |
| LSD at p<.05 | 5.3 | 3.10 | | NS | | | 8.02 | 84.0 |
| Entries in the trial | | 6 | | | | | 5 | |
| | | Hisar | | | | Pantnagar | | |
| Early | | | | | | | | |
| PPE-45-2-7B | 8.9 | 32.9 | | 1928 | 15.2 | 25.8 | 41.7 | |
| ICP-7349-1-S4o-5EB | 6.3 | 23.5 | | 2266 | 15.6 | 26.3 | 50.1 | |
| Sehore 197-5EB | 14.4 | 14.0 | NR | 2018 | 14.8 | 24.9 | 40.7 | NR |
| T21 check | 7.2 | 15.5 | | 2600 | 9.7 | 34.3 | 44.0 | |
| ICP-909-E1-5EB | 5.7 | 20.0 | | 1306 | 11.2 | 40.6 | 51.9 | |
| TT-6 | | | | | | | | |
| LSD at p<.05 | 4.63 | 3.92 | | | NS | NS | NS | |
| Entries in the trial | | 5 | | | | 5 | | |

| Pigeonpea Selections | Borer | Pod-fly | Total PD% | Yield Kg/ha | Borer | Pod-fly | Total PD% | Yield kg/ha |
|---|---|---|---|---|---|---|---|---|
| | | Sehore | | | | Varanasi | | |
| **Mid and late** | | | | | | | | |
| ICPL-84060 | 18.0 | 40.0 | | | | | | |
| C-11 Check | 16.3 | 30.0 | | | | | | |
| ICP-1903 | 10.7 | 29.7 | NR | NR | | NT | | |
| ICP-3328-E1-6EB | 19.3 | 30.0 | | | | | | |
| ICP-4070-E1-6EB | 10.7 | 36.0 | | | | | | |
| ICP-7946-E1-6EB | 20.3 | 21.0 | | | | | | |
| AS-71-37 | 32.3 | 38.7 | | | | | | |
| ICP-7176-18-E2-5EB | | | | | 62.3 | 37.5 | | 1892 |
| ICP-4745-2-6EB | | | | | 60.0 | 32.1 | | 2162 |
| NP(WR)151 check | | NT | | | 52.0 | 25.6 | NR | 2235 |
| MA-2-3EB | | | | | 33.7 | 14.3 | | 3200 |
| ICP-8127-E1-5EB | | | | | 51.3 | 26.7 | | 2026 |
| Bahar Check | | | | | 49.0 | 23.3 | | 1449 |
| LSD at p<.05 | | | | | | | | 684 |
| Entries in the trial | | 7 | | | | | 10 | |
| | | Badnapur | | | | | | |
| **Mid and late** | | | | | | | | |
| BDN-1 | 30.4 | 6.6 | 36.0 | 453 | | | | |
| BDN-2 | 20.1 | 8.9 | 27.5 | 462 | | | | |
| BDN-7 | 13.5 | 10.9 | 24.3 | 402 | | | | |
| ICPL-84060 | 8.7 | 10.9 | 19.4 | 313 | | | | |
| C-11 Check | 14.9 | 8.6 | 22.8 | 97 | | | | |
| ICP-1903 | 16.6 | 13.9 | 27.9 | 95 | | | | |
| ICP-3328-E1-6EB | 18.5 | 12.3 | 30.1 | 70 | | | | |
| LSD at p<.05 | | | NS | 151 | | | | |
| Entries in the trial | | 7 | | | | | | |

NT = Not tested; NR = Not recorded.

| | | |
|---|---|---|
| MA-2 | - Do - | at Varanasi |
| ICP-8102-E1 | Low podfly and high yield | at Varanasi |
| IP-8094 | Low podfly | at Varanasi |

## II <u>Collaboration with Department of Agriculture, Andhra Pradesh</u>

In collaboration with Astt. Director of Agriculture, Vikharabad Taluk, four selections: ICP-909-EB, ICPL-84060, BDN-1 and BDN-2 were tested by Dr.S.Sithananthan in two farmers' fields at Gundarpally, Vikharabad, with no pesticide application. The selections ICPL-84060 and BDN-2 performed well and produced higher yields than the others. BDN-2 showed a high level of borer damage, but still produced the greatest yield. We intend to continue this type of testing in farmers' fields in collaboration with the Department of Agriculture.

### <u>Pest incidence and damage to borer resistant and susceptible genotypes in sole and mixed situations</u>

To examine the problem of plant to plant variation in pest damage within the same genotype and also in mixed genotype populations, we compared PP-45-2 (resistant) and ICP-7203 (susceptible) again this year in an attempt to confirm the previous year's observations. These selections were grown (a) separately in plots of 8 rows of 9 m (75 x 75 cm spacing), and (b) in alternating rows and (c) as alternating plants within rows, in similar sized plots in 3 replications-RBD on BUS-8C wih no pesticide application.

In all the combinations of both selections, we tagged 14 plants for insect counts and pod damage assessments. Only one count of eggs and larvae were made after flowering, and pods were harvested at maturity in only one picking (on 6 Jan 1985). The summarised data are presented in Table 23. At the time of pest counts <u>Heliothis</u> egg laying and larval infestations were low, so resulting in poor data for the comparison.

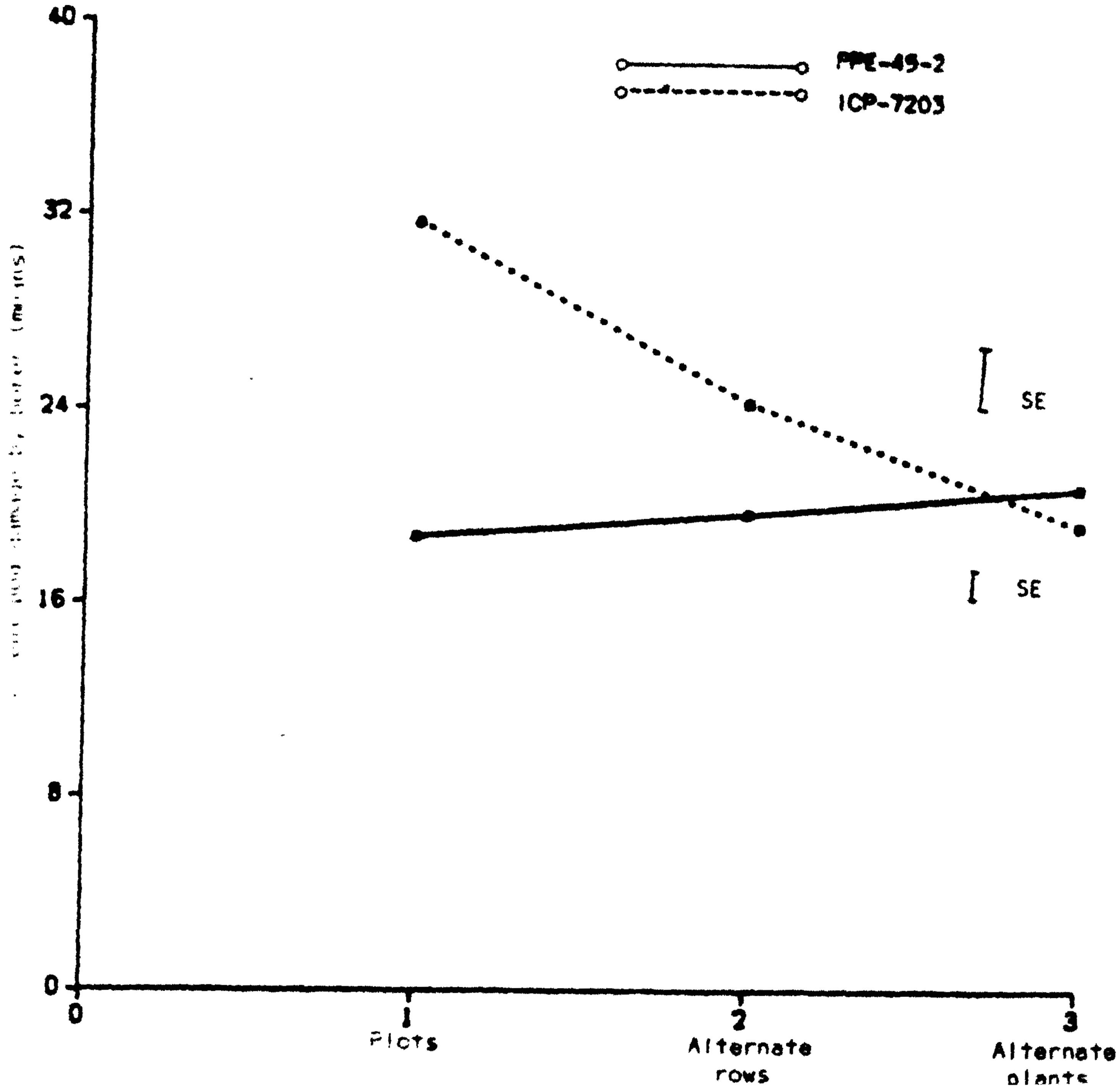
The pod damage assessment data confirmed our earlier observations that the pest damage on the susceptible plants in general showed a decrease when they are grown in mixtures with the resistant plants (Fig.1). It can be seen that the differences in percent pod damage between resistant and susceptible plants were reduced when these were in close proximity.

This alternating resistant and susceptible plants treatment is similar to the situation that will occur in segregating breeding progenies. To overcome this problem we have suggested that our breeders should sow segregating populations, intended for pest resistance selection, at wider spacings. A spacing that would prevent the plants from touching each other would also reduce the larval migration from plant to plant.

Table 23: The percentage of pods damaged by different pests in resistant (PPE-45-2) and susceptible (ICP-7203) cultivars grown in differing proximities to each other at ICRISAT Center, 1985/86 (unsprayed spacing 75 x 75 cm).

| Genotypes | Proximities | Pod damage (%) mean | | | | Sample yield(g) |
|---|---|---|---|---|---|---|
| | | Borer | Podfly | Hymn. | Total | (14 pts) |
| PPE-45-2 | Plots | 18.8 | 1.9 | 38.3 | 55.8 | 218 |
| PPE-45-2 | Alternate rows | 19.7 | 1.4 | 30.3 | 49.3 | 262 |
| PPE-45-2 | Alternate plants | 20.8 | 1.8 | 25.5 | 45.7 | 254 |
| Estimated SE ± | | 1.02 | 0.24 | 2.03 | 1.41 | 18.2 |
| CV% | | 9 | 24 | 11 | 5 | 13 |
| ICP-7203 | Plots | 31.7 | 2.5 | 2.2 | 36.9 | 442 |
| ICP-7203 | Alternate rows | 24.3 | 4.0 | 3.4 | 31.9 | 414 |
| ICP-7203 | Alternate plants | 19.2 | 6.0 | 3.1 | 29.8 | 464 |
| Estimated SE ± | | 2.37 | 0.91 | 1.07 | 2.40 | 28.9 |
| CV% | | 16 | 38 | 64 | 13 | 11 |

Fig.1: Borer damage to pods of PPE45-2 (resistant) and ICP-7203 (susceptible) cultivars in plots, alternate rows and alternate plants under unsprayed situations, 1985/86.



Testing of borer resistant/susceptible cultivars in isolations

This year we tested a *Heliothis* resistant (ICP-1903-E1) and a *Heliothis* susceptible (ICP-1691-E1) selection in isolations separately on plots of 16 rows of 15 m under unsprayed conditions. These isolation blocks were on two soil types, Alfisol and Vertisol and were distributed all over the farm. These isolations provided no choice situation to the different pests. The two in replication type of blocking (resistant/susceptible) cultivars were distributed randomly among the four different locations.

For pests damage assessments, pods were collected from 10 plants from each plot. The results of these assessments are presented in Table 24. In all these blocks plant growth was good, except for BS-10 where germination was delayed due to lack of water. In the BS-blocks flowering in these cultivars was found to be a few days earlier. Borer damage (mainly *Heliothis*) was low in all the isolations. The susceptible selection showed slightly more damage by *Heliothis*. Podfly damage was substantially greater in ICP-1903.

The isolation blocks on ICRISAT-farm are not ideal, in size or location for pests resistance studies. However, it is very difficult to have good managable isolations in farmers fields where other host plants will be available for *Heliothis* to feed on.

Studies of mechanisms of resistance to Heliothis in laboratory and field

We conducted oviposition preference tests and antibiosis studies (larval feeding tests) in our laboratory and studied the performance of cultivars under sprayed and unsprayed situations in the field (to record the tolerance), in efforts to study the mechanisms of *Heliothis* resistance in borer-resistant genotypes.

In the field we also tried to ascertain the moth preference for oviposition on resistant and susceptible selections and larval retention on these. Plant to plant movement of the larvae was also recorded in some field studies.

For the assessment of chemicals that are found on and in the podwalls that may affect resistant/susceptibility, we are collaborating with the scientists at Max-Planck Institute, Munich, West Germany.

Laboratory studies on oviposition preference of moths

In our laboratory, oviposition preference studies were conducted with some of our borer-resistant and susceptible genotypes of short and medium duration and with a selection from an intergeneric cross. In an attempt to see whether we can accelerate our screening of the germplasm and breeding material, we raised seedlings of the test material in our nethouse and at 15 days old the seedlings were exposed to moths for oviposition in cages. In a number of replicated tests,

Table 24: Testing of pigeonpea resistant and susceptible genotypes for pest reactions in no choice situation under unsprayed conditions at ICRISAT Center, during rainy season 1985/86 on different blocks. Net plot harvested: 72 sq.m.

| Cultivar | Block | DF 50% | Percent pod damage (mean) Borer | Pod- | Hymn. | Bru-chid | Total | Sample yld(10 pts)g | Plot yld kg/ha |
|---|---|---|---|---|---|---|---|---|---|
| ICP-1903 | RL-25B | 106 | 9.1 | 5.7 | 30.5 | 1.4 | 43.1 | 545.0 | 650 |
| | RUS-6A | 106 | 5.1 | 9.0 | 2.4 | 1.2 | 17.6 | 790.0 | 1140 |
| | BM-26 | 106 | 5.1 | 10.5 | 10.9 | 1.1 | 26.9 | 422.1 | 500 |
| | BS-3C | 102 | 9.8 | 28.7 | 5.7 | 2.2 | 44.1 | 635.4 | 1440 |
| Mean | | 105 | 7.3 | 13.5 | 12.4 | 1.5 | 32.9 | 598.1 | 933 |
| ICP-1691 | RL-25C | 106 | 11.8 | 6.6 | 10.9 | 0.9 | 29.0 | 723.6 | 1110 |
| | Q-5 | 106 | 10.7 | 2.8 | 0.8 | 0.7 | 14.8 | 1203.0 | 1840 |
| | BUS-23B | 106 | 5.5 | 2.7 | 3.3 | 0.5 | 11.8 | 364.8 | 620 |
| | BS-10 | 100 | 9.0 | 3.8 | 7.7 | 0.4 | 20.2 | 446.7 | 870 |
| Mean | | 105 | 9.3 | 4.0 | 5.7 | 0.6 | 19.0 | 684.5 | 1110 |
| SE of mean ± | | | 0.99 | 3.87 | 3.35 | | 3.06 | 93.9 | 195 |
| CV% | | | 24 | 89 | 74 | | 24 | 29 | 38 |

We found more egg laying on the seedlings of susceptible cultivars. However, significant differences in egg laying was noticed only in seedlings of short-duration selections. The seedlings of the intergeneric cross 1918(IG) was found to be a preferred host for *Heliothis* moths (Table 25).

In the second set of trials, flowering twigs (10-15 cm in length) from the resistant and susceptible selections were used for oviposition tests in laboratory. These twigs were collected from the pesticide-free plots in the BUS-area. Several tests were conducted with only one resistant and one susceptible test plant (flowering twig) of similar maturity. In general it was recorded that moths preferred the genotypes that were known to be susceptible and the standard checks for oviposition. Many eggs were also laid on the cage surfaces. It is evident, from the data shown in Table 24, that resistance in our selections is partly due to oviposition non-preference of the moths.

## Studies on feeding preference of *Heliothis* larvae

Fresh flowers and green pods collected from the resistant and susceptible genotypes were used for feeding preference studies in our laboratory.

In 13 cm petri-dishes, 2-3 flowers of a resistant and a susceptible genotype were placed near the edge of the dish, opposite each other. A second instar larva was released in the center of the petri-dish. The larval movement in search of the food was recorded at different intervals. Later, 24 hrs after the larva was introduced, the extent of damage caused to the flowers was scored. A rating of 1-9 for severity of damage was given. Similarly, tests were also conducted with green pods collected from the resistant and susceptible genotypes. The damage ratings, from means of 4 replications are furnished in Table 26. The results showed that there was a clear preference for the pods of susceptible cultivars and a high damage rating was found in the susceptible checks. Larval preference and a high damage rating was found in the flowers of susceptible cultivars of test groups 2 and 3 of Table 26. No difference in larval preference was detected when flowers of ICP-7203 and C-11 were compared.

## Studies on antibiosis to *Heliothis* larvae in laboratory

**Development of *Heliothis* larvae on green seeds and pods of pigeonpea genotypes:**

In an attempt to detect antibiosis in our borer resistant selections, PPE-45-2, ICP-909, ICP-1903, ICPL-84060 and 1918 (IG), we reared newly hatched larvae of *Heliothis* on the green seeds and pods collected from these selections and a comparison was made of the development of larvae on the same type of food collected from the borer susceptible genotypes and check cultivars. Larvae in individual glass tubes (2.5 x 7.5 cm) were placed in the incubator at 28 ± 1 C. In all these tests, 21 larvae were used for the development and weight loss studies. In these tests larval mortality, comparison of weights of larvae after 10

Table 25: Oviposition preference by *Heliothis armigera* moths on seedlings and flowering twigs of pigeonpea genotypes in the laboratory at ICRISAT, 1985/86.

| Genotypes tested | Test-1 Total eggs laid | Test-1 Eggs laid (mean) | Test-2 Total eggs laid | Test-2 Eggs laid (mean) | Test-3 Total eggs laid | Test-3 Eggs laid (mean) | Egg no. means of tests |
|---|---|---|---|---|---|---|---|
| **I Studies with 15 days old seedlings (5 replication each)** | | | | | | | |
| **Set-1** | **9-1-86** | | **17-1-86** | | **27-1-86** | | |
| PPE-45 (R) | 22 | 4 | 62 | 12 | 119 | 24 | 14 |
| ICP-7203 | 25 | 5 | 89 | 18 | 298 | 60 | 28 |
| ICP-909 | 35 | 7 | 8 | 2 | 132 | 26 | 12 |
| T-21 | 45 | 0 | 150 | 30 | 256 | 51 | 30 |
| Other surfaces | 587 | 117 | 473 | 95 | 235 | 47 | 86 |
| SE of mean ± | | 13.8 | | 11.2 | | 7.2 | 6.9 |
| CV% | | 108 | | 80 | | 39 | 46 |
| **Set-2** | **27-2-86** | | **14-3-86** | | **21-3-86** | | |
| ICP-1903(R) | 64 | 13 | 133 | 27 | 178 | 36 | 25 |
| BDN-1 | 223 | 45 | 212 | 42 | 153 | 31 | 39 |
| ICP-1691 | 91 | 18 | 266 | 53 | 263 | 53 | 41 |
| ICPL-84060 | 156 | 31 | 198 | 40 | 226 | 45 | 39 |
| Other surfaces | 184 | 37 | 427 | 85 | 198 | 40 | 54 |
| SE of mean ± | | 14.4 | | 22.2 | | 13.7 | 9.3 |
| CV% | | 112 | | 101 | | 75 | 52 |
| **Set-3** | **14-3-86** | | **21-3-86** | | **4-4-86** | | |
| C-11 | 237 | 47 | 184 | 37 | 283 | 57 | 47 |
| 1918(IG) | 179 | 36 | 249 | 50 | 316 | 63 | 50 |
| Other surfaces | 209 | 42 | 113 | 32 | 158 | 32 | 35 |
| SE of mean ± | | 13.8 | | 14.9 | | 12.0 | 7.9 |
| CV% | | 74 | | 84 | | 53 | 40 |

| Genotypes tested | Test-1 Total eggs laid | Test-1 Eggs laid (mean) | Test-2 Total eggs laid | Test-2 Eggs laid (mean) | Test-3 Total eggs laid | Test-3 Eggs laid (mean) | Egg no. means of tests |
|---|---|---|---|---|---|---|---|
| **II Studies with flowering twigs (4"-6") having buds, flowers and pods in 3 replications** | | | | | | | |
| **Set-1** | 21-10-85 | | 24-10-85 | | 7-11-85 | | |
| PPE-45(R) | 195 | 65 | 208 | 69 | 236 | 79 | 71 |
| ICP-7203 | 444 | 148 | 177 | 59 | 185 | 62 | 90 |
| Other surfaces | 701 | 234 | 148 | 49 | 79 | 26 | 103 |
| SE of mean ± | | 18.8 | | 21.3 | | 30.7 | 13.4 |
| CV% | | 22 | | 62 | | 96 | 26 |
| **Set-2** | 24-10-85 | | 31-10-85 | | 7-11-85 | | |
| ICP-1903(R) | 87 | 29 | 179 | 60 | 250 | 83 | 57 |
| ICP-1691 | 365 | 122 | 161 | 54 | 730 | 243 | 140 |
| Other surfaces | 227 | 76 | 215 | 72 | 200 | 67 | 71 |
| SE of mean ± | | 54.9 | | 19.7 | | 63.3 | 26.2 |
| CV% | | 126 | | 55 | | 84 | 51 |
| **Set-3** | 7-11-85 | | 14-11-85 | | 22-11-85 | | |
| BDN-1 | 458 | 153 | 262 | 87 | 156 | 52 | 97 |
| ICP-1903(R) | 116 | 39 | 270 | 90 | 142 | 47 | 59 |
| Other surfaces | 85 | 28 | 98 | 33 | 105 | 35 | 32 |
| SE of mean ± | | 6.9 | | 40.3 | | 16.5 | 14.1 |
| CV% | | 16 | | 100 | | 64 | 39 |
| **Set-4** | 7-11-85 | | 14-11-85 | | 22-11-85 | | |
| ICP-909 | 185 | 62 | 196 | 65 | 137 | 46 | 58 |
| ICP-1691 | 561 | 187 | 548 | 183 | 282 | 94 | 155 |
| Other surfaces | 198 | 66 | 200 | 67 | 40 | 13 | 49 |
| SE of mean ± | | 35.6 | | 20.5 | | 3.0 | 13.1 |
| CV% | | 59 | | 34 | | 10 | 26 |

| Genotypes tested | Test-1 Total eggs laid | Test-1 Eggs laid (mean) | Test-2 Total eggs laid | Test-2 Eggs laid (mean) | Test-3 Total eggs laid | Test-3 Eggs laid (mean) | Egg no. means of tests |
|---|---|---|---|---|---|---|---|
| <u>Set-5</u> | <u>15-11-85</u> | | <u>21-11-85</u> | | <u>26-11-85</u> | | |
| C-11 | 417 | 139 | 263 | 88 | 209 | 70 | 99 |
| 1918(IG) | 271 | 90 | 247 | 82 | 289 | 96 | 90 |
| Other surfaces | 38 | 13 | 59 | 20 | 283 | 94 | 42 |
| SE of mean ± | | 32.0 | | 26.9 | | 12.7 | 7.6 |
| CV% | | 69 | | 74 | | 25 | 17 |
| <u>Set-6</u> | <u>9-1-86</u> | | <u>17-1-86</u> | | <u>27-2-86</u> | | |
| PPE-45(R) | 165 | 33 | 140 | 28 | 368 | 74 | 50 |
| ICP-7203 | 142 | 28 | 277 | 55 | 357 | 71 | 52 |
| ICP-909(R) | 105 | 21 | 60 | 12 | 428 | 86 | 40 |
| T-21 | 182 | 56 | 47 | 9 | 283 | 57 | 41 |
| Other surfaces | 159 | 32 | 59 | 12 | 283 | 57 | 33 |
| SE of mean ± | | 12.6 | | 9.5 | | 12.6 | 5.5 |
| CV% | | 82 | | 91 | | 41 | 29 |
| <u>Set-7</u> | <u>30-1-86</u> | | <u>17-2-86</u> | | <u>24-2-86</u> | | |
| ICP-1903(R) | 492 | 98 | 200 | 40 | 227 | 45 | 61 |
| BDN-1 | 563 | 113 | 387 | 77 | 329 | 66 | 85 |
| ICP-1691 | 253 | 51 | 285 | 57 | 359 | 72 | 60 |
| ICPL-84060 (R) | 184 | 37 | 210 | 42 | 211 | 42 | 40 |
| Other surfaces | 33 | 8 | 53 | 11 | 281 | 56 | 25 |
| SE of mean ± | | 25.4 | | 17.5 | | 15.0 | 10.9 |
| CV% | | 93 | | 86 | | 60 | 45 |
| <u>Set-8</u> | <u>17-1-86</u> | | <u>30-1-86</u> | | <u>21-2-86</u> | | |
| C-11 | 216 | 43 | 94 | 19 | 183 | 36 | 33 |
| 1918(IG) | 331 | 66 | 126 | 25 | 251 | 50 | 47 |
| Other surfaces | 401 | 80 | 107 | 21 | 301 | 60 | 54 |
| SE of mean ± | | 16.4 | | 8.0 | | 11.9 | 6.6 |
| CV% | | 58 | | 82 | | 54 | 33 |

Table 26: Feeding preference of *Heliothis armigera* larvae in pigeonpea flowers and pods in laboratory during 1985/86 (each test replicated 4 times).

| | On flowers | | | | On green pods | | | |
|---|---|---|---|---|---|---|---|---|
| Pigeonpea | No.of tests cond-cted (n= ) | Duration of obse-rvation (dates) | Mean(4) damage scor-ing (1-9) | PL* | No.of tests cond-cted (n= ) | Duration of obse-rvation (dates) | Mean(4) damage scor-ing (1-9) | PL* |
| PPE-45-2(R) | 1 | 6-7/10/85 | 2.75 | (2) | 5 | 7/11/85 | 1.95 | (4) |
| ICP-7203 | | | 2.00 | (2) | | 21/11/85 | 4.35 | (16) |
| SE of mean ± | | | 1.27 | | | | 0.66 | |
| CV% | | | 107 | | | | 42 | |
| ICP-1903(R) | 2 | 23/10/85 | 2.88 | (3) | 2 | 18/11/85 | 1.13 | (1) |
| BDN-1 | | 25/10/85 | 4.88 | (5) | | 21/11/85 | 4.25 | (7) |
| SE of mean ± | | | 0.750 | | | | 0.418 | |
| CV% | | | 39 | | | | 31 | |
| ICPL-84060(R) | 2 | 24/10/85 | 2.88 | (2) | 2 | 21/11/85 | 2.75 | (3) |
| ICP-1691 | | 26/10/85 | 4.50 | (6) | | 26/11/85 | 3.75 | (5) |
| SE of mean ± | | | 1.84 | | | | 0.95 | |
| CV% | | | 100 | | | | 58 | |
| ICP-1918(IG) | 2 | 29/10/85 | 4.13 | (5) | 2 | 21/11/85 | 2.75 | (3) |
| C-11 | | 31/10/85 | 3.88 | (3) | | 26/11/85 | 3.63 | (5) |
| SE of mean ± | | | 1.82 | | | | 1.40 | |
| CV% | | | 91 | | | | 88 | |

* PL = Position of larvae in tests.
Damage rating 1-9 (1 = no damage; 9 = severe damage)

days of feeding seeds and pods collected from resistant and susceptible sources, number of pupae survived and their weights were ascertained. These data are summarised in Table 27.

In these tests, larval survival was poor on seeds alone. Pupal survival was also poor in tests with ICP-1903, ICPL-84060 and 1918(IG). A low larval weight was recorded in the green seeds tests from ICP-1903, ICPL-84060 and 1918(IG). In green pod tests differences in larval and pupal weight loss were not obvious and so require further testing.

Development of *Heliothis* larvae on powdered whole seeds and dhals of resistant and susceptible genotypes

During the period when fresh food is not available for antibiosis studies on *Heliothis* larvae, we utilized powdered whole seeds and dhal for larval development studies, by mixing these as main ingredient of the semi-synthetic diet. The components of our semi-synthetic diet used for these antibiosis tests are as follows:

| | | | |
|---|---|---|---|
| Flour of test material | 75.0 g | | |
| Ascorbic acid | 1.17 g | Agar agar | 4.31 g |
| Methyl-4-hydroxybenzoate | 0.75 g | Water | 202.5 ml |
| Sorbic acid | 0.37 g | | |
| Aureomycin | 1.87 g | (This quantity of media will be sufficient to feed 50-60 larvae) | |
| Linseed oil | 3.0 ml | | |
| Vitamin sol. | 2.5 ml | | |
| Yeast tablets | 1.20 g | | |
| Water | 127.5 ml | | |

A small block of the semi-synthetic diet was placed in sterilised rearing tubes of (7.5 x 2.5 cm) dia closed with a cotton plug. One newly hatched larva was carefully released in each tube. A number of larvae were tested on different test diets. The tubes with the diet and larvae were kept in plastic trays randomly arranged in replication groups and placed in a Percival incubator at 28 ±1 C and 60 ±5% R.H. with 12 h light. These tubes were checked daily for larval mortality and pupation. Pupal weight was ascertained a day after pupation. Larval period, pupal period, pupal weight and pupal survival were recorded in all tests.

For confirming the role of some chemicals present in the seed coat of pigeonpea, we also treated the seeds before they are powdered, as follows.

a) For removing the polyphenols present in the seed coat, about 200 g whole seeds were boiled in distilled water for 40 min.

b) For removing the amylase inhibitors, the whole seeds were soaked in 10% sodium bicarbonate solution for 16 h.

Later, these seeds were dried, powdered and mixed in the diet as mentioned above.

Table 27: Development of *Heliothis* larvae on green seeds and green pods of pigeonpea genotypes in the laboratory at ICRISAT Center, 1985-86.

| Pigeonpea genotypes | Dt of larvae released 1985 | No. of larvae survived out of 21 | Mean larval period (d) | SE | Mean larval mass g | SE | Mean pupal mass g | SE |
|---|---|---|---|---|---|---|---|---|
| ***Tests with green seeds of pigeonpea*** | | | | | | | | |
| PPE-45-E2 | 21/10 | 4 | 17 | ±0.66 | 0.186 | ±0.082 | 0.323 | ±0.018 |
| ICP-7203 | | 7 | 17 | ±0.50 | 0.271 | ±0.062 | 0.293 | ±0.014 |
| ICP-909 | | 1 | 18 | ±1.33 | 0.344 | ±0.164 | 0.313 | ±0.036 |
| T-21(check) | | 3 | 19 | ±0.77 | 0.158 | ±0.095 | 0.278 | ±0.021 |
| ICP-1903 | 20/11 | 11 | 18 | ±0.34 | 0.166 | ±0.033 | 0.274 | ±0.010 |
| BDN-1 | | 3 | 17 | ±0.65 | 0.241 | ±0.063 | 0.295 | ±0.020 |
| ICP-1691 | | 9 | 17 | ±0.38 | 0.241 | ±0.037 | 0.245 | ±0.011 |
| ICPL-84060 | | 6 | 17 | ±0.46 | 0.203 | ±0.045 | 0.276 | ±0.014 |
| C-11(check) | | 9 | 18 | ±0.38 | 0.178 | ±0.037 | 0.275 | ±0.011 |
| 1918(IG) | | 2 | 18 | ±0.80 | 0.231 | ±0.078 | 0.247 | ±0.024 |
| ***Tests with green pods of pigeonpea*** | | | | | | | | |
| PPE-45-E2 | 14/10 | 18 | 19 | ±0.35 | 0.167 | ±0.018 | 0.299 | ±0.008 |
| ICP-7203 | | 15 | 19 | ±0.39 | 0.106 | ±0.019 | 0.336 | ±0.008 |
| ICP-909 | | 18 | 19 | ±0.35 | 0.179 | ±0.018 | 0.321 | ±0.008 |
| T-21(check) | | 16 | 20 | ±0.37 | 0.141 | ±0.019 | 0.325 | ±0.008 |
| ICP-1903 | 11/11 | 5 | 19 | ±0.76 | 0.218 | ±0.030 | 0.295 | ±0.019 |
| BDN-1(check) | | 16 | 20 | ±0.42 | 0.141 | ±0.017 | 0.336 | ±0.010 |
| ICP-1691 | | 8 | 21 | ±0.60 | 0.103 | ±0.024 | 0.300 | ±0.015 |
| ICPL-84060 | | 5 | 19 | ±0.76 | 0.211 | ±0.030 | 0.333 | ±0.019 |
| C-11(check) | | 5 | 21 | ±0.76 | 0.115 | ±0.030 | 0.277 | ±0.019 |
| 1918 (IG) | | 2 | 22 | ±1.20 | 0.073 | ±0.048 | 0.332 | ±0.030 |

During this year we conducted two tests, one with untreated whole seeds and dhal of a resistant genotype with a brown seed coat (ICP-1903), compared with a borer susceptible genotype PPE-50 (brown seeds) and ICP-1691 (white seeds), L-550 (kabuli chickpea) standard media was used as the check in all these tests.

Another test was conducted with the whole seeds and dhal of the above mentioned genotypes, but with the addition of treated seeds (for a) and b) as mentioned above) as separate treatments. The data on larval survival, larval period, pupal survival and pupal weights are furnished in Table 28.

In these tests it was evident that Heliothis larval development was normal and healthy with a high number of surviving larvae in the chickpea based diet (L-550). The diet with powdered dhal of resistant and susceptible cultivars was also found to be good for larval development, but some difference in larval survival and pupal weight were detected between the resistant and susceptible cultivars. But, large differences existed in the whole seed treatment of resistant and susceptible cultivrs. When the ground whole seeds were used as a main ingredient in the diet media, larvae took a very long time (50 to 70 days) to reach the pupation stage when compared to those in dhal and L-550 check treatments (19 to 27 days). These differences are illustrated in Fig.2.

In the tests with treated seeds, all larvae died in all the treatments in which the diets were made from whole seeds, except for the treatment incorporating the whole seed of the susceptible genotype, where some survival and development was recorded, both in the whole seeds boiled treatment and also in seeds soaked with sodium bicarbonate treatment. These tests indicated that strong antibiosis to Heliothis exists in the seed coats of some pigeonpea cultivars. More antibiosis was expressed in the brown seeded, borer-resistant genotypes. The chemicals which are present in the seed coat and responsible for antibiosis could not be removed either by boiling or by soaking in sodium bicarbonate solution. We will study such antibiosis in further tests.

Field studies of movement of Heliothis larvae

A trial using two sets of short and short-medium duration pigeonpea selections, that were known to have a wide range of susceptibilities to Heliothis, was laid out in an RBD with 3 replicates on a pesticide free block BUS-8C. This trial was sown on June 24, 1985. The experimental plots were of 2 rows of 9 m each with a plant to plant spacing of 1.5 x 1.0 m. Weekly counts of the Heliothis eggs and larvae were made on five tagged plants per row in each trial. 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 counts. Four such counts were taken soon after flowering of the test entries. Pod damage was assessed on the tagged plants of unbrushed and brushed rows after harvest. The results of pests counts and pest damage percentages are summarised in Table 29.

Table 28: Development of *Heliothis armigera* larvae on artificial diet containing powdered pigeonpea seeds/dhal of resistant/susceptible genotypes in the laboratory during 1985/86.

| P.pea geno-types | 1* | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **I Tests with dhal/whole seeds untreated** | | | | | | | | | | |
| ICP-1903 | Dhal | 18 Jul | 32 | 12 | 25 | ±1.47 | 15 | ±0.57 | 0.305 | ±0.0098 |
| ICP-1903 | WS | 1985 | 32 | 3 | 70 | ±2.95 | 14 | ±1.14 | 0.192 | ±0.0197 |
| PPE-50 | Dhal | | 32 | 11 | 25 | ±1.54 | 16 | ±0.60 | 0.340 | ±0.0103 |
| PPE-50 | WS | | 32 | 0 | 0 | ±1.93 | 0 | | | |
| ICP-1691 | Dhal | | 32 | 7 | 27 | ±1.54 | 14 | ±0.75 | 0.341 | ±0.0129 |
| ICP-1691 | WS | | 32 | 11 | 50 | ±1.54 | 15 | ±0.60 | 0.230 | ±0.0103 |
| L-550 | WS | | 32 | 20 | 21 | ±1.14 | 16 | ±0.44 | 0.334 | ±0.0076 |
| ICP-1903 | Dhal | | 50 | 45 | 23 | ±0.72 | 17 | ±0.27 | 0.266 | ±0.0059 |
| ICP-1903 | WS | | 50 | 1 | 52 | ±4.83 | 22 | ±1.81 | 0.107 | ±0.0397 |
| PPE-50 | Dhal | 14 Sep | 50 | 46 | 27 | ±0.71 | 16 | ±0.27 | 0.241 | ±0.0059 |
| PPE-50 | WS | 1985 | 50 | 1 | 65 | ±4.83 | 9 | ±1.81 | 0.101 | ±0.0397 |
| ICP-1691 | Dhal | | 50 | 37 | 25 | ±0.79 | 16 | ±0.30 | 0.249 | ±0.0065 |
| ICP-1691 | WS | | 50 | 30 | 51 | ±0.88 | 12 | ±0.33 | 0.195 | ±0.0072 |
| L-550 (check) | WS | | 50 | 46 | 20 | ±0.71 | 15 | ±0.27 | 0.282 | ±0.0059 |
| **II Tests with whole seeds treated and dhal** | | | | | | | | | | |
| *Borer resistant (brown seeds)* | | | | | | | | | | |
| ICP-1903 | WS | 10 Apr | 12 | 0 | - | - | - | - | - | - |
| | WSB | 1986 | 12 | 0 | - | - | - | - | - | - |
| | WSS | | 12 | 0 | - | - | - | - | - | - |
| | Dhal | | 12 | 11 | 16 | ±1.11 | 10 | ±0.49 | 0.303 | ±0.0103 |
| *Borer susceptible (brown seeds)* | | | | | | | | | | |
| PPE-50 | WS | | 12 | 0 | - | - | - | - | - | - |
| | WSB | | 12 | 0 | - | - | - | - | - | - |
| | WSS | | 12 | 0 | - | - | - | - | - | - |
| | Dhal | | 12 | 10 | 16 | ±1.17 | 11 | ±0.51 | 0.331 | ±0.0108 |
| *Borer susceptible (white seeds)* | | | | | | | | | | |
| ICP-1691 | WS | | 12 | 0 | - | - | - | - | - | - |
| | WSB | | 12 | 7 | 27 | ±1.39 | 9 | ±0.61 | 0.307 | ±0.0130 |
| | WSS | | 12 | 1 | 20 | ±3.69 | 8 | ±1.62 | 0.302 | ±0.0343 |
| | Dhal | | 12 | 7 | 17 | ±1.39 | 11 | ±0.61 | 0.308 | ±0.0130 |
| L-550 check | WS | | 12 | 9 | 15 | ±1.23 | 10 | ±0.54 | 0.358 | ±0.0114 |

| P.pea geno-types | 1* | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Borer resistant (brown seeds** | | | | | | | | | | |
| ICP-1903 | WS | | 25 | 0 | - | - | - | - | - | - |
| | WSB | | 25 | 0 | - | - | - | - | - | - |
| | WSS | 17 Apr | 25 | 0 | - | - | - | - | - | - |
| | Dhal | 1986 | 25 | 8 | 17 | ±0.80 | 10 | ±0.92 | 0.283 | ±0.0160 |
| **Borer susceptible (brown seeds)** | | | | | | | | | | |
| PPE-50 | WS | | 25 | 0 | - | - | - | - | - | - |
| | WSB | | 25 | 0 | - | - | - | - | - | - |
| | WSS | | 25 | 0 | - | - | - | - | - | - |
| | Dhal | | 25 | 12 | 17 | ±0.65 | 10 | ±0.75 | 0.303 | ±0.0131 |
| **Borer susceptible (white seeds)** | | | | | | | | | | |
| ICP-1691 | WS | | 25 | 0 | - | - | - | - | - | - |
| | WSB | | 25 | 2 | 24 | ±1.60 | 13 | ±1.83 | 0.281 | ±0.0320 |
| | WSS | | 25 | 1 | 18 | ±2.27 | 12 | ±2.58 | 0.362 | ±0.0453 |
| | Dhal | | 25 | 14 | 19 | ±0.61 | 11 | ±0.69 | 0.270 | ±0.0121 |
| L-550 check | | | 25 | 14 | 14 | ±0.61 | 11 | ±0.69 | 0.302 | ±0.0121 |

1 = Main diet ingredient; 2 = Date of larval release; 3 = No. of larvae released; 4 = Larvae survived; 5 = Mean larval period (days); 6 = SE; 7 = Mean pupal period (days); 8 = SE; 9 = Mean pupal wt. (g); 10 = SE.

WS = Whole seeds untreated; WSB = Whole seeds boiled in water for 40 minutes; WSS = Whole seeds soaked in 10% sod. bicarb. sol. for 16 hours.; Dhal = Cotyledons only - seed coat removed.

## H. ARMIGERA DEVELOPMENT ON SEMI SYNTHETIC MEDIA

July 18 to August 23, 1985

Table 29: Studies on pigeonpea resistance/escape mechanisms in unbrushed and brushed comparison under unsprayed conditions (rainy season 1985/86). Entries: 6; Reps.: 3; Date sown: 24-6-1985.

| Pigeonpea | DF 50% | Chara-cters* | Total of 4 counts, 3 reps (Mean) Eggs | Larvae | Pod damage mean (%) Borer | Pod-fly | Hymn. | Total | Sample yield g |
|---|---|---|---|---|---|---|---|---|---|
| **On unbrushed rows** | | | | | | | | | |
| ICP-909-E3-6EB | 88 | LB | 22 | 29 | 55.3 | 1.6 | 20.2 | 72.6 | 82 |
| ICP-7203-E1-7EB | 88 | HB | 7 | 56 | 53.7 | 1.8 | 2.4 | 59.9 | 164 |
| PPE-45-2-7B | 108 | LB | 13 | 16 | 30.9 | 2.5 | 29.8 | 61.1 | 160 |
| ICP-10466-E1-7EB | 127 | LB | 30 | 35 | 49.7 | 4.7 | 12.7 | 63.2 | 95 |
| ICP-1691-E1-7EB | 127 | HB | 38 | 88 | 71.7 | 1.9 | 5.3 | 77.1 | 56 |
| ICP-1903-E1-7EB | 129 | LB | 25 | 21 | 49.8 | 3.5 | 22.7 | 69.7 | 78 |
| SE of mean ± | | | 5.2 | 7.4 | 9.72 | (1.17)** | 3.88 | 7.41 | 28.8 |
| CV% | | | 40 | 32 | 33 | 22 | 43 | 19 | 47 |
| LSD at p<0.05 | | | 15.7 | 22.3 | - | (3.5)** | 11.7 | - | - |
| **On brushed rows** | | | | | | | | | |
| ICP-909-E3-6EB | 88 | LB | 13 | 32 | 41.5 | 2.2 | 19.5 | 60.4 | 143 |
| ICP-7203-E1-7EB | 88 | HB | 6 | 35 | 35.3 | 1.2 | 4.9 | 44.1 | 203 |
| PPE-45-2-7B | 108 | LB | 12 | 11 | 30.6 | 3.2 | 29.8 | 59.8 | 147 |
| ICP-10466-E1-7EB | 127 | LB | 30 | 33 | 50.3 | 5.8 | 13.9 | 67.9 | 93 |
| ICP-1691-E1-7EB | 127 | HB | 28 | 76 | 51.8 | 4.1 | 8.4 | 60.7 | 124 |
| ICP-1903-E1-7EB | 129 | LB | 24 | 16 | 47.6 | 3.9 | 22.6 | 70.2 | 75 |
| SE of mean ± | | | 6.3 | 9.2 | 6.42 | (1.4)** | 4.6 | 3.91 | 18.6 |
| CV% | | | 58 | 47 | 26 | 24 | 48 | 11 | 25 |
| LSD at p<0.05 | | | - | 27.7 | - | (4.2)** | 13.9 | 11.8 | 55.9 |

* For abbreviations see page 5.

** Arcsin $\sqrt{\%}$ transformation was used for the analysis of data.

Counts from the plants that were cleared of eggs and larvae after each count showed that there must have been substantial dispersal of larvae from row to row for the counts of larvae (including large larvae) on these plants were almost as great as those on the plants in the rows from which eggs and larvae were not removed. This indicates that larvae have an opportunity to demonstrate plant preference at least as far as neighbouring plants are concerned.

The borer damage on the two borer susceptible genotypes (ICP-7203 [short duration] and ICP-1691 [medium duration]) were generally greater than on the resistant selections, particularly in the unbrushed rows. The differences in numbers of eggs were related to the time of flowering and there is no clear differences between the oviposition on resistant and susceptible selections of the short duration group. There were far more larvae on the susceptible selections than on the resistant of both the duration groups. This confirms the results of our earlier tests.

Project: P-110(85)IC

## STUDIES ON THE PIGEONPEA PODFLY, MELANAGROMYZA OBTUSA INCLUDING INVESTIGATIONS OF THE MECHANISMS OF HOST PLANT RESISTANCE

### Objectives

To supplement the current knowledge of the biology of podfly. To study the ecology including factors influencing the fluctuations of populations across areas and years. To study the mechanisms of host plant resistance. To develop our knowledge of the potential elements of practical management of this pest.

### Pattern of Podfly Incidence in Relation to Host Plant Resistance.

To understand the pattern of podfly incidence as influenced by host plant resistance, we conducted a field trial with two pairs of podfly 'resistant' and 'susceptible' genotypes in an RBD trial with 6 replications in plot of 12 rows of 4 metres (75 cm between rows and 30 cm between plots) in BIL-6A at ICRISAT Center, sown in June 1985.

The phenology of the plants was recorded as days (from sowing) to bud initiation, early flowering, 50% flowering, early podding, mid podding and 70% maturity (Table 30).

The pattern of oviposition was recorded (in random samples of 50 partly mature pods per plot) by counting eggs per pod, eggs per locule and eggs per "infested" locule. At 2 weeks after this sampling, swollen (mature, green) pods were sampled in the same manner in each plot, to record the number of larvae and pupae of podfly per pod. The ratio of egg per pod to that of larvae and pupae per pod was also calculated as an index of apparent survival from egg to larval/pupal stages. At harvest, 10 random plants were harvested from each plot and the total pods per plant was recorded on these. From these plants 100 pods were randomly sampled for assessing the podfly damage on a pod and seed basis.

Data on the phenology (Table 30) indicated no significant difference in days to flowering or podding between the resistant and susceptible genotypes. However, days to 70% maturity were significantly less in the resistant genotypes. In an earlier study, we had found that the pod development duration did not differ significantly between resistant and susceptible genotypes. In the present season study resistant genotypes completed their podding more synchronously than the suceptible ones and so minimised the overall duration susceptibility for fresh infestation. We should ascertain the role of such a trait among more genotypes.

We chose one pair of resistant and susceptible genotypes and recorded the eggs laid in 50 randomly chosen young pods and counted the larvae/puparia in 50 mature pods collected in the same plots 1 and 2 weeks later (Table 31)

Table 30: Flowering and podding pattern in two pairs of podfly resistant and susceptible pigeonpea genotypes, ICRISAT Center, rainy season, 1985-86.

| Genotype | No. of days taken from sowing to | | | | | |
|---|---|---|---|---|---|---|
| | Bud initiation | Early flowering | 50% flowering | Early podding | Mid podding | 70% maturity |
| ICP-4941 (LPf) | 128 | 133 | 140 | 146 | 157 | 192 |
| ICP-7337-2 (HPf) | 135 | 141 | 147 | 152 | 164 | 214 |
| ICP-8102-5 (LPf) | 145 | 150 | 155 | 163 | 175 | 217 |
| ICP-8595 (HPf) | 143 | 148 | 154 | 156 | 168 | 223 |
| Overall comparison between less and more susceptible groups of cultivars | | | | | | |
| Resistant | 137 | 141 | 147 | 154 | 166 | 204 |
| Susceptible | 139 | 145 | 150 | 154 | 166 | 218 |
| SE (m) | 2.1 | 1.9 | 1.8 | 1.8 | 2.0 | 2.8 |
| CV% | 5.3 | 4.7 | 4.2 | 4.1 | 4.2 | 4.7 |
| Sig. | NS | NS | NS | NS | NS | S |

LPf = Resistant to podfly; HPf Susceptible to podfly; S Significant; NS = Non significant.

Table 31: Podfly oviposition and apparent survival pattern (different parameters) in a resistant and susceptible pair of genotypes at 3 periods, ICRISAT Center, rainy season, 1985-86.

| Period | Cultivar | No.of eggs/ pod | No.of eggs/ locule | No.of eggs/ infested locule | % pods with eggs | % locules with eggs | No.of larvae/ pod | No.of pupae/ pod | Egg/ larva+ pupa ratio |
|---|---|---|---|---|---|---|---|---|---|
| P1 | C1 | 0.37 | 0.095 | 1.12 | 24.7 | 8.5 | 0.09 | 0.09 | 2.25 |
| | C2 | 1.70 | 0.394 | 1.26 | 67.3 | 31.4 | 0.38 | 0.48 | 2.03 |
| | Mean | 1.04 | 0.245 | 1.19 | 46.0 | 19.9 | 0.24 | 0.28 | 2.14 |
| P2 | C1 | 0.06 | 0.015 | 0.83 | 5.0 | 1.5 | 0.07 | 0.02 | 1.03 |
| | C2 | 0.23 | 0.055 | 1.05 | 16.7 | 5.2 | 0.04 | 0.26 | 0.87 |
| | Mean | 0.14 | 0.035 | 0.94 | 10.8 | 3.3 | 0.06 | 0.14 | 0.95 |
| P3 | C1 | 0.06 | 0.017 | 0.68 | 4.3 | 1.6 | 0.01 | 0.02 | 3.0 |
| | C2 | 0.40 | 0.100 | 1.05 | 25.0 | 9.5 | 0.22 | 0.15 | 1.32 |
| | Mean | 0.23 | 0.059 | 0.87 | 14.7 | 5.6 | 0.12 | 0.09 | 2.16 |
| Overall | | | | | | | | | |
| | C1 | 0.16 | 0.042 | 0.88 | 11.3 | 3.9 | 0.06 | 0.04 | 2.09 |
| | C2 | 0.78 | 0.183 | 1.12 | 36.3 | 15.4 | 0.22 | 0.30 | 1.40 |
| Effect of Main Treatment (Period) | | | | | | | | | |
| SE(m) ± | | 0.040 | 0.001 | 0.090 | 1.91 | 0.88 | 0.031 | 0.026 | 0.731 |
| CV% | | 21 | 22 | 22 | 20 | 23 | 56 | 37 | 102 |
| Sig(5%) | | Sig | Sig | NS | Sig | Sig | Sig | Sig | NS |
| Effect of Sub Treatment (Cultivar) | | | | | | | | | |
| SE(m) ± | | 0.023 | 0.0048 | 0.064 | 1.09 | 0.53 | 0.017 | 0.022 | 0.457 |
| CV% | | 21 | 18 | 27 | 20 | 24 | 52 | 55 | 111 |
| Sig(5%) | | Sig | Sig | NS | Sig | Sig | Sig | Sig | NS |
| Effect of Interaction (Period x Cultivar) | | | | | | | | | |
| SE(m) ± M | | 0.040 | 0.0084 | 0.111 | 1.89 | 0.92 | 0.029 | 0.038 | 0.792 |
| SE(m) ± S | | 0.049 | 0.0116 | 0.119 | 2.33 | 1.10 | 0.037 | 0.037 | 0.921 |
| Sig(5%) | | Sig | Sig | NS | Sig | Sig | Sig | Sig | NS |

Egg Counts : P1 = 4-12-1985; P2 = 11-12-1985; P3 = 18-12-1985
Larval Counts: P1 = 18-12-1985; P2 = 26-12-1985; P3 = 2-1-1986.

C1 = ICP-7941 (res.); C2 = ICP-7337-2 (sus.); Replication = 6;
Sig = Significant; NS = Not significant.

It was clear, in all the three dates of sampling, that the overall number of eggs per pod or per locule was significantly less in the resistant genotype (Table 31). Further, the percent pods or locules with podfly eggs was also clearly less in the resistant one. This indicated that the podfly limited its egg laying to fewer pods and locules in the resistant cultivar. However, the number of eggs laid per 'infested' locule (locule in which any egg was laid) did not differ between the resistant and susceptible genotype. This suggests that once the adult decides to deposit its egg into a locule, it does not regulate the numbers laid in the locule differentially between resistant and susceptible genotypes.

The podfly resistant genotype also had less larvae/pupae in mature pods (Table 31). However, the "apparent survival" (ratio of eggs in young pods to larvae plus pupae in mature pods) did not differ significantly between the genotypes. This indirectly indicates that the survival subsequent to hatching into larvae till pupation did not differ significantly between the genotypes and so antibiosis could not be detected in the resistant genotype.

While these studies were based on three sets of data in one pair of resistant and susceptible genotypes, we collected similar data in two counts on another pair of genotypes - ICP-8102-5-S1 (resistant) and ICP-8595-E1-E5 (susceptible). The trend of results was similar to those the former pair (Table 32). We also combined the results from these two pairs (Table 33) and ascertained that there was significant reduction in overall egg numbers per pod or locule, percent pods or locules with eggs, overall number of larvae or pupae per pod, but no significant influence of resistance on the number of eggs laid per infested locule nor on the apparent survival (ratio of eggs to larvae plus pupae).

At harvest, we recorded pods/plant and the damage caused by podfly on a pod and locule basis in the two pairs of resistant and susceptible genotypes (Table 34). In one of the pairs, there was nearly three times more pods in the resistant genotype. The percent pods and seeds damaged were significantly less in this pair as well as in the other pair in which podding (pods per plant) did not differ appreciably between the resistant and susceptible genotype. We intend to conduct studies which will further clarify the basis of resistance, by subjecting these genotypes to oviposition under no choice conditions, with a uniform ratio between pods and podfly adults in these studies. However, it is evident that oviposition non-preference rather than antibiosis is the major cause of resistance in the two comparisons studied here.

## Podfly Incidence in Some Promising Selections

Twelve of the selections made by Dr.S.S.Lateef for podfly 'resistance' (9) and 'susceptible' (3) were chosen for study under unsprayed conditions. We had seeds of these selections from two sources (a) 'selfed' (by bagging) and (b) 'open pollinated' (no bagging). Each selection was sown in 12 rows of 4 meters (75 cm between rows; 25 cm

Table 32: Podfly incidence pattern (different parameters) in a resistant and susceptible pair of genotypes at 2 periods, ICRISAT Center, rainy season, 1985-86.

| Period | Cultivar | No.of eggs/ pod | No.of eggs/ locule | No.of eggs/ infested locule | % pods with eggs | % locules with eggs | No.of larvae/ pod | No.of pupae/ pod | Egg/ larva+ pupa ratio |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C1 | 0.38 | 0.11 | 1.11 | 25.7 | 11.0 | 0.22 | 0.003 | 2.16 |
| | C2 | 0.85 | 0.24 | 1.14 | 44.7 | 23.8 | 0.33 | 0.067 | 2.14 |
| | Mean | 0.61 | 0.17 | 1.13 | 35.2 | 17.4 | 0.28 | 0.035 | 2.15 |
| 2 | C1 | 0.29 | 0.08 | 1.02 | 20.3 | 8.3 | 0.05 | 0.020 | 7.16 |
| | C2 | 0.47 | 0.14 | 1.05 | 35.0 | 14.3 | 0.24 | 0.050 | 1.69 |
| | Mean | 0.38 | 0.11 | 1.03 | 27.7 | 11.3 | 0.15 | 0.035 | 4.43 |
| Overall | | | | | | | | | |
| | C1 | 0.34 | 0.10 | 1.06 | 23.0 | 9.6 | 0.14 | 0.012 | 4.66 |
| | C2 | 0.66 | 0.19 | 1.10 | 39.8 | 19.0 | 0.29 | 0.058 | 1.91 |
| Effect of Main Treatment (Period) | | | | | | | | | |
| SE(m) ± | | 0.034 | 0.012 | 0.032 | 0.89 | 1.17 | 0.021 | 0.0073 | 0.909 |
| CV% | | 17 | 20 | 7 | 7 | 20 | 24 | 51 | 68 |
| Sig(5%) | | Sig | Sig | NS | Sig | Sig | Sig | NS | NS |
| Effect of Sub Treatment (Cultivar) | | | | | | | | | |
| SE(m) ± | | 0.058 | 0.012 | 0.015 | 2.67 | 1.77 | 0.021 | 0.0080 | 0.927 |
| CV% | | 40 | 43 | 5 | 29 | 43 | 35 | 79 | 98 |
| Sig(5% | | Sig | Sig | NS | Sig | Sig | Sig | Sig | NS |
| Effect of Interaction (Period x Cultivar) | | | | | | | | | |
| SE(m) ± M | | 0.082 | 0.025 | 0.021 | 3.77 | 2.50 | 0.030 | 0.0113 | 1.310 |
| SE(m) ± S | | 0.067 | 0.021 | 0.035 | 2.81 | 2.12 | 0.030 | 0.0108 | 1.298 |
| Sig(5%) | | NS | NS | NS | NS | NS | NS | NS | NS |

C1 = Resistant (ICP 8102-5-S1); C2 = Susceptible (ICP 8595-E1-E5).

Egg counts: P1 = 18-12-1985; P2 26-12-1985.
Larval counts: P1 = 2-1-1986; P2 9-1-1986.

Table 33: Podfly incidence pattern (different parameters) in resistant and susceptible genotypes (2 pairs) at ICRISAT Center, rainy season, 1985-86.

| Genotype | No.of eggs/ pod | No.of eggs/ locule | No.of eggs/ infested locule | % pods with eggs | % locules with eggs | No.of larvae/ pod | No.of pupae/ pod | Egg/ larva+ pupa ratio |
|---|---|---|---|---|---|---|---|---|
| C1 | 0.06 | 0.02 | 0.68 | 4.3 | 1.7 | 0.01 | 0.020 | 3.0 |
| C2 | 0.40 | 0.10 | 1.05 | 25.0 | 10.0 | 0.22 | 0.150 | 1.3 |
| C3 | 0.38 | 0.11 | 1.11 | 25.7 | 11.0 | 0.22 | 0.003 | 2.2 |
| C4 | 0.85 | 0.24 | 1.14 | 44.7 | 23.8 | 0.33 | 0.067 | 2.1 |
| SE(m) ± | 0.070 | 0.021 | 0.110 | 2.81 | 2.08 | 0.031 | 0.019 | 1.10 |
| CV% | 40 | 44 | 27 | 28 | 44 | 38 | 76 | 125 |
| Sig(5%) | Sig | Sig | Sig | Sig | Sig | Sig | Sig | NS |
| Comparison between less and more susceptible cultivars | | | | | | | | |
| Res (LPf) | 0.22 | 0.06 | 0.89 | 15.0 | 6.4 | 0.12 | 0.01 | 2.58 |
| Sus (HPf) | 0.63 | 0.17 | 1.10 | 34.8 | 16.9 | 0.28 | 0.11 | 1.73 |
| SE(m) ± | 0.072 | 0.022 | 0.089 | 3.69 | 2.19 | 0.034 | 0.017 | 0.750 |
| CV% | 60 | 65 | 31 | 51 | 65 | 60 | 95 | 121 |
| Sig(5%) | S | S | NS | S | S | S | S | NS |

C1 = ICP-7941 (LPf); C2 = ICP-7337-2 (HPf); C3 = ICP-8102-5 (LPf); C4 = ICP-8595 (HPf).

Significant; NS = Not significant.

Table 34: Podding and podfly incidence of two pairs of podfly 'resistant' and 'susceptible' genotypes of pigeonpea, ICRISAT Centre, rainy season, 1985-86.

| Cultivar | Total pods/ plant | % pod damage* | | % seed damage* | |
|---|---|---|---|---|---|
| | | Total | Podfly | Total | Podfly |
| **Pair-1** | | | | | |
| ICP-7941 (LPf) | 227 | 36.0 | 16.8 | 20.4 | 7.2 |
| ICP-7337-2 (HPf) | 58 | 66.5 | 29.0 | 27.9 | 11.2 |
| **Pair-2** | | | | | |
| ICP-8102-5 (LPf) | 130 | 50.3 | 17.3 | 22.5 | 6.8 |
| ICP-8595 (HPf) | 120 | 55.7 | 32.5 | 29.1 | 14.6 |
| Overall comparison between less and more susceptible groups | | | | | |
| Resistant (LPf) | 178 | 43.2 | 17.1 | 21.5 | 7.0 |
| Susceptible (HPf) | 89 | 61.1 | 30.8 | 28.5 | 12.9 |
| SE(m) ± | 13.4 | 3.77 | 1.61 | 1.87 | 0.80 |
| CV% | 35 | 25 | 23 | 26 | 28 |
| Sig(5%) | S | S | S | S | S |

LPf = Resistant to podfly; HPf = Susceptible to podfly.

S = Significant; NS = Not significant.

* Based on 100 pods sample.

within row) and of these 6 rows each were subplots in which the two seed sources were randomly allocated. The trial consisted of 4 replications, with 12 selections as main plots, in a split-plot design and sown on 25 June 1986 in field BIL-6A.

We recorded the days to 50% flowering, to early podding and to 70% maturity in each subplot. It was found that there were no significant differences in these criteria between plots raised from 'selfed' and 'open pollinated' seeds of the same genotype.

From each of the plots we collected 100 pods at random at harvest and recorded the podfly damage on pod and seed basis, 100 seed mass and grain yield (Table 35). Except for 100 seed, there was no significant difference between samples from 'selfed' and 'open pollinated' seed progenies.

In addition, we chose from these, three pairs of "resistant" and "susceptible" genotypes of comparable flowering and maturity. In plots raised from selfed seeds of these genotypes, we collected 50 young pods at random on 20 Dec 1985 and recorded the percent pods or locules with eggs as well as the mean number of eggs per pod or locule. The data are summarised in Table 36. In each pair, the percent pods or locules with eggs as well as the mean eggs per pod or locule were always less in the resistant genotype.

Podfly Incidence in Podfly Resistance Selections from Patancheru in Comparison with Long-Duration Cultivars at Gwalior

In this year, we laid out a trial incorporating 4 genotypes each of podfly resistant and susceptible genotypes selected at Patancheru, 4 standard check cultivars (Bahar, T-7, Gwalior.3 and NP(WR)-15) and 4 promising long duration selections from our breeders at Gwalior. All these (16) genotypes were grown in a split-plot design, the main plot treatment being insecticide sprayed (T1) and unsprayed (T2). There were four replications and the plots were 5 rows of 4 meters. The trial was sown (in field 325) at Gwalior on 13 July 1985. The sprayed plots received weekly sprays of dimethoate 0.07% from January 1986 onwards till all plots reached 70% maturity. We recorded the days taken to 50% flowering and 70% maturity in all the plots. At harvest we sampled 10 plants per plot at random for grain yield. We also sampled 100 random pods per plot for assessing the podfly damage on a pod and seed basis.

The insecticide treatment failed to control the podfly attacks, for the % seed damaged by podfly in the sprayed plots averaged 18% which was only slightly below the 21.5% recorded in the unsprayed plots. This may have been a result of poor coverage by the sprays (such large and dense plant growth is difficult to spray) and/or the rapid reinfestation by podfly into the sprayed plots by podfly emerging from the unsprayed plots.

The entomologist's selections from Patancheru flowered and podded from November, well before the locally adapted cultivars and breeders'

Table 35: Podfly damage and grain yield in genotypes of pigeonpea, less (LPf) and more (HPf) susceptible to podfly, in plants grown from selfed and open pollinated seeds, ICRISAT Center, 1985/86.

| Genotype (days to maturity) | Seed type | % pod damage Total | % pod damage Podfly | % seed damage Total | % seed damage Podfly | 100 seed mass (g) | Grain yield kg/ha |
|---|---|---|---|---|---|---|---|
| ICP-10531 (LPf) | Selfed | 32.5 | 9.5 | 15.8 | 3.8 | 5.7 | 790 |
| (173) | Open | 27.5 | 13.0 | 14.6 | 4.5 | 5.5 | 790 |
| | Mean | 30.0 | 11.3 | 15.2 | 4.1 | 5.6 | 790 |
| ICP-6977 (LPf) | Selfed | 33.8 | 18.3 | 22.8 | 9.6 | 8.0 | 940 |
| (180) | Open | 24.3 | 18.0 | 13.8 | 7.5 | 8.0 | 1000 |
| | Mean | 29.0 | 18.1 | 18.3 | 8.6 | 8.0 | 970 |
| ICP-7050 (LPf) | Selfed | 26.8 | 8.3 | 11.3 | 3.1 | 6.1 | 710 |
| (192) | Open | 28.0 | 7.8 | 13.8 | 3.1 | 6.3 | 560 |
| | Mean | 27.4 | 8.0 | 12.5 | 3.1 | 6.2 | 640 |
| ICP-10466 (LPf) | Selfed | 34.5 | 17.8 | 18.2 | 6.7 | 6.1 | 1020 |
| (182) | Open | 36.0 | 20.8 | 16.7 | 7.8 | 6.9 | 1020 |
| | Mean | 35.3 | 19.3 | 17.4 | 7.2 | 6.5 | 1020 |
| ICP-7941 (LPf) | Selfed | 29.5 | 11.3 | 15.8 | 3.8 | 5.0 | 1060 |
| (191) | Open | 22.8 | 7.3 | 13.8 | 3.0 | 5.9 | 950 |
| | Mean | 26.1 | 9.3 | 14.8 | 3.4 | 5.4 | 1000 |
| ICP-7946 (LPf) | Selfed | 19.5 | 4.3 | 9.1 | 1.4 | 5.6 | 970 |
| (192) | Open | 24.3 | 9.3 | 15.8 | 3.8 | 5.8 | 1000 |
| | Mean | 21.9 | 6.8 | 12.4 | 2.6 | 5.7 | 980 |
| ICP-8102-5 (LPf) | Selfed | 61.0 | 21.5 | 24.5 | 8.5 | 9.2 | 700 |
| (206) | Open | 56.8 | 19.5 | 26.2 | 7.6 | 9.9 | 750 |
| | Mean | 58.9 | 20.5 | 25.4 | 8.1 | 9.5 | 720 |
| ICP-3615 (LPf) | Selfed | 41.0 | 19.0 | 18.5 | 7.1 | 7.8 | 820 |
| (201) | Open | 52.3 | 20.3 | 23.8 | 6.8 | 8.0 | 780 |
| | Mean | 46.6 | 19.6 | 21.1 | 7.0 | 7.9 | 800 |
| ICP-7176-5 (LPf) | Selfed | 52.5 | 23.0 | 23.9 | 8.7 | 8.5 | 800 |
| (214) | Open | 49.5 | 21.3 | 24.1 | 7.6 | 8.5 | 770 |
| | Mean | 51.0 | 22.1 | 24.0 | 8.2 | 8.5 | 780 |
| ICP-5036 (HPf) | Selfed | 44.3 | 18.0 | 20.5 | 7.6 | 7.2 | 360 |
| (183) | Open | 36.3 | 18.5 | 18.3 | 7.1 | 6.9 | 870 |
| | Mean | 40.3 | 18.3 | 19.4 | 7.4 | 7.1 | 620 |

| Genotype (days to maturity) | Seed type | % pod damage | | % seed damage | | 100 seed mass (g) | Grain yield kg/ha |
|---|---|---|---|---|---|---|---|
| | | Total | Podfly | Total | Podfly | | |
| ICP-8595 (HPf) | Selfed | 57.3 | 35.0 | 26.1 | 13.7 | 8.0 | 770 |
| (214) | Open | 54.8 | 27.5 | 27.9 | 10.2 | 8.0 | 850 |
| | Mean | 56.0 | 31.3 | 27.0 | 12.0 | 8.0 | 810 |
| ICP-8583 (HPf) | Selfed | 65.0 | 26.8 | 24.9 | 11.9 | 7.0 | 620 |
| (210) | Open | 57.3 | 23.8 | 23.2 | 9.6 | 7.5 | 850 |
| | Mean | 61.1 | 25.3 | 24.1 | 10.7 | 7.3 | 730 |
| Overall | Selfed | 41.5 | 17.7 | 19.3 | 7.2 | 7.0 | 800 |
| | Open | 39.1 | 17.2 | 19.3 | 6.5 | 7.3 | 850 |
| Effect of Main Treatment (Cultivar) | | | | | | | |
| SE (m) ± | | 3.26 | 1.77 | 2.04 | 0.78 | 0.16 | 79 |
| CV% | | 16 | 20 | 21 | 23 | 4 | 19 |
| Sig | | S | S | S | S | S | S |
| Effect of Sub Treatment (Seed Type) | | | | | | | |
| SE(m) ± | | 1.20 | 0.75 | 0.81 | 0.32 | 0.06 | 19 |
| CV% | | 21 | 30 | 29 | 32 | 6 | 16 |
| Sig | | NS | NS | NS | NS | S | NS |
| Interaction (Cultivars X Seed Type) | | | | | | | |
| SE (m) ± Main | | 4.14 | 2.61 | 2.80 | 1.11 | 0.22 | 65 |
| SE (m) ± Sub | | 4.38 | 2.56 | 2.85 | 1.11 | 0.22 | 92 |
| Sig(5%) | | NS | NS | NS | NS | NS | S |

NS = Not significant; S = Significant.

Table 36: Pattern of egg laying by podfly in three pairs of resistant and susceptible pigeonpea genotypes, ICRISAT Center, 1985/86.

| Cultivar | DM 70% | No. of eggs/ pod | No. of pods with eggs | No. of eggs/ locule | % locules with eggs | % pod-fly pod damage | % pod-fly seed damage |
|---|---|---|---|---|---|---|---|
| Podfly resistant | | | | | | | |
| ICP-7050 | 192 | 0.10 | 7.0 | 0.03 | 2.8 | 8.3 | 3.1 |
| ICP-8102-5 | 207 | 0.61 | 38.0 | 0.18 | 16.4 | 21.5 | 8.5 |
| ICP-7176-5 | 214 | 0.56 | 28.0 | 0.16 | 13.4 | 23.0 | 8.7 |
| Podfly susceptible | | | | | | | |
| ICP-5036 | 183 | 0.17 | 11.0 | 0.05 | 4.6 | 18.0 | 7.6 |
| ICP-8595 | 214 | 0.88 | 43.5 | 0.25 | 20.9 | 35.0 | 13.7 |
| ICP-8583 | 211 | 0.60 | 37.0 | 0.18 | 15.7 | 26.8 | 11.9 |
| Overall comparison | | | | | | | |
| Resistant | | 0.42 | 24.3 | 0.13 | 10.9 | 17.6 | 6.8 |
| Susceptible | | 0.55 | 30.5 | 0.16 | 13.7 | 26.6 | 11.1 |
| SE(m) ± | | 0.091 | 4.44 | 0.026 | 2.17 | 2.66 | 1.04 |
| CV% | | 65 | 56 | 64 | 61 | 42 | 40 |
| Sig(5%) | | NS | NS | NS | NS | S | S |

S = Significant; NS = Not significant.

selections. Although the overall numbers of podfly in the area low in the winter (November-January) the entomologists selections were heavily infested, presumably because they were the only hosts available at that time. The "resistant" selections showed only a slightly lower infestation by podfly (30% seed damage) than the "susceptible" selections (34% seed damage). The standard cultivars and breeders selections flowered and podded from February onwards at the same time as the bulk of the pigeonpea crop grown at Gwalior. At that time podfly populations were high, but when dispersed over the available crop they were diluted. Thus the seed damage by podfly in these later flowering genotypes averaged only 11% and the yields were 10 times greater than the unadapted entomologists' selections.

We learned several lessons from this trial which will enable us to improve our methodology in the future. Selection of podfly resistance at Patancheru cannot be directly and usefully transferred to Gwalior conditions unless the resistance is in a genotype that is adapted to the Gwalior conditions. We may be able to select for sources of resistance at ICRISAT Center, but it will be necessary to actually breed and select for resistance to podfly at Gwalior, where the climatic and podfly infestation conditions are very different to those at ICRISAT.

## Host Plant Characters in Relation to Podfly Resistance

In this year, we sampled the podwalls, young seeds, mature seeds and flowers of the following four pigeonpea genotypes to determine their protein and total soluble sugar contents (through the ICRISAT Biochemistry Unit).

| | |
|---|---|
| ICP 7941 | (Resistant) |
| ICP 8102-5 | (Resistant) |
| ICP 7337-2 | (Susceptible) |
| ICP 8595 | (Susceptible) |

The samples were obtained from random collection in plots, separately from each of 4 replications in the trial that was grown in field BIL-6A for podfly resistance studies.

The results (Table 37) showed no significant relationship between resistance and protein content of the plant parts analysed. However, the resistant varieties had significantly higher levels of soluble sugars in the flowers and in mature seeds, but lower levels in the young seeds and in podwalls.

Similar biochemical analysis of podwalls during the previous two seasons (1983-84 and 1984-85) suggested a positive relationship between podfly infestation and total soluble sugar content of the podwall.

## Podfly Avoidance Studies

During the previous year, Dr.S.S.Lal, Entomologist of the Project

Table 37: Summary of biochemical comparison of pigeonpea flowers, podwalls and seeds in relation to podfly susceptibility, ICRISAT Center, rainy season, 1985/86.

| Cultivar | Protein (%) | | | | Total sugars (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Flowers | Pod-walls | Young seeds | Mature seeds | Flowers | Pod-walls | Young seeds | Mature seeds |
| ICP-7941 (LPf) | 4.35 | 12.83 | 28.45 | 19.03 | 6.05 | 8.35 | 10.05 | 6.72 |
| ICP-7337-2 (HPf) | 3.77 | 14.08 | 27.17 | 19.68 | 5.78 | 10.41 | 13.32 | 6.42 |
| ICP-8102-5 (LPf) | 3.65 | 12.97 | 26.63 | 19.62 | 7.31 | 10.81 | 14.16 | 6.77 |
| ICP-8595 (HPf) | 4.12 | 12.67 | 28.87 | 20.30 | 6.44 | 10.28 | 12.63 | 6.30 |
| SE(m)± | 0.149 | 0.211 | 0.247 | 0.442 | 0.142 | 0.286 | 0.506 | 0.148 |
| CV% | 9 | 4 | 2 | 6 | 5 | 7 | 10 | 6 |
| Sig(5%) | S | S | S | NS | S | S | S | NS |
| Overall comparison between resistant and susceptible | | | | | | | | |
| Low podfly | 4.0 | 12.90 | 27.54 | 19.33 | 6.68 | 9.58 | 12.10 | 6.75 |
| High podfly | 3.9 | 13.38 | 28.02 | 19.99 | 6.11 | 10.34 | 12.98 | 6.36 |
| SE(m)± | 0.13 | 0.208 | 0.313 | 0.3 | 0.181 | 0.322 | 0.543 | 0.109 |
| CV% | 11 | 6 | 4 | 5 | 10 | 11 | 15 | 6 |
| Sig(5%) | NS | NS | NS | NS | S | NS | NS | S |

LPf = Less susceptible to podfly; HPf = Highly susceptible to podfly.
NS = Not significant; S = Significant.

Directorate of Pulses, AICPIP, Kanpur, expressed an interest in utilising genotypes which can avoid/reduce podfly damage by flowering and podding during Dec-Feb, when the pest activity in northern India is expected to be low. He sent us 10 of his preliminary selections (5 from cv. Bahar; 5 from others) for comparing with the standard check cultivars for podfly damage at Gwalior. Due to the limited quantities of seeds, these selections could not be sown with the locally adapted genotypes in the main trial, but were sown in a separate trial in an adjacent block on the same date, in plots of 2 rows of 4 meter. The experiment was in a split-plot design involving two main treatments - sprayed (with dimethoate 0.07% - weekly) and non-sprayed in three replications.

Data were recorded on days to flowering and maturity, pod damage, seed damage and grain yield at harvest. The harvest estimates were made on 5 plants at random.

The range of days to flowering and podding in these 10 selections is summarised below, in comparison with the check genotypes grown in the adjacent block.

| | Kanpur selections (10) | Standard long-duration checks (4) |
|---|---|---|
| Days to 50% flowering | 153-161 | 148-159 |
| Days to 70% flowering | 271-276 | 260-267 |
| % pod damage by podfly | 28-50 | 21-35 |
| % seed damage by podfly | 12-26 | 12-26 |
| Grain yield/plant (unsp | 147-327 | 55-109 |

The Kanpur selections did not flower and pod earlier than the local standard checks, and so did not "avoid" the podfly build up. The mean yields per plant of the Kanpur selections were high, but this was largely because of a poor plant stand in most of the plots which resulted in the plants that survived having much more space in which to grow. The plot yields did not reflect the plant yield differences. However, some of the Kanpur selections did well at Gwalior.

The results for the main trial, described earlier, indicated that gentoypes flowering in the winter do not escape severe podfly damage, particularly where they are grown in small areas. We need to know more about podfly development and populations if we are to utilize such "avoidance" possibilities.

Search for Attractants for Adult Podfly

One of the major limitations in podfly research and field experimentation is the lack of a simple device to monitor the adult populations in the field. In previous seasons a range of possible attractants from different groups of substances were tested for their attractancy to adult podflies, but there was no distinct attraction seen in any. In a preliminary test, however, ammonium sulphide was found promising.

In this year, we conducted a few more field attractancy tests with several substances including ammonium sulphide. The chosen substances (Table 38) were dispersed as aqueous solutions (20 ml) in plastic cups which had perforations on the upper half and in the lid to allow the vapour/aroma to disperse. The cups had a 1 cm thick sponge padding at the bottom to retain the solutions without spillage. A circular card board collar coated with Tanglefoot was placed around each cup so that flies attracted to the aroma would be caught on the surfaces. The traps were suspended at crop height from wires.

Eight traps were fixed at equal distances along the border of a pigeonpea crop. The adult podflies caught in each trap were recorded and removed at 3-4 day intervals and the trap positions were interchanged after each observation.

The results (Table 38) indicate that ammonium sulphide traps caught nearly 8 times more podflies than the control traps. However, the catches, even in the ammonium sulphide traps, were low and inconsistent and did not appear to offer a satisfactory means of monitoring the podfly populations. We will continue our search for a means of monitoring the populations.

**Table 38: Podfly adult catches in sticky traps containing different substances, ICRISAT Center, rainy season 1985/86.**

| Substances tested | | No. of podfly adults caught per trap |
|---|---|---|
| Brown sugar solution | (20%) | 0.17 (1.07) |
| Molasses solution | (20%) | 0.42 (1.16) |
| Ethanol | (20%) | 0.83 (1.31) |
| Ethanol | (50%) | 0.42 (1.16) |
| Ammonium sulphide | (50%) | 2.75 (1.8) |
| Yeast solution | (20%) | 0.50 (1.20) |
| Honey solution | (20%) | 0.58 (1.23) |
| Control | | 0.33 (1.12) |
| SE (m) ± | | (0.106) |
| CV% | | 29 |
| Sig. | | S |

Figures in parentheses indicate the $\sqrt{X+1}$ transformations.

S = Significant.

Project No.CP-123(85)IC

**STUDIES LEADING TO INTEGRATED PEST MANAGEMENT ON PIGEONPEA AND CHICKPEA INCLUDING THE AUGMENTATION OF NATURAL CONTROL ELEMENTS**

Objectives

To develop information needed for implementing integrated pest management. To study the ways of augmenting natural control of the pests of pigeonpea and chickpea. To evaluate the combinations of pest management elements, including host plant resistance, cultural practices and pesticide use in field trials. To develop economic threshold. To assess potential pest problems. To evaluate the relative economic benefits of control practices and identify constraints if any on their adoption by farmers in close collaboration with national programmes, to help in ultimate adoption by farmers.

Tests on Different Regimes of Insecticide Use in Short Duration Pigeonpeas

During the previous season we initiated trials to assess the benefit caused by different regimes of insecticide use during flowering/podding in short duration pigeonpea. In general, it was found that 3-4 sprays could result in economic benefit to the crop in the first flush, while the use of insecticides for the second flush appeared uneconomical.

In this year, we repeated the trials as in last year, but restricted our studies to the effects of insecticide use during first flush, both at Patancheru and at Hisar.

At Patancheru, the trial consisted of two cultivars (ICPL 1 and ICPL 87) as main plots in a split plot design (sown in field BP-14C on 27 June 1985) with the following subtreatments:

T1 - 4 sprays (0,10,20 and 30 days after 50% flowering)
T2 - 2 sprays (20 and 30 days after 50% flowering)
T3 - 1 spray (20 and 30 days after 50% flowering)
T4 - 1 spray (30 and 30 days after 50% flowering)
T5 - Unsprayed check

The pod borers (mainly *Heliothis*) were the major targets for the insecticide use, but populations of borers were low in this season, as can be seen in the data recorded in Table 39. Much of the pod damage was caused by the hymenopteran pest and by sucking bugs and these pests were not controlled by the insecticide. The yields from the control plots averaged only 125 kg/ha (10%) less than those in the insecticide treated plots. Such a difference is unlikely to be economic. However, trials with such a design in which small plots of sprayed and unsprayed pigeonpea are adjacent may not reflect the benefits obtained from insecticide use on larger isolated plots.

Table 39: Effect of spray regimes on pest damage and grain yield in 2 short duration pigeonpea genotypes grown on the Vertisol BP-14C at ICRISAT Center, rainy season 1985/86.

| Genotypes | Treatments | % pod damage | | Grain yield kg/ha | |
|---|---|---|---|---|---|
| | | Total | Borer | I flush | II flush |
| ICPL-1 | T1 | 26.7 | 6.0 | 1130 | 300 |
| | T2 | 39.3 | 9.0 | 1160 | 250 |
| | T3 | 29.7 | 10.0 | 1040 | 220 |
| | T4 | 47.3 | 11.8 | 1200 | 240 |
| | T5 | 36.5 | 11.3 | 970 | 290 |
| | Mean | 35.9 | 9.6 | 1100 | 260 |
| ICPL-87 | T1 | 35.0 | 5.3 | 1320 | 280 |
| | T2 | 27.5 | 7.0 | 1350 | 180 |
| | T3 | 34.3 | 9.3 | 1310 | 220 |
| | T4 | 23.5 | 9.8 | 1350 | 200 |
| | T5 | 34.5 | 10.8 | 1240 | 230 |
| | Mean | 30.9 | 8.4 | 1310 | 220 |
| Overall | T1 | 30.9 | 5.6 | 1220 | 290 |
| | T2 | 33.4 | 8.0 | 1260 | 210 |
| | T3 | 32.0 | 9.6 | 1170 | 220 |
| | T4 | 35.4 | 11.8 | 1270 | 220 |
| | T5 | 35.5 | 11.0 | 1110 | 260 |
| **Genotype effects** | | | | | |
| SE (m) ± | | 0.56 | 1.07 | 58.3 | 15 |
| CV% | | 3 | 24 | 10 | 12 |
| Sig(5%) | | S | NS | NS | NS |
| **Spray regime effects** | | | | | |
| SE (m) ± | | 2.67 | 1.81 | 40.7 | 13 |
| CV% | | 23 | 57 | 10 | 16 |
| Sig(5%) | | NS | NS | S | S |
| **Interaction** | | | | | |
| SE(m) ± Main | | 3.78 | 2.56 | 57.6 | 19 |
| SE(m) ± Sub | | 3.43 | 2.53 | 77.8 | 22 |
| Sig(5%) | | S | NS | NS | NS |

T1 = 4 sprays 0,10,20 and 30 days after 50% flowering.
T2 = 2 sprays 20 and 30 days after 50% flowering
T3 = 1 spray 20 days after 50% flowering
T4 = 1 spray 30 days after 50% flowering.
T5 = Control

S = Significant; NS = Not significant.
(4 replications)

In another trial in field BIL-6A however, we grew the same two cultivars as subplots (22 rows of 4 metres) in a split-plot design with 'spray protection' and 'no protection' as the main plots in five replications. A total of 3 sprays (endosulfan) were given for the first flush. Similar spray protection was also given for the second flush. The results (Table 40) indicated a significant increase in yield (330 kg/ha) from the sprayed plots from the first flush. In the second flush, the spray treatments did not bring about any appreciable reduction in pod or seed damage. The overall yield levels were considerably lower than in many other fields probably because of the poor fertility/water status of the soil.

At Hisar, a trial on insecticide regimes was conducted with two cultivars (ICPL 1 and ICPL 151) in split-plot design with the following subtreatments in four replications:

| | | |
|---|---|---|
| T1 | 5 sprays | 0,10,20,30,and 40 days after 50% flowering |
| T2 | 4 sprays | 0,15,30 and 40 days after 50% flowering |
| T3 | 3 sprays | 0,20 and 40 days after 50% flowering |
| T4 | 3 sprays | 0,15 and 30 days after 50% flowering |
| T5 | 2 sprays | 0 and 20 days after 50% flowering |
| T6 - Control (no spray) | | |

The subplots were of 6 rows of 4 meters with 30 cm between rows and 10 cm between plants. The insecticide sprays (monocrotophos 0.04%) were applied with knapsack sprayer at 500 litres of spray mix/ha.

The spray regimes resulted in a significant reduction in pod damage and increase in yield (Table 41). The greatest yields were obtained from the indeterminate ICPL 1 when sprayed at least 3 times to 40 days after flowering. The major pest in the trial was _Heliothis armigera_, _Maruca testulalis_ was of little importance.

In another field trial conducted at Hisar we tested whether short-duration genotypes differed substantially in the extent of loss caused by pests. Five genotypes (Table 42) were sown in a split plot design with eight replications, the main plot treatments being T1 - 'spray protected' and T2 - 'non protected'. The plots were of 6 rows of 9 meters in T1 and 6 rows of 14 meters in T2. Sprays of decamethrin (DECIS 2.5E @ 600 ml in 500 litres/ha) and monocrotophos (NUVACRON 40 EC @ 500 ml in 500 litres/ha) were applied in alternate weeks from bud initiation till 70% maturity.

During each week from 50% flowering till 70% maturity, the damage caused by webbers (_Maruca/Cydia_) was visually rated on a 1-9 scale in the unsprayed plots (T2). At harvest, 20 plants were chosen at random and the pod damage as well as grain yield were recorded. The results (Table 42) indicated an overall improvement in pod set, especially in ICPL 4 (determinate). All five genotypes gave similar yield increases when the sprayed plots were compared with the unsprayed. ICPL 85024 gave the lowest yields in both treatments and was the most heavily damaged, both by borers and podfly in the untreated plots. Check ICPL

Table 40: Effect of insecticide use on pest damage and grain yield in two short duration pigeonpea genotypes grown on Vertisol (BIL-6A) at ICRISAT Center, rainy season, 1985/86.

| Treatment | Cultivar | I flush | | II flush | |
|---|---|---|---|---|---|
| | | % pod damage | Grain yield kg/ha | % pod damage | Grain yield kg/ha |
| Protected | ICPL-1 | 16.6 | 590 | 64.9 | 430 |
| | ICPL-87 | 32.0 | 590 | 26.6 | 660 |
| | Mean | 24.3 | 590 | 45.8 | 550 |
| Not-protected | ICPL-1 | 22.3 | 370 | 54.4 | 410 |
| | ICPL-87 | 56.6 | 160 | 29.5 | 690 |
| | Mean | 39.5 | 260 | 41.9 | 550 |
| Overall | ICPL-1 | 19.5 | 480 | 59.6 | 420 |
| | ICPL-87 | 44.3 | 370 | 28.0 | 670 |
| Treatment effects | | | | | |
| SE (m) ± | | 2.89 | 45 | 2.2 | 46 |
| CV% | | 20 | 24 | 11 | 19 |
| Sig(5%) | | S | S | NS | NS |
| Cultivar effects | | | | | |
| SE(m) ± | | 1.7 | 37 | 2.01 | 44 |
| CV% | | 17 | 27 | 15 | 26 |
| Sig(5%) | | S | NS | S | S |
| Interaction | | | | | |
| SE(m) ± Main | | 2.41 | 52 | 2.85 | 62 |
| SE(m) ± Sub | | 3.35 | 58 | 2.99 | 64 |
| Sig(5%) | | S | NS | S | NS |

3 sprays for first flush; 3 sprays for second flush.

**Table 41: Effect of graded regimes of spray protection on crop maturity, pod set, pod damage and grain yield in an indeterminate (C1) and determinate (C2) genotypes of short duration pigeonpea at Hisar, rainy season, 1985/86.**

| Cultivar | Treatment | Total pods/ plant | % damaged pods Total | % damaged pods Borer | % damaged pods Podfly | Yield kg/ha |
|---|---|---|---|---|---|---|
| C1 | T1 | 102 | 7.3 | 5.9 | 1.4 | 2500 |
| | T2 | 104 | 5.6 | 4.8 | 1.0 | 2670 |
| | T3 | 80 | 10.8 | 7.6 | 3.0 | 2590 |
| | T4 | 81 | 16.9 | 10.4 | 6.5 | 2120 |
| | T5 | 88 | 20.3 | 12.8 | 8.0 | 2090 |
| | T6 | 76 | 26.8 | 13.9 | 13.3 | 1880 |
| | Mean | 89 | 14.6 | 9.2 | 5.5 | 2310 |
| C2 | T1 | 31 | 5.4 | 4.6 | 0.9 | 2230 |
| | T2 | 40 | 8.1 | 6.9 | 1.3 | 2570 |
| | T3 | 31 | 16.5 | 13.[illegible] | 3.6 | 1960 |
| | T4 | 34 | 21.7 | 18.0 | 3.8 | 2210 |
| | T5 | 34 | 24.0 | 21.5 | 2.5 | 2060 |
| | T6 | 32 | 33.0 | 22.2 | 11.3 | 1760 |
| | Mean | 34 | 18.1 | 14.4 | 3.9 | 2130 |
| Overall | T1 | 66 | 6.3 | 5.3 | 1.1 | 2370 |
| | T2 | 72 | 6.9 | 5.8 | 1.1 | 2620 |
| | T3 | 55 | 13.6 | 10.4 | 3.3 | 2270 |
| | T4 | 60 | 19.3 | 14.2 | 5.1 | 2170 |
| | T5 | 61 | 22.1 | 17.1 | 5.3 | 2070 |
| | T6 | 54 | 29.9 | 18.1 | 12.3 | 1820 |
| **Effect of Main Treatment (Cultivar)** | | | | | | |
| SE(m) ± | | 7.0 | 1.17 | 1.11 | 0.26 | 115 |
| CV% | | 23 | 14 | 19 | 11 | 10 |
| Sig 5% | | S | NS | S | S | NS |
| **Effect of Sub Treatment (Spray Regimes)** | | | | | | |
| SE(M) ± | | 4.4 | 1.12 | 1.07 | 0.72 | 115 |
| CV% | | 21 | 19 | 26 | 43 | 15 |
| Sig 5% | | NS | S | S | S | S |
| **Effect of Interaction (Cultivar x Spray Regimes)** | | | | | | |
| SE(M) ± Main | | 6.3 | 1.58 | 1.52 | 1.02 | 163 |
| SE(M) ± Sub | | 9.1 | 1.85 | 1.78 | 0.97 | 188 |
| Sig (5%) | | NS | NS | S | NS | NS |

C1 = ICPL [illegible]; C2 = ICPL 151; S = Significant; NS = Not significant.
T1 = 5 sprays (0,10,20,30,40 DAF); T2 = 4 sprays (0,15,30,40 DAF);
T3 = 3 sprays (0,20,40 DAF); T4 = 3 sprays (0,15,30 DAF);
T5 = 2 sprays (0,20 DAF); T6 = No spray. 4 replications.

Table 42: Crop maturity, pod set, pod damage and grain yield in five short duration pigeonpeas under sprayed and unsprayed situations at Hisar, Kharif, 1985/86.

| Treatment | Cultivar | Total pods/ plant | % damaged pods | | Grain yield kg ha-1 |
|---|---|---|---|---|---|
| | | | Borer | Podfly | |
| T1 | C1 | 57 | 9.4 | 2.9 | 2260 |
| | C2 | 63 | 7.7 | 3.9 | 2540 |
| | C3 | 31 | 8.8 | 3.9 | 1570 |
| | C4 | 94 | 9.1 | 2.8 | 2620 |
| | C5 | 74 | 7.7 | 3.4 | 2460 |
| | Mean | 64 | 8.5 | 3.4 | 2290 |
| T2 | C1 | 54 | 26.6 | 5.7 | 1860 |
| | C2 | 45 | 22.2 | 5.8 | 1870 |
| | C3 | 29 | 31.3 | 11.6 | 1090 |
| | C4 | 64 | 22.8 | 5.1 | 1950 |
| | C5 | 55 | 24.9 | 7.3 | 1780 |
| | Mean | 49 | 25.5 | 7.1 | 1710 |
| Overall | C1 | 56 | 18.0 | 4.3 | 2060 |
| | C2 | 54 | 14.9 | 4.9 | 2210 |
| | C3 | 30 | 20.0 | 7.8 | 1330 |
| | C4 | 79 | 15.9 | 4.0 | 2290 |
| | C5 | 65 | 16.3 | 5.3 | 2120 |
| ***Effect of main treatment*** | | | | | |
| SE(m) ± | | 3.8 | 1.88 | 0.53 | 67 |
| CV% | | 19 | 31 | 29 | 9 |
| Sig(5%) | | S | S | S | S |
| ***Effect of sub treatment (cultivar)*** | | | | | |
| SE(m) ± | | 3.4 | 1.07 | 0.90 | 86 |
| CV% | | 24 | 25 | 68 | 17 |
| Sig(5%) | | S | S | S | S |
| ***Effect of interaction (treatment x cultivar)*** | | | | | |
| SE(m) ± Main | | 4.8 | 1.51 | 1.27 | 121 |
| SE(m) ± Sub | | 5.8 | 2.31 | 1.25 | 127 |
| Sig(5%) | | S | S | NS | NS |

T1 = Sprayed; T2 = Unsprayed. S = Significant; NS = Not significant.
C1 = ICPL-316 (Det); C2 = ICPL-8318 (Det); C3 = ICPL-85024 (Det);
C4 = ICPL-4 (Det-Check); C5 = ICPL-81 (Indet-Check)
(8 replications)

4 gave the greatest yields in both treatment. *Maruca* incidence in this trial was relatively low.

## Preliminary Attempts to Relate *Heliothis* Larval Numbers to Pod Damage

With the objective of developing economic thresholds for *Heliothis* on this crop, we made preliminary attempts to study field methodology problems in relating *Heliothis* larval numbers to pod damage at harvest.

We grew large plots ICPL 1 (short duration - indeterminate) ICPL 87 (short duration - determinate) and ICPL 1-6 (medium duration - indeterminate). We erected 9 x 3 m net cages in each of these plots. Plants in these cages were sprayed with dichlorvos (Nuvan) at the flower bud stage to knock down any pest infestation on the plants. Three days later young (3 day old) *Heliothis* larvae were released on the plants at the rate of 0, 2, 4 and 8 larvae per plant. Two weeks later when the released larvae should have completed their larval period all the plants were again sprayed with dichlorvos and from then onwards, weekly sprays were applied until maturity. At maturity the pods from each test plant (5 replicates for each genotype) were harvested and analysed for pod damage. The results are briefly summarized as follows.

| | | No.of larvae released/pl | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 2 | 4 | 8 | SE(m) | CV% | Sig |
| 1. Total pods per plant | ICPL 1 | 46 | 39 | 58 | 76 | 9.3 | 38 | NS |
| | ICPL 87 | 53 | 41 | 55 | 36 | 7.6 | 37 | NS |
| | ICP 1-6 | 31 | 28 | 33 | 29 | 14.9 | 111 | NS |
| 2. Percent bored pods | ICPL 1 | 34 | 82 | 77 | 95 | 8.5 | 26 | Sig |
| | ICPL 87 | 73 | 94 | 88 | 99 | 5.2 | 13 | Sig |
| | ICP 1-6 | 33 | 57 | 72 | 70 | 11.4 | 44 | NS |
| 3. Percent bored seeds | ICPL 1 | 17 | 57 | 61 | 78 | 7.3 | 31 | Sig |
| | ICPL 87 | 34 | 59 | 56 | 86 | 5.8 | 22 | Sig |
| | ICP 1-6 | 18 | 45 | 67 | 61 | 10.4 | 49 | Sig |
| 4. Grain yield (g/pl) | ICPL 1 | 5.4 | 1.4 | 3.0 | 1.2 | 1.09 | 89 | NS |
| | ICPL 87 | 6.5 | 3.0 | 4.0 | 0.4 | 1.18 | 76 | Sig |
| | ICP 1-6 | 5.7 | 3.4 | 2.7 | 1.3 | 1.90 | 129 | NS |

The substantial pod/seed damage observed in plants in which no larvae (0 per plant) were released, indicates that disinfestation was ineffective. This should be taken care of if we are to make progress in these studies, by suitable changes in the methodology.

**Consumption Rate of Flowers, Young Seeds and Mature Seeds by *Heliothis* Larvae**

In an effort to quantify the potential of *Heliothis* larvae to consume individual plant parts, we conducted a laboratory study. One-day-old larvae were used and there were three types of plant parts provided - flowers alone, young seeds alone and green mature seeds alone. These three types of plant parts were fed to the larvae at two temperature regimes - 35 C (day): 30 C (night) and 25 C (day): 20 C (night). The plant parts were replaced daily by fresh material from the field.

In each test 15-40 replications were kept, but some mortality occurred during the test and the data were recorded per surviving larva per day.

The results showed the daily consumption increased with the age of the larvae. Although the per day consumption was reduced at the lower temperature regime, the larval duration was extended by up to 7 days and so the overall consumption during larval life was almost the same under both the temperature regimes. On an average each larvae consumed about 160 flowers or 100 young or 15 mature seeds during their development.

**Test of *Heliothis* Virus (NPV) on Pigeonpea (AICPIP Collab. Trial)**

In the previous season, we conducted a field trial on the efficacy of *Heliothis* virus (NPV) as a part of AICPIP collaboration. In this year, we laid out a trial, as suggested by AICPIP, in RBD with 5 treatments (as in Table 43) in 4 replications, the plot size being 7 rows of 4 meters. The cultivar ICP 1-6 was used.

*Heliothis* larval populations in this trial were generally low, as the plant growth was poor. Although the pod/seed damage by borers (mainly *Heliothis*) was the least in plots with weekly sprays of NPV (500 LE/ha) plus jaggery (0.5%), the differences among the treatments were not significant. The yield differences were not significant.

**Tests with the Egg Parasite, *Trichogramma* species on *H.armigera***

a) Laboratory tests:

Previously we found that pigeonpea is not a favoured host plant for *Trichogramma* spp. activity. In an attempt to determine whether genotypes of pigeonpea differ in their "friendliness" or otherwise to *Trichogramma* we undertook a series of laboratory tests. Four pairs of pigeonpea genotypes which are known to be 'resistant' and 'susceptible' to lepidopteran pod borers (mainly *Heliothis*) were chosen (Table 44). For each genotype (no choice

**Table 43: Effect of virus (NPV) spray on pod damage, seed damage and grain yield in pigeonpea, kharif 1985/86, ICRISAT Center*.**

| Treatment | % pod damage | | Grain yield kg/ha |
|---|---|---|---|
| | By borer | By all pests | |
| NPV 500 LE/ha weekly (3 sprays) | 22.2 (28.0) | 62.5 (52.3) | 710 |
| NPV 500 LE/ha + Jaggery weekly (3 sprays) | 14.7 (22.3) | 54.5 (47.8) | 550 |
| NPV 500 LE/ha First week Endosulfan (0.07%) next week - NPV 500 LE/ha again on third week | 19.4 (25.1) | 54.1 (47.5) | 700 |
| Endosulfan (0.07%) at interval of 2 weeks (2 sprays) | 18.1 (25.1) | 53.5 (47.0) | 800 |
| Control (no spray) | 27.6 (31.6) | 59.8 (50.7) | 650 |
| SE(m) ± | (2.30) | (3.11) | 82 |
| CV% | 17 | 13 | 24 |
| Sig(5%) | (NS) | (NS) | NS |

NS = Not significant.
Figures in parentheses are transformed angular values.
* Date of sowing: June 24, 1985; Fd.: BIL6A; based on 2 samples of 10 plants each from 4 replications.

Table 44: *Trichogramma* egg parasitism on borer resistant and susceptible pigeonpeas at ICRISAT Center, 1985-86* (lab. study).

| Name of the variety | Borer Res/ sus. | Total eggs obsvd: Reps. | Total eggs obsvd: Flower | Total eggs obsvd: Pod | % parasitism: Flower | % parasitism: Pod | % parasitism: Overall |
|---|---|---|---|---|---|---|---|
| ICP-10466-E3-7EB | Res | 10 | 80 | 82 | 42.3 | 23.8 | 33.1 |
| | | | | | (39.0) | (24.7) | (31.8) |
| BDN1 | Sus | 10 | 64 | 93 | 32.2 | 10.7 | 21.4 |
| | | | | | (31.3) | (11.0) | (21.2) |
| | SE(m)± | | | | | | (4.43) |
| | CV% | | | | | | 53 |
| | Sig(5%) | | | | | | (NS) |
| ICP-1903-E1-7EB | Res | 10 | 93 | 104 | 30.7 | 4.0 | 17.4 |
| | | | | | (31.5) | (6.4) | (19.0) |
| ICP-1691-E3-6EB | Sus | 10 | 91 | 88 | 33.7 | 12.0 | 22.9 |
| | | | | | (32.5) | (14.1) | (23.0) |
| | SE(m)± | | | | | | (3.56) |
| | CV% | | | | | | 54 |
| | Sig(5%) | | | | | | (NS) |
| ICP-3328-E3-7EB | Res | 15 | 246 | 244 | 72.3 | 67.5 | 69.9 |
| | | | | | (59.7) | (55.4) | (57.5) |
| C-11 | Sus | 15 | 241 | 203 | 42.8 | 38.9 | 40.8 |
| | | | | | (39.5) | (36.8) | (38.2) |
| | SE(m)± | | | | | | (3.04) |
| | CV% | | | | | | 25 |
| | Sig(5%) | | | | | | (S) |
| ICP-8134-1-S4-7EB | Res | 15 | 207 | 208 | 27.7 | 9.1 | 18.4 |
| | | | | | (29.3) | (11.6) | (20.5) |
| T-7 | Sus | 15 | 246 | 231 | 18.7 | 3.5 | 11.1 |
| | | | | | (20.2) | (4.9) | (12.5) |
| | SE(m)± | | | | | | (2.86) |
| | CV% | | | | | | 6.7 |
| | Sig(5%) | | | | | | (NS) |

* Cultivars grown by Dr.S.S.Lateef.

(Statistical analysis on split plot design with plant parts as sub treatments and cultivar groups as main treatment). Figures in parentheses are transformed values.

test), there were 10-15 replications. In each replication, we kept a few flowering/podding terminals with about 20 eggs of *H.armigera* each on flowers and on young pods. Each plant terminal was kept inside a transparent polythene cage and several 1-day old adults of *Trichogramma chilonis* were released on these. The percent eggs survived and parasitised was recorded, after about 15 days.

The results indicated that i) under forced conditions, the extent of parasitism on flowers was greater than on pods and ii) the overall differences in parasitism of eggs were significant only in one out of the four pairs studied, - where eggs on ICP 3328 were more extensively parasitized than those on C-11.

b) Field trials:

In an attempt to determine if differences are obtainable among genotypes in egg parasitism in the open field situation, we sowed four genotypes, as below, in large plots (12 rows of 9 meters) in 6 replications in BUS-8B.

| | |
|---|---|
| Low borer | - ICP-10466-E3-5EB |
| High borer | - PPE-50 |
| Low hymenopteran | - ICP-7175-5-E1-5EB |
| High hymenopteran | - ICP-8606 |

During the flowering/podding period of these genotypes, we released the three species of *Trichogramma*, T.*chilonis*, T.*brasiliensis* and T.*pretiosum* each at weekly intervals at about 50,000 adults/ha/week in this trial at different sites. Sampling of eggs of *Heliotbis* found on the four genotypes at 2-3 intervals during this release period indicated no parasitism by *Trichogramma*. These results, though disappointing, showed that releases of local and exotic *Trichogramma* species did not result in any useful parasitism across the range of pigeonpea genotypes studied.

Project: CP-122(85)IC

## STUDIES OF *HELIOTHIS* POPULATIONS TO SUPPORT THE PEST MANAGEMENT PROGRAMS, AND TO REAR *HELIOTHIS* FOR EXPERIMENTS

### Objectives

To monitor *Heliothis armigera* population throughout each year as eggs and larvae on the host plants and as moths in traps. To correlate the population fluctuations with the factors that are likely to influence them, such as climatic, natural enemies and crop changes. To determine the role of migration as a factor in population changes. To modify or develop a model for *Heliothis* populations and to attempt forecasts of infestations. To determine maximum threat period for *H.armigera* on our target crops in the specified locations and to arrive at sound pest management criteria. To build a bank of *Heliothis* data. To rear *Heliothis* for experiments.

### General

We continued to collect and receive catch data from pheromone and light traps across the Indian sub-continent. Preliminary analyses of these data indicated very large variances both between traps and between nights, however these variances were reduced in the traps in the north of India. A Departmental Progress Report, Pulse Entomology (18) "Population studies of *Heliothis armigera* Hubner (Lepidoptera: Noctuidae) through the analyses and interpretation of light and pheromone trap catches and larval counts" summarized the work from 1983-85 and is available on request.

We expect to be able to correlate the trap data with factors likely to affect populations (climatic and crop) in analyses in our computers within the next two years.

In cooperation with the Tropical Development and Research Institute a major study involving radar tracking of *Heliothis* moths was initiated in November 1985. Unfortunately the very low populations of *Heliothis* in this year greatly hindered this initiative which was intended to determine whether the moths flew to the high altitudes indicative of long range migration. However, the radar and other equipment worked well and the exercise will be repeated in 1986 providing adequate populations of moths appear. A separate report by our TDRI entomologists will give more details of these studies.

We continued the rear *Heliothis armigera* on diet based upon kabuli chickpea flour. Various improvements were made to our facilities and methodology and in general we were more successful in the rearing. However, we are still not able to eliminate the occasional virus outbreak in our cultures and we also suffer from sporadic problems of sterility in some egg batches which we cannot explain. During the year our unit supplied eggs, larvae, pupae and moths for use in our laboratory and field experiments and to cooperating scientists outside ICRISAT.

# COLLABORATIVE STUDIES

## Studies on Pigeonpea Nodule Fly, Rivellia angulata (Pulse Agronomy Collaboration)

a) **Field populations of adult *Rivellia*:**

By keeping sticky traps, with and without fishmeal in three locations at the ICRISAT Center (BP2C, BIL2B and BUS8G), we recorded the catches of adult *Rivellia* weekly from June till the cessation of catches.

The catches in fishmeal traps showed two peaks, one in early August and the other at the end of August. As expected the catches in traps with fishmeal were far greater than in traps without fishmeal (Fig 3). It is possible that the two peaks represent two generations. Further studies are needed to confirm this speculation.

b) **Pot culture test for creating nodule damage by caging adult *Rivellia*:**

We conducted preliminary tests with pot grown pigeonpea plants (ICPL 81) to see if we could create different levels of nodule damage by altering the numbers of adults *Rivellia* females caged on individual plants, so that they laid differing amount of eggs, resulting in differing number of larvae that damage the nodules.

In a first trial with 5 reps. we obtained the following results.

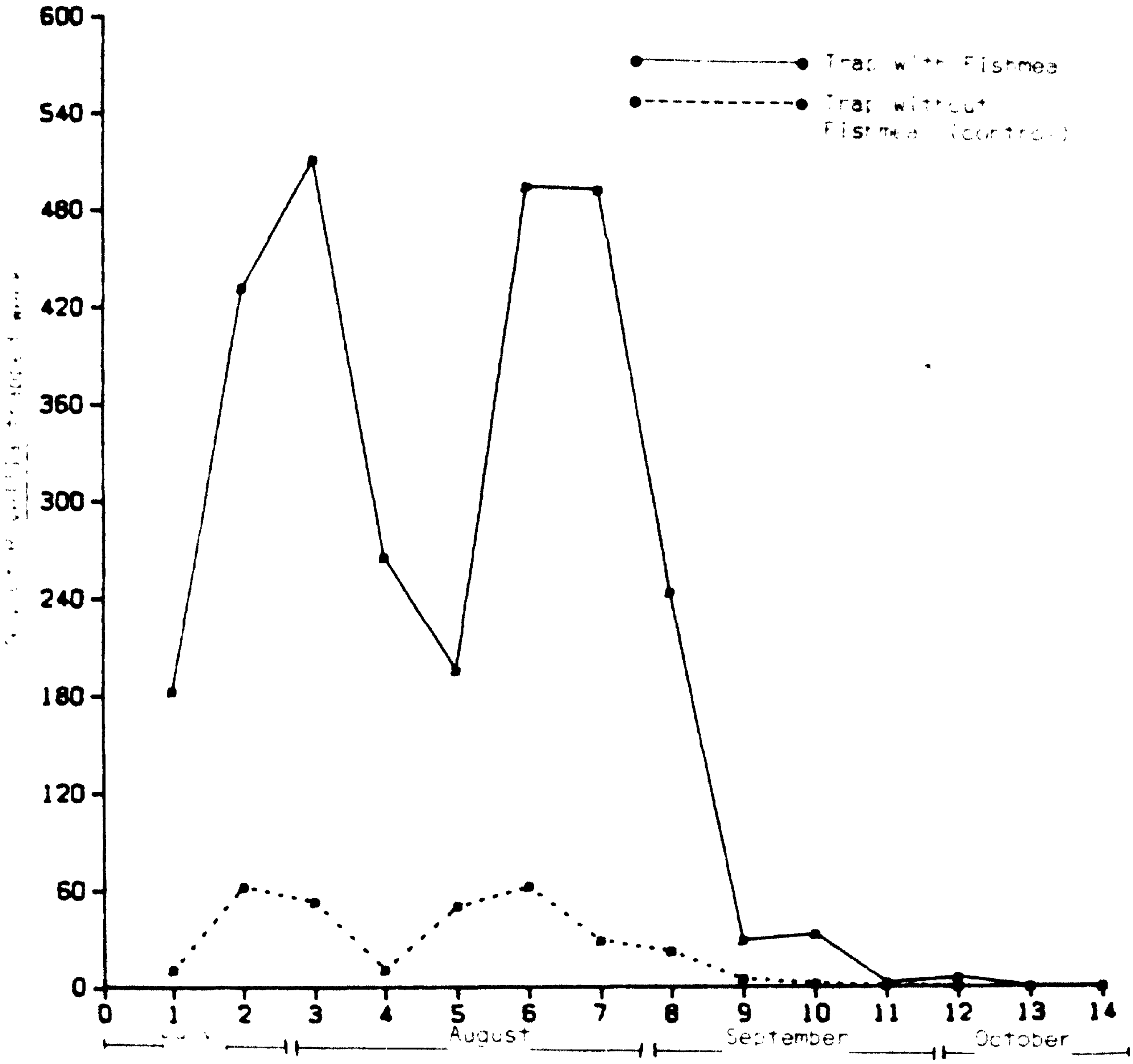
| | No. of adults caged/pl | | | SE(m) | CV% | Sig |
|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | | | |
| Nodules damaged/pl. | 5.6 | 8.2 | 13.0 | 2.05 | 51 | NS |
| % damaged nodules | 11.2 | 18.1 | 41.6 | 5.49 | 52 | Sig |

Thus we found clear indications of the utility of adult releases in creating different levels of nodule damage.

A subsequent test with 4 doses did not lead to clear results due to heavy infestation occurring in the zero dose (no adults caged), indicating the need to disinfest the soil prior to such tests.

Fig3 : Week , trap catches of adult Rivellia angulata (nodule fly) at ICRISAT Center, Pigeonpea, rainy season 1985-86.

(Mean of 3 locations - BP-2C, BIL-2B, and BUS-6G)



## Survey for Offseason Survival of *Heliothis* Parasites in Farmers Fields (RMP Collaboration)

In collaboration with our RMP entomologist, we sampled *Heliothis* larvae on tomatoes and groundnuts in farmers fields in the offseason (April-September 1986) and incubated these for parasitism.

The results revealed (Table 45) *Campoletis chlorideae*, *Goniophthalmus halli*, *Carcelia illota* and *Ovomermis albicans* to be largely surviving on *Heliothis* in tomatoes and groundnut.

Table 45: Summary of offseason incidence of natural enemies of *Heliothis armigera* (farmers fields around ICRISAT survey) 1985.

| Natural enemy | Month | Crop | % incidence | No. of hosts parasitised/ ha |
|---|---|---|---|---|
| *Campoletis chlorideae* Uchida | Apr | Tomato | 4.2 | 389 |
| | May | Tomato | 0.7 | 123 |
| | Jun | Tomato | 2.6 | 36 |
| | Jul | Tomato | 0.0 | 0 |
| | Aug | Tomato | 0.0 | 0 |
| | Sep | Tomato | 4.7 | 258 |
| *Goniophthalmus halli* Mes | Apr | Tomato | 0.0 | 0 |
| | May | Tomato | 0.2 | 41 |
| | Jun | Tomato | 0.0 | 0 |
| | Jul | Tomato | 7.1 | 286 |
| | Aug | Tomato | 0.0 | 0 |
| | Sep | Tomato | 0.0 | 0 |
| *Carcelia illota* Curran | Apr | Tomato | 0.0 | 0 |
| | May | Tomato | 0.0 | 0 |
| | Jun | Tomato | 0.0 | 0 |
| | Jul | Tomato | 0.0 | 0 |
| | Aug | Tomato | 2.2 | 24 |
| | Aug | G.nut | 3.4 | 69 |
| | Sep | Tomato | 15.6 | 859 |
| *Ovomermis albicans* (Seib) | Apr | Tomato | 0.0 | 0 |
| | May | Tomato | 0.0 | 0 |
| | Jun | Tomato | 0.0 | 0 |
| | Jul | Tomato | 3.6 | 143 |
| | Aug | Tomato | 35.6 | 391 |
| | Aug | G.nut | 48.3 | 966 |
| | Sep | Tomato | 1.6 | 86 |

# METEOROLOGICAL OBSERVATIONS AT ICRISAT
## JUNE 4, 1985 TO JUNE 3,1986
Source: Agroclimatology, FSRP, ICRISAT

| Std week | Dates | Month | Rain-fall in (mm) | Average temp. C Max | Min | Average % humidity 0717 | 1417 | Average wind velo-city (km/h) | Average sunshine (hr/day) | Average daily evapo-ration (mm/day |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | 04-10 | Jun | 21.9 | 33.7 | 23.5 | 86.0 | 47.9 | 17.6 | 5.2 | 52.4 |
| 24 | 11-17 | Jun | 1.8 | 34.5 | 23.0 | 82.3 | 41.3 | 20.5 | 7.4 | 67.3 |
| 25 | 18-24 | Jun | 25.4 | 32.4 | 23.4 | 80.3 | 49.3 | 19.0 | 4.3 | 56.0 |
| 26 | 25-01 | Jul | 26.1 | 29.7 | 22.3 | 88.6 | 68.7 | 20.5 | 2.2 | 34.3 |
| 27 | 02-08 | Jul | 27.3 | 31.6 | 22.2 | 85.4 | 52.7 | 18.5 | 6.6 | 52.2 |
| 28 | 09-15 | Jul | 5.6 | 32.2 | 23.3 | 82.3 | 49.6 | 16.0 | 3.5 | 49.8 |
| 29 | 16-22 | Jul | 36.1 | 29.4 | 21.7 | 93.7 | 62.9 | 10.9 | 2.3 | 31.8 |
| 30 | 23-29 | Jul | 68.2 | 29.2 | 21.9 | 95.4 | 69.0 | 7.8 | 5.5 | 34.4 |
| 31 | 30-05 | Aug | 41.0 | 28.4 | 21.8 | 88.9 | 69.4 | 14.5 | 3.6 | 28.6 |
| 32 | 06-12 | Aug | 9.2 | 29.9 | 22.0 | 85.7 | 57.9 | 12.8 | 4.7 | 41.1 |
| 33 | 13-19 | Aug | 9.4 | 29.0 | 22.4 | 86.3 | 67.0 | 10.3 | 3.6 | 33.9 |
| 34 | 20-26 | Aug | 15.8 | 31.6 | 23.0 | 81.3 | 53.4 | 7.5 | 7.0 | 42.1 |
| 35 | 27-02 | Sep | 7.0 | 30.8 | 22.7 | 83.9 | 58.3 | 7.3 | 6.8 | 39.8 |
| 36 | 03-09 | Sep | 13.4 | 30.6 | 22.0 | 88.3 | 56.4 | 7.6 | 4.2 | 37.5 |
| 37 | 10-16 | Sep | 26.6 | 30.0 | 22.1 | 84.4 | 61.6 | 8.3 | 3.0 | 34.4 |
| 38 | 17-23 | Sep | 30.2 | 31.2 | 21.1 | 88.1 | 58.0 | 6.2 | 6.5 | 36.7 |
| 39 | 24-30 | Sep | 5.6 | 32.6 | 22.3 | 91.1 | 47.9 | 6.0 | 9.7 | 41.1 |
| 40 | 01-07 | Oct | 80.4 | 29.1 | 21.8 | 94.1 | 75.6 | 11.5 | 3.9 | 28.2 |
| 41 | 08-14 | Oct | 11.4 | 29.1 | 20.8 | 93.9 | 61.1 | 7.6 | 6.4 | 25.8 |
| 42 | 15-21 | Oct | 1.2 | 30.4 | 17.8 | 80.4 | 39.3 | 4.9 | 8.7 | 38.1 |
| 43 | 22-28 | Oct | 0.0 | 29.0 | 13.5 | 80.4 | 32.4 | 4.9 | 11.0 | 41.7 |
| 44 | 29-04 | Nov | 0.0 | 28.7 | 12.7 | 84.0 | 35.1 | 6.8 | 10.2 | 42.0 |
| 45 | 05-11 | Nov | 0.0 | 29.3 | 17.7 | 86.9 | 45.3 | 7.3 | 8.8 | 34.3 |
| 46 | 12-18 | Nov | 0.0 | 28.8 | 12.0 | 77.0 | 29.9 | 6.9 | 9.8 | 40.1 |
| 47 | 19-25 | Nov | 0.0 | 29.9 | 12.0 | 73.3 | 25.4 | 5.9 | 10.4 | 38.2 |
| 48 | 26-02 | Dec | 0.0 | 28.2 | 12.2 | 77.3 | 28.4 | 7.6 | 10.5 | 40.0 |
| 49 | 03-09 | Dec | 0.0 | 28.5 | 10.7 | 73.7 | 29.1 | 5.6 | 8.4 | 33.8 |
| 50 | 10-16 | Dec | 8.1 | 26.9 | 15.6 | 90.7 | 47.7 | 11.5 | 7.1 | 32.8 |
| 51 | 17-23 | Dec | 0.0 | 29.4 | 14.1 | 90.9 | 33.9 | 6.0 | 9.9 | 33.9 |
| 52 | 24-31 | Dec | 0.0 | 29.4 | 13.0 | 80.7 | 31.4 | 6.1 | 10.2 | 40.3 |
| 1 | 01-07 | Jan | 0.0 | 27.8 | 10.9 | 75.6 | 26.0 | 6.3 | 10.0 | 37.7 |
| 2 | 08-14 | Jan | 0.0 | 27.4 | 14.1 | 90.0 | 37.0 | 9.2 | 8.9 | 35.1 |
| 3 | 15-21 | Jan | 53.0 | 23.3 | 13.1 | 96.0 | 58.3 | 8.7 | 6.8 | 24.2 |
| 4 | 22-28 | Jan | 0.0 | 28.9 | 13.9 | 93.6 | 33.0 | 8.9 | 10.3 | 38.7 |
| 5 | 29-04 | Feb | 0.0 | 30.0 | 16.8 | 82.3 | 34.4 | 9.2 | 9.6 | 39.0 |
| 6 | 05-11 | Feb | 4.4 | 30.1 | 17.0 | 91.4 | 35.6 | 14.0 | 10.0 | 47.7 |
| 7 | 12-18 | Feb | 39.2 | 29.9 | 18.1 | 96.1 | 41.6 | 11.6 | 9.4 | 40.8 |
| 8 | 19-25 | Feb | 0.0 | 29.9 | 18.0 | 90.9 | 40.3 | 9.4 | 10.1 | 44.5 |
| 9 | 26-04 | Mar | 0.0 | 31.7 | 17.7 | 76.1 | 29.7 | 13.7 | 10.6 | 60.9 |
| 10 | 05-11 | Mar | 0.0 | 32.7 | 19.9 | 78.6 | 32.1 | 12.0 | 9.7 | 58.3 |

| Std week | Dates | Month | Rain-fall in (mm) | Average temp. C Max | Min | Average % humidity 0717 | 1417 | Average wind velo-city (km/h) | Average sunshine (hr/day) | Average daily evapo-ration (mm/day |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 12-18 | Mar | 0.0 | 35.4 | 19.4 | 62.0 | 21.1 | 8.7 | 10.4 | 64.7 |
| 12 | 19-25 | Mar | 0.0 | 36.9 | 20.0 | 56.1 | 21.0 | 8.4 | 10.2 | 68.0 |
| 13 | 26-01 | Apr | 0.0 | 37.7 | 21.6 | 49.0 | 21.3 | 10.0 | 10.7 | 79.8 |
| 14 | 02-08 | Apr | 0.0 | 37.7 | 21.3 | 72.6 | 21.0 | 8.0 | 11.1 | 76.1 |
| 15 | 09-15 | Apr | 0.0 | 39.0 | 24.6 | 57.1 | 21.9 | 8.9 | 8.8 | 75.7 |
| 16 | 16-22 | Apr | 9.6 | 39.9 | 24.1 | 66.6 | 23.3 | 9.6 | 9.8 | 73.7 |
| 17 | 23-29 | Apr | 25.7 | 35.9 | 23.6 | 60.9 | 29.9 | 11.1 | 9.7 | 75.6 |
| 18 | 30-06 | May | 0.0 | 37.8 | 24.6 | 62.1 | 27.7 | 11.2 | 9.1 | 72.4 |
| 19 | 07-13 | May | 0.0 | 40.3 | 25.2 | 47.1 | 17.7 | 10.1 | 10.2 | 89.1 |
| 20 | 14-20 | May | 0.0 | 41.1 | 26.9 | 50.1 | 18.9 | 17.3 | 10.8 | 111.0 |
| 21 | 21-27 | May | 0.0 | 40.6 | 26.8 | 43.3 | 19.3 | 13.4 | 10.8 | 102.1 |
| 22 | 28-03 | Jun | 2.2 | 37.5 | 24.7 | 61.3 | 32.6 | 11.7 | 8.0 | 76.3 |